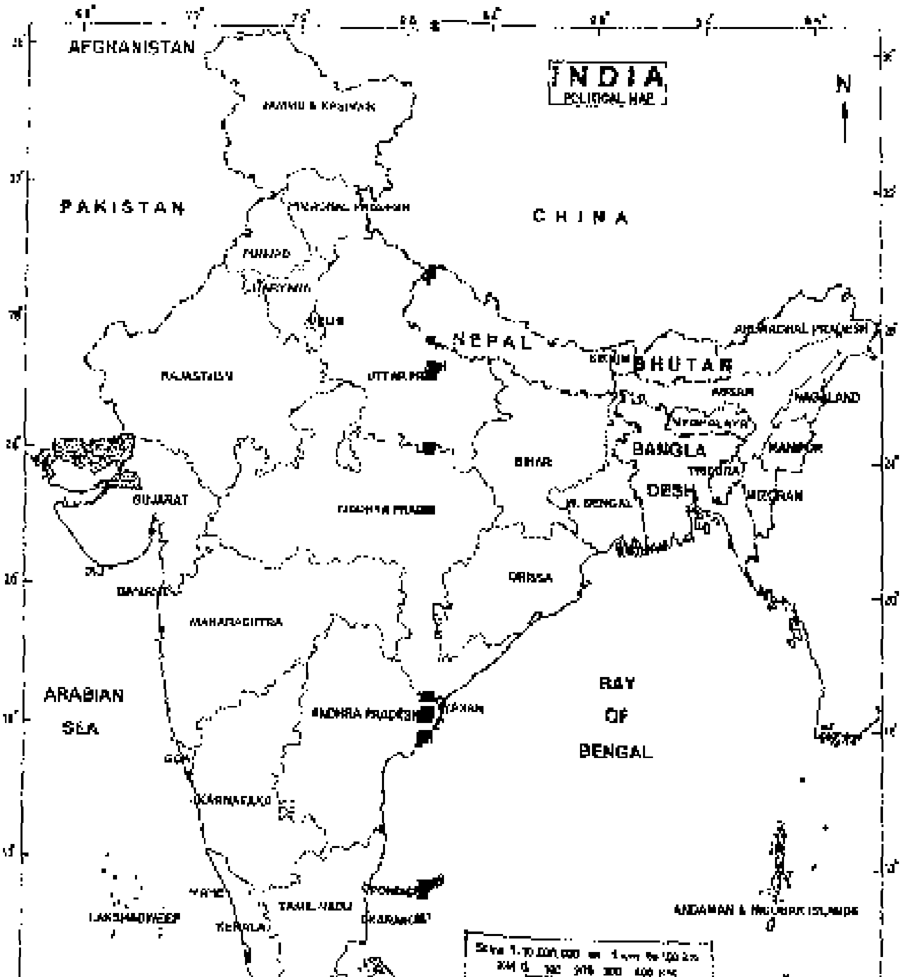
FLORA OF INDIA

INTRODUCTORY VOLUME

PART I

BOTANICAL SURVEY OF INDIA



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MIZORAM
TRIPURA
ARUNACHAL PRADESH
ANDAMAN & NICOBAR ISLANDS

FLORA OF INDIA

Introductory volume
(Part I)

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Contents

Foreword

India with over 45,000 species of flora and 75,000 species of fauna distributed in its two major biogeographic realms having 10 biogeographic zones and two biodiversity hotspot regions of the world, is justifiably recognized as one of the World's 12 magacentres of biodiversity. Such a richness of varied biomes from tropical wet evergreen forests to deserts and alpine vegetation to coastal systems understandably needed the establishment of a well organized institution like the Botanical Survey of India for undertaking detailed botanical explorations and to document systematically this natural heritage.

Since its inception in the year 1890 the BSI, now under the Ministry of Environment and Forests, has been rendering a signal service to the nation through its intensive and extensive surveys and taxonomic studies of India's floristic wealth. The survey work has also unearthed much.information on less understood forest Wealth. This has augmented greatly the information base of our wild plant genetic domain so essential for research in agriculture, horticulture, economic botany, medicinal plants, ecosystem dynamics and conservation of natural resources for sustainable development. Decisions on industrial location and infrastructure development are shaped by the work of the BSI on endangered plant species, threatened habitats and fragile ecosystems.

I am glad that BSI's recently launched programme on the preparation of new 'Flora of India' volumes is progressing steadily with five volumes published since 1993 besides the 22 fascicles of the Flora of India with taxonomic revisionary studies. These studies have won international acclaim. I am confident that these two volumes will prove to be of high reference value to students, researchers and project planners and useful in evaluating the status of our flora and conservation needs.

I congratulate the Director, BSI, the authors and the editors for their efforts in bringing out these volumes.

NRKrishnan

(N.R. Krishnan)

Date : 4th June, 1996

Preface

Since the publication of the Flora of British India and the subsequent regional floras, several botanical explorations have been undertaken in different parts of India and publications describing the forests, vegetation types, floristic characteristics (in many cases with detailed lists of floral elements) of many botanically less understood parts in the country have been published especially after the stepping up of botanical exploratory activities by the reorganised Botanical Survey of India in the year 1954. This activity contributed vastly to our better understanding of the vegetation, forest types and floristics and has also greatly enriched the Indian herbaria with botanical specimens from several remote areas and regions of the country which were botanically poorly known in the past enabling the BSI to bring out several state and district floras or of floristically significant areas. The data collected on different aspects relating to the natural vegetation and certain man-made changes in the vegetation patterns particularly during the last one hundred years have necessitated to make suitable amendments to our knowledge on the forest types, phytogeography, endemism on one hand and on the gradual loss of pristine vegetation, habitats and certain floristic elements of significance on the other. This enriched data bank has paved the way to undertake the revision of Flora of India in a new format. Since 1978, the Botanical Survey of India has drawn up plans to bring out revisionary accounts of the flowering plant families and this effort has resulted in the publication of 22 Fascicles of Flora of India and 5 volumes of the revised National Flora till date. It is thought appropriate and necessary to describe different salient aspects pertaining to the Indian floristic richness in different phytogeoraphical zones in a manner more perceptible and understandable to botanists, forestrs, ecologists, conservationists, ethnobotanists, and others interested in our wild plants through several suitably captioned chapters with a view to present an overall panorama of the Indian floristic estate in a book : *Flora of India - Introductory Volume*. In all about 30 different chapters describing the prime vegetation types in different pytogeographical and ecological systems; ecozones; endemism, centres of plant diversity and phytogeopgraphical affinities; exotics; ethnobotanical, medicinal and plants of economic value; plant based industries; wild relatives of cultivated plants; wild plants of horticultural significance; endangered plants, habitats and their conservation; protected area network; botanic gardens, and the statistical analysis of flowering plants in Indian flora have been considered for this volume.

Accordingly, expertise for writing these chapters has been harnessed both from within the Botanical survey of India and outside organisations, and every possible effort has been made to render them coherent and readable. It is hoped that the collective knowledge in this volume being presented in two parts not only gives an overview of the flora of India but also highlights the most important aspect of action viz., conservation of plant diversity and areas needing urgent action.

In the course of preparation of this volume, the authors and the editors have received great encouragement and valuable suggestions from the Programme Advisory Committee for BSI, several senior botanists in the country and the former Directors of the Botanical Survey of India, from the Secretary, Ministry of Environment and Forests, Government of India and several scientists working in the BSI, which is deeply appreciated and placed on record.

Any suggestions for improvement of the contents of this volume are welcome.

Acknowledgements

It gives the editors great pleasure to record their thanks to all the contributors.

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List of Illustrations and Maps

1. PHYSIOGRAPHY

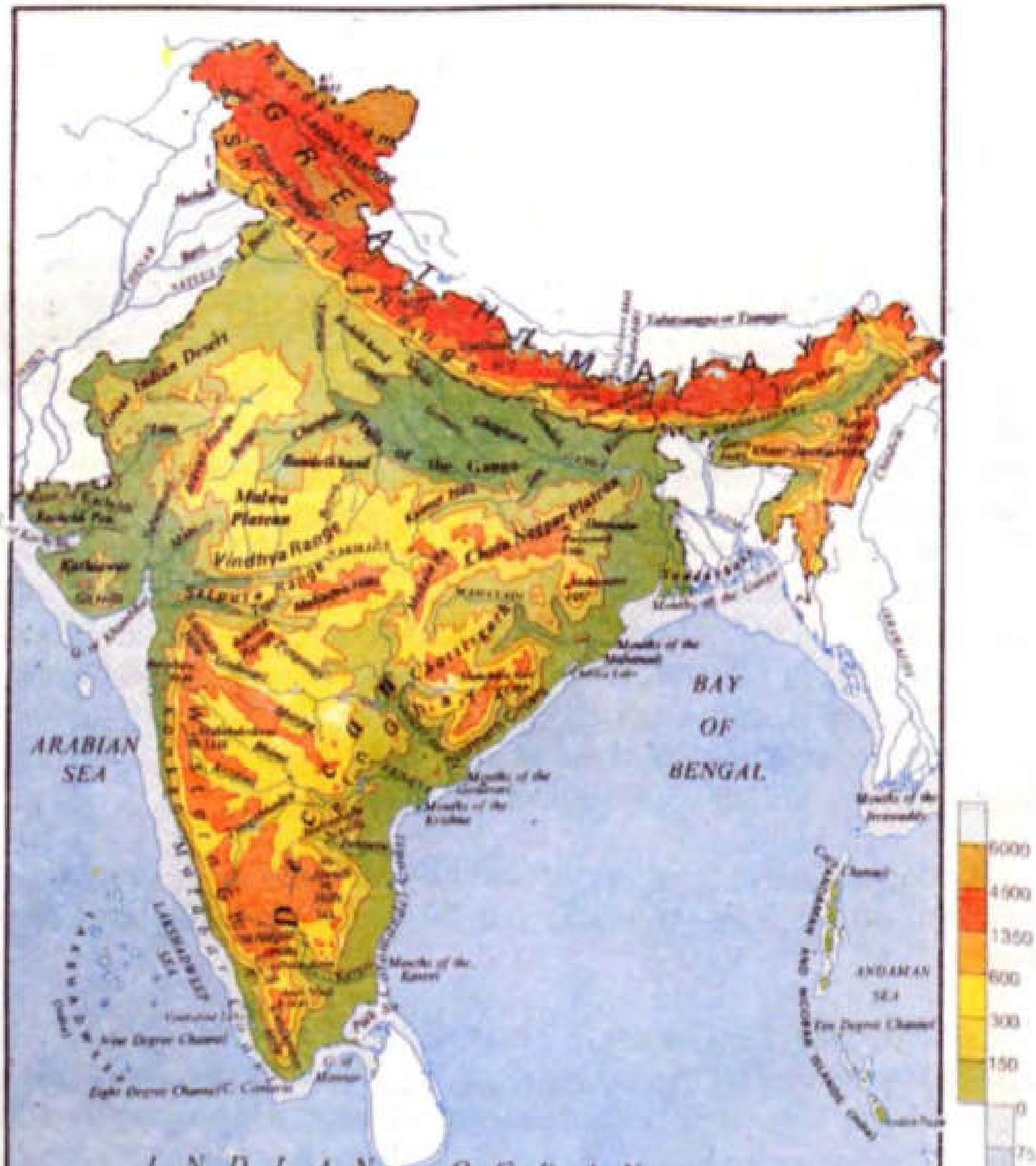
(G. V. S. Murthy, P. Venu & M. Sanjappa)

India lies between Latitudes 8° 4' and 37° 6' North and between Longitudes 68° 7' and 97° 25' East. It lies entirely to the north of the Equator with a greater area in the subtropical zone. The country occupies the largest Peninsula of the continent of Asia and measures 3219 km from north to south and about 2977 km from east to west. The land frontier is about 15,200 km while the coast-line is of 7516.6 km. It includes the mainland's coast-line as well as that of the Indian Islands. It is the seventh largest country in the world with an area of 32,87,263 sq. km. With regard to natural boundaries, the Great Wall of the Himalayas lies in the north. The Thar Desert of Rajasthan stretches across its north-west. In the south it narrows down to form the great Indian Peninsula which ends up in the Indian ocean with Cape Comorin (Kanyakumari) at its southern-most tip. Bay of Bengal lies in the eastern side of Peninsula wherein lie the Andaman and Nicobar Islands. On the West is the Arabian sea with another group of Islands called the Lakshadweep. (Laccadive and Minicoy Islands). These islands are parts of the Indian territory. In the east, the country is separated from Myanmar by long mountain ranges in north-south direction. The countries that touch India's border from west to east are Pakistan, Afghanistan, Nepal, Bhutan, China, Tibet Bangladesh and Myanmar (Anonymous, 1992 ; Singh, 1971).

Physiographically, India can be divided into three major divisions (a) the Peninsula, (b) the Extra Peninsula and (c) the North Indian Alluvial Plains. (Map 1)

Location-wise, the Peninsula is a triangular plateau bordered by the Vindhyan ranges in the north. The Extra-Peninsula at the northern extremity of the country constitutes the lofty Himalayan and other mountains. The third division, the Alluvial Plains exist in between the Peninsula and the Extra-Peninsula. Comprising extensive plains of Assam, West Bengal, Bihar, Uttar Pradesh and Punjab.

Stratigraphically, the Peninsula constitutes rocks of different age groups. Majorly, it is made of very ancient rocks of Archaean and Precambrian groups. Some of these Archaen rocks got metamorphosed to varying degrees. Besides, there exists the Deccan Traps and the Rajamahal lava flows of Jurassic and Eocene ages of Mesozoic and Coenozoic group. Post Cambrian sedimentary formations also occur in the Gondwana basins and occasionally along the coastal tracts of the Peninsular Shield. On the other hand, in the Extra-Peninsular division, granitic



Map 1. India - Physiography.

(Source : Based upon Survey of India map with permission from Surveyor General of India. Territorial waters of India extend in the sea to a distance of twelve nautical miles measured from the appropriate base line. Copy right Government of India, 1991).

rocks of Tertiary age occur in the core of Himalaya. Feldspar and quartz are essential minerals. The Indo-Gangetic alluvial plains formed in the quaternary era and are made of sand, clay and peat beds.

From the Physiographic point of view, the Peninsula represents ancient table-land and the major part of it was eroded since its formation. The mountains in the eastern and western coasts are the remnants of the ancient plateau. Sahyadris (The Western Ghats) are the major ranges in the Western coast. The Eastern Ghats are composed of a series of disconnected ranges all along the Eastern coast from Orissa down to the Nilgiris where they meet the Western Ghats (Mukerjee, 1990).

The Peninsula

The Peninsular Plateau is highest in the south and west and slopes eastwards. Large areas in the south exceed 600 m in elevation and sometimes even 900 m. The Western Ghats rise abruptly from the coastal plains to an averge height of 1200 m, and run parallel to the sea coast so they are known as Sahyadri meaning "facing the sea." In the northern half of the Western Ghats stand two high peaks - *Kalsubai* 1646 m and *Salher* 1567 m. Mahabaleshwar, a hill station in Maharashtra lies at a height of 1438 m. There are many gaps and passes in the Western Ghats, the most important are the *Thalghat* and the *Bhorghat*. They connect the interior of the Deccan with Bombay (now Mumbai). The railway lines proceeding from Bombay to Nasik and Pune go via the *Thalghat* and the *Bhorghat* respectively.

The Eastern edge is much broken and is known the *Eastern Ghats*. The Eastern Ghats stretch from the Mahanadi river valley up to the Nilgiris and form the eastern fringe of the dissected plateau. They have an average height of 450 m and rarely exceed 1200 m. *Mahendragiri* Peak in Orissa is 1500 m high. They disappear for about 150 km between Godavari and the Krishna Valleys. Near the southern end and to the east of the Eastern Ghats are some isolated hills: *Biligirirangan* Hills, the '*Shevaroy*' (*Sherevrayans*) and the *Javadi* Hills.

The Eastern and Western Ghats meet in south of Mysore and form the lofty plateau of the *Nilgiri*. The Nilgiri have in them two of the highest peaks, *Dodabetta* (2637 m) and *Makurti* (2554 m). To the south of the Nilgiri are the *Anamalai*, *Cardamom* and *Palni Hills*. The *Anaimudi* in the Anamalai hills is the highest peak in Peninsular India, being 2695 m high. The Palghat Gap lies to the south of the Nilgiris and is about 24 km wide. It forms an easy passage across the Western Ghats. The Cardamom Hills constitute the divide between the east and west coasts. The Peninsular Plateau is flanked by a narrow coastal strip on the west and by a much broader coastal area on the east.

In the north some lines of mountains rise above the general surface of the plateau from the west to the east. It begins from the Aravalli Hills in the north-west. The Aravallis have an average height of 1500 m and are the remnants of a much bigger mountain range. *Guru Sikhar or Mount Abu* is the highest peak in them (1722 m) and is an excellent hill station. Further south between the Aravallis and the Vindhyas lies the *Malwa Plateau*. Then follow almost parallel ranges of the *Vindhyas* and the *Satpuras*. The Vindhyas extend in an east-west direction for about 1000 km with an average elevation of 300 m. They form the northern boundary of the Deccan plateau. The plateau slopes northward from Vindhya Range gradually into the Indo-Gangetic Plains of North-India but in north-west, the Aravalli Range interrupts the slope.

In the north-east of the Peninsula is the Chhota Nagpur Plateau made famous for its rich mineral deposits. There are some minor ranges in the northern part of the Peninsula. They are the *Rajmahal* in Bihar, *Mahadeo Hills* and *Maikala range* in the Madhya Pradesh and the *Ajanta* and *Satmala Hills* in Maharashtra.

The Deccan Plateau is the largest plateau in India, covering an area of about 700,000 sq km. It begins from the Vindhyas and has an average height of about 600 m. It is higher in the west and south than in the east and north. The north-western part is called the "*Deccan Trap* ". The northern half forms the Plateau of Maharashtra and towards the south lies the *Mysore Plateau* with an average elevation of 600 m. Numerous streams and rivers carved deep valleys and made the Deccan plateau a dissected one.

The Peninsula is a compact natural unit of geo-morphological and biogeographical evolution. It is considered that now it is merely a relic of a much larger landmass, the major part of which now lies concealed under the alluvium of the northern plains and thrust under the high Himalaya and Tibet. Parts of the Peninsula appear also in detached blocks, both in the extreme north-east and in the north-west.

The northern boundary of the Peninsular block is generally set along an imaginary line extending from Kutch over the western flank of the Aravalli Ranges to within the environs of Delhi, and then eastwards nearly parallel to the rivers Yamuna and Ganga, as far as the Rajmahal Hills and curving south to the west of the Delta of Ganges in Bengal. The Peninsular Plateau covers 1. the Western Ghats, including Coorg; 2. the Southern Block of the Nilgiri, Anamalai and the Cardamom Hills; 3. the Deccan Lavas; 4. Karnataka or southern Bombay, Deccan and Mysore; 5. the upper Mahanadi and the adjacent basins (the Wainganga Valley, Chhatisgar, the Upper Brahmani and the Jamshedpur Gap); 6. Telangana or the south east Hyderabad and the Madras Deccan; 7. Anantapur-Chittor Basins and 8. the Eastern Hills of Orissa and Bastar, the Cuddapah ranges and valleys (Mani, 1974).

The Extra-Peninsula

It extends for about 2500 km from the eastern extremity of Arunachal Pradesh to Kashmir with an average breadth in the west varying from 240 to 320 km. It consists of the Hindukush, the Karakoram and the Himalaya. The Himalaya can be divided into four zones. The *Siwalik Zone,* forming the foot hills of the Himalaya, rarely exceeds 900 m in altitude and is 8 to 48 km wide. The *Lesser Himalayan Zone* has an average height of 3050 m and is about 65 to 80 km in width. *The Great Himalaya* or the *Central Himalaya* comprises high snow-capped peaks rising above 4570 m. North of this is the *Trans-Himalayan Zone* which ultimately merges with the Tibetan plateau.

North Indian Plains

They are about 3000 km long from east to west and 240 to 320 km broad. This flat monotonous terrain is composed of unconsolidated sands, silts and clays and is drained by the three major river systems namely, the Indus, the Ganges and the Brahmaputra. It is the most fertile part of the country suited for agriculture. The Northern Plains can be divided into many sub-divisions.

The Upper Ganga region represents the states of Uttar Pradesh and Delhi. The soil is fertile but the average rainfall is less than 100 cm.

The state of Bihar represents the Middle Ganga Valley. This is an intermediate zone. The Western half has an average rainfall of 100 cm while the eastern part receives about 150 cm.

The Lower Ganga Valley forms the state of West Bengal. This is a wet region with over 200 cm rainfall.

The Brahmaputra Valley in Assam has more than 200 cm of rain fall. However in the region of Garo, Khasi and Jaintia Hills, the rainfall is far higher.

The Punjab Plain is part of Upper Indus Valley. It is nearly dry area.

The Thar desert begins roughly from southern edge of the Punjab and continues through north-western Rajasthan up to the Aravalli range. It is a fairly flat region with general elevation varying between 150 and 300 m (Charles, 1975).

RIVER SYSTEMS AND LAKES

A portion of earth's water is found to evaporate into atmosphere and returns to the earth surface in the form of rain and snow. The water that reaches the surface of the earth follow two pathways. Some portion percolates through the pore-spaces in the soils and rocks to form *underground water,* the remaining portion flows down along the slopes of the hills and valleys and give rise to the streams and river systems which constitute the so called *running water*.

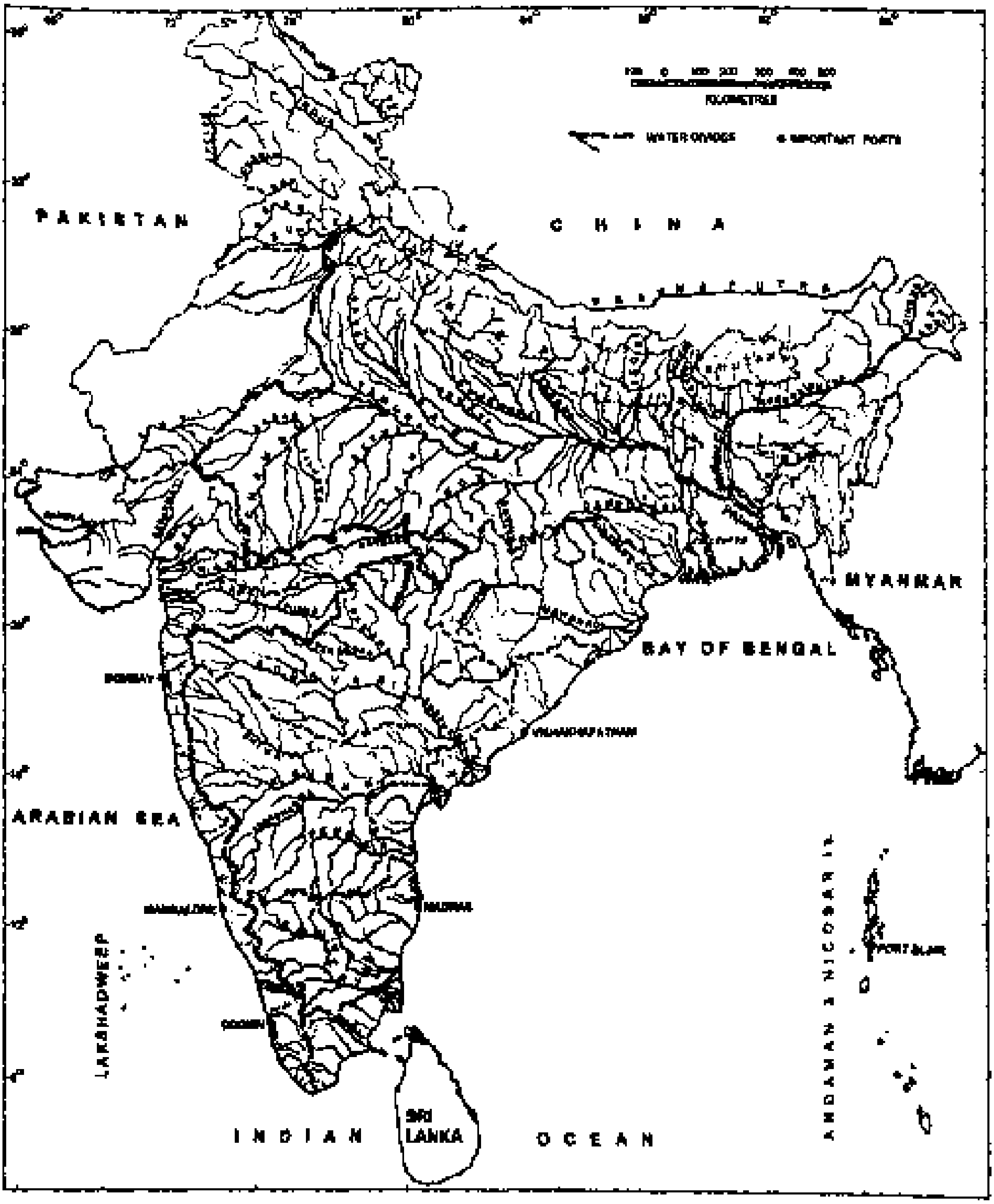
A river's *source* is the place at which it begins to flow. The source may be in the melt waters of a glacier or in a lake or in a spring or in a region of steady rainfall. Rivers generally have their origin in the highlands and they traverse in succession through the hilly tracts and the plains. Along the fringes of the plains the rivers usually end in the sea, somtimes in a lake. The place where the river ends is called river's *mouth*. The course of any river can, therefore, be broadly divided into three sections. Initially, a river flows through the hills and along the converging slopes of the valleys to reach the plains and this part is described as the upper part of the river. The flow of a river through the plains constitute the middle part and the third part of the course commences a bit off from the mouth of the river. The three sections of the course of any river may vary in length depending upon the physical features of the country and the paths followed by the river concerned.

In the upper part of a river, the process of erosion becomes very conspicuous in excavating or downcutting the valley-floor. At this stage it flows through a narrow and deep valley which is known as a *gorge* or *canyon*. Where the gradient of the valley floor is suddenly steep the waterfalls or rapids are formed. In the middle and lower portions the gradient of the valley-floor is much less, so its power of erosion and the velocity of running water is reduced and deposition now becomes active. The rivers move in zig-zag paths and form curvatures which are known as *meanders* or loops. During floods, the running water may cut straight through a meander and follow a short course, abandoning its previous round about tract. Such abandoned meanders containing some amount of confined water, give rise to *horse-shoe* or *ox-bow* lakes.

The products of erosion, such as boulders, pebbles, fine sand, silt, clay and soluble constituents are transported downstream alongwith the flow of the river. These constitute its *load*. Deposition of this load commences when it enters the plains and continues to increase as it flows towards the sea. Deposits thus formed along the course of a river are known as *fluvial deposits*. Such deposits form a new landmass at the mouth of the river, known as *delta*. Deltas commonly grow with time and gradually extend towards the sea. They are therefore, low lying land-masses and are swampy in nature.

The area drained by a river and its tributaries is known as *river basin* and its boundary is formed by the crest line of the surrounding highland. This boundary forms the main watershed of the basin (Mukerjee, 1990).

There are three main watersheds in India. (1) Himalayan in North India, (2) Vindhyan and Satpura ranges in Central India and (3) Sahyadri or Western Ghats in the West Coast. All the major rivers originate in one or other of these watersheds



Map 2. **India - River Systems.**

(*Source : India - A Regional Geography*, R. L. Singh, 1971)

(Map 2). There are 113 river basins (12 major river basins, 46 medium river basins and 55 minor river basins) with a total catchment area of 3.12 million sq. km. (Anonymous, 1994). These river systems run to a total length of over a 45,000 km and are estimated to carry 1,683,000 million cubic meters of water per year and in the process they do a lot of geological work. The north-Indian Plain is the creation of the Indus, the Ganga and the Brahmaputra rivers. The East Coast deltas are the handiwork of Mahanadi, Godavari, Krishna, Kauvery and Pennar rivers.

The rivers of India fall into two natural major groups viz. (1) Extra-Peninsular rivers (The Himalayan rivers), (2) The Peninsular rivers. The Himalayan rivers and the Peninsular rivers drain 70% and 30% of water discharge respectively. The perennial rivers such as the Indus, the Ganga and the Brahmaputra are fed by the mountain springs or glaciers, whereas the torrential rivers depend on the monsoon rains.

Extra-Peninsular rivers (Himalayan rivers)

Himalayas are drained by nineteen major rivers, of which the Indus, the Ganga and the Brahmaputra are the largest and most important. Of these nineteen rivers, six belong to the Indus system *Indus, Jhelum, Chenab, Ravi, Beas* and *Sutlej* ; 9 belong to Ganges system - *Ganga, Yamuna, Ramganga, Kali (Sarda), Karnali, Rapti, Gandak, Baghmati* and *Kosi;* 4 belong to Brahmaputra system - *Brahmaputra* (Tsangpo), *Tista, Raidak* and *Manas*. The rivers of the Indus system follow north-westerly course, while Ganges Brahmaputra systems flow easterly course.

The river Indus (Sanskrit *Sindhu*) is one of the great rivers of the world and is about 3000 km long. Historically, it is from this river that India gets its name and also the land of Hindus (river *Hindu* a Persian version for *Sindhu*). The Indus rises about 100 km north of Manasarowar at an elevation of 5182 m in Tibet Plateau and flows north - west through Tibet before entering Kashmir. After flowing for about 290 km parallel to the north of Ladakh range, it turns south through this range and flows for about 480 km along souhern flank of the range. Then it flows through the Sind province of Pakistan and forms a delta before entering the Arabian sea. It has five main tributaries on its left bank (eastern side), namely *Jhelum* (Sanskrit *Vitasta*), *Chenab* (Sanskrit *Askini*), *Ravi* (Sanskrit *Irawati*), *Beas* (Sanskrit *Vipasha*) and Sutlej (Sanskrit *Satadru*). Between each of the tributaries there is a fertile plain.

The river Sutlej has its source deep in the Himalayas at an elevation of 4630 m in the springs near Dulchu Gompa in the Tibet. First it flows in a northwesterly course along the southern slopes of the Kailas Range, then turns southwest and enters the plains of North India near Rupar in Punjab. It flows through Indian territory for a large part of its course, gathers many tributaries and then flows into Pakistan. The river Beas traverses through Kulu and Kangra Valleys and joins the Sutlej. The Jhelum rises in the Verinag Spring, at the bottom of the Pir Panjal Range in Kashmir. It is joined by the river Chenab, formed by the confluence of the Chandra and Bagha, rises in Lahul-Spiti and flows through Jammu and Kashmir. It joins the river Sutlej after receiving the water of Ravi.

The Ganga is the most important river and is about 2480 km long. Its basin drains one fourths of the country's area. The Ganga originates in the Himalaya at a height of 6000 m in the Gangotri glacier from a little ice cave, Gomukh. Thereafter, it flows in a westerly direction for about 30 km before turning southwards. There are five streams as the source of the river Ganga viz., the *Bhagirathi, Alaknanda, Mandakini, Dhauli-Ganga* and the *Pindari*. The Bhagirathi is considered as the main source stream of the Ganga. The main tributory, Alaknanda rises from the glaceirs Bhagirath Kharak and Santopanth of the Chaukhamba Massif and flows along the Bardrinath. The Mandakini rises from the Chorbari Glacier near Kedarnath and joins the Alakananda at Rudraprayag. The Dhauli-Ganga joins Alaknanda at Vishnuprayag. The Pindari rises in the Pindari Glacier and joins Alaknanda at Karnaprayag. The river Bhagirathi and the combined waters of Alaknanda and its tributaries join at Devprayag to form the river Ganga. Then the river Ganga passes through the Siwalik mountains and enters the plains at Haridwar. Then it broadens out and flows southeast. Many tributaries join the Ganga on its course through the plain. The *Yamuna*, and *Son* join the Ganga on its right bank, while the *Ramganga, Gomti, Ghaghara, Gandak,* and *Kosi* are joining on the left bank. All these tributaries rise on the slopes of the Himalayas. However, the *Chambal* and *Betwa*, the tributaries of Yamuna and Son rise in the hills on the edge of the plateau. Near Bhagalpur, the Ganga bends round the Rajmahal hills and flows south. Before joining the Bay of Bengal it divides itself into many distributaries forming a large delta. The Hooghly is a famous distributary which forms the western river mouth. The rivers *Damodar*, and *Rupnarain* joins Hooghly before it flows into sea. The main channel flows in a southeasterly direction through Bangladesh where it meets the *Brahmaputra* (Jamuna). The combined Ganga-Brahmaputra river is known as *Padma* till it joins the tributary *Meghna*. After that it is known as *Meghna* and flows into Bay of Bengal. The northern part of Ganga delta is rich and fertile, where as the southern part is swampy, saline and covered by Marshy forests known as *Sunderbans*.

The river *Yamuna* originates from Yamunotri Glacier on the Western slopes of the mount Bandarpunch (6387 m). After traversing a distance of 172 km, it enters the plains near Tajewala in Haryana and travelling further 1200 km up to the confluence with Ganga at Allahabad. It is fed by Peninsular rivers viz., *Chambal, Betwa, Sind* and *Ken*.

The river *Brahmaputra* rises in a glacier about 100 km south-east of Manasarowar. It runs eastward for about 1250 km through Tibet, where it is known as *Tsangpo*. Then it turns southward and flows into India cutting through the deep gorges in the Himalayas in Arunachal Pradesh ; this part of the river is known as *Dihang* or *Siang*. It enters the Assam Valley at Saudiya where it is joined by the rivers *Dibang* (or *Sikang*) and *Lohit* to become Brahmaputra and courses down the Assam Valley. The main tributaries on the right bank are *Subansiri, Baroli, Manas* and *North Dhansiri,* while on the left bank there are *Buri, Dibang, Lohit, South Dhansiri* and *Teesta*. The Brahmaputra flows through Assam for about 800 km, then turns towards south and enters Bangladesh to join the Ganga. In Bangladesh it is known by many names during its course towards sea. In the upper reaches, from Dhubri (India) to Goalundo (Bangladesh) it is known as the *Jamuna* ; near Goalundo it joins the *Ganga* and the combined river is known as the *Padma* up to the confluence of the river *Meghna*. Finally, the combined waters of Ganga Brahmaputra Meghna flow into the Bay of Bengal as Meghna.

The Peninsular Rivers

These are three systems of drainage in the Peninsular plateau :

(1) The rivers *Chambal, Sind, Betwa* and *Son* rise to the north of Vindhya mountains and flow north to join Ganga (2) The rivers *Mahanadi, Godavari, Krishana, Kauvery, Penner, Palar* and *Vaigai* flow eastward into the Bay of Bengal (3) The *Luni, Sabarmati, Mahi, Narmada* and *Tapti* rivers flow westward into the Arabian sea. The Central India has a typical radial drainage pattern : it has north flowing rivers the *Chambal, Betwa* and *Son*, the east flowing *Damodar, Ajay, Subarnarekha,* and *Mahanadi* and its tributaries, the south flowing *Wainganga, Wardha* (tributaries of the Godavari) and the west flowing *Narmada* and *Tapti*. The south Indian rivers and their tributaries rise on the slopes of the Western Ghats.

The Peninsular rivers are entirely fed by monsoon and often more or less dry in summer. Two groups of Peninsular rivers are recognised. 1) the coastal rivers and 2) the inland rivers. The coastal rivers are relatively small streams hardly 80 km in length, and there are over six hundred on the west coast from Gujarat in the north to Kanyakumari in the south. They drain the western side of the Western Ghats, pass through narrow plains and flow into the Arabian sea. The inland rivers include the west flowing *Narmada* and *Tapti* the east flowing *Mahanadi, Godavari, Krishna* and *Kauvery*. The east - flowing inland rivers have wide and fan-shaped catchment areas and have extensive deltaic deposits. The western rivers flow between the mountain ridges, hence their catchment areas are elongate and narrow and lack, delta formation at their mouths.

(1) Rivers flowing towards west :

The river *Luni* originates at Ana Sagar at Ajmer and flows through Rajasthan towards the south west into Arabian sea. It is a seasonal river which receives a tributary from Pushkar Valley and from the Western slope of Aravalli range. The river *Sabarmati* is one of the major rivers flowing westward, originating from Aravalli hills in Rajasthan. It enters Gujarat traversing a distance of 372 km and finally flows into the Gulf of Cambay. Its tributaries are *Hatmati* and *Mesha.* The river *Mahi* originates in the Madhya Pradesh and flows through Rajasthan and Gujarat and drains into Gulf of Cambay. Its tributary the river *Aras* also rises in Madhya Pradesh.

The river *Narmada* is the longest west flowing river and the fifth largest river in India. It traverses a distance of about 1300 km. It rises on the Amarkantak Plateau from a spring at a height of about 1060 m on the Maikal Hills. At Bheraghat it falls down from a height of 15 m forming the *Marble Falls.* Its basin in Madhya Pradesh is one of the most fertile areas of the country. After the Marble Falls it flows through a gorge and finally enters the Gulf of Cambay.

The river *Tapti* rises on the Satpura range at Multai of Betul district of Madhya Pradesh and flows between the Satpura and Ajantha hills, from north to south, near Bhushawal it turns towards west and flows into the Arabian sea, west of Surat. The *Purna, Girna* and the *Panjhara* are its tributaries. The Tapti basin covers a large area in Madhya Pradesh, Maharashtra and Gujarat. It is the second largest river draining westward of the Peninsula.

The river *Sharavati* in Karnataka though small, is famous for the *Gersoppa* or *Jog Falls* in the Western Ghats. During the monsoon these falls could be considered one of the world's greatest waterfalls. But like all other rivers of the Deccan, it has very little water in the dry season.

There are more than 40 rivers with their tributaries originating from the western slopes of the Western Ghats and cutting across Kerala plains to join the Arabian sea. *Bharathapuza* (*Ponnani*) river the longest originates from Anamalai Hills The river *Periyar* the second longest in Kerala originates from Sabarimala Hills.

2. Rivers flowing towards east :

The river *Subarnarekha* originates from a place near south east of Ranchi in Bihar. It traverses about 450 kms through Bihar, Orissa and West Bengal and finally to join Bay of Bengal.

The river *Mahanadi* basin is the third biggest basin in the Peninsula and fourth in India. It has its source in the Maikal Hills in Madhya Pradesh and flows east, through the state of Orissa. The river flows through the Eastern Ghats in a gorge 65 km and enters the Bay of Bengal east of Cuttack, forming an enormous delta in Orissa. The important tributaries are *Tel* and *Seonath* rise in the Chhota Nagpur region.

The *Godavari* is the largest river of the Deccan and second largest river basin in India. Its basin covers 10% of the total area of India. It has its source near Trimbak in the Nasik district of Maharashtra. It flows through a deep gorge in the Western Ghats before reaching Nasik City. It crosses Maharashtra, then enters the Telangana region in Andhra Pradesh. Its tributaries are *Darna, Pravara, Manjira, Purna, Pranhita, Penganga, Sabari, Indiravati* and *Wainganga*. The river Godavari cuts across the Eastern Ghats in a gorge and reaches the Bay of Bengal forming a large delta, east of Rajamundary in Andhra Pradesh. The tributaries *Indiravati, Kolab* and *Sileru* drain the districts Ganjam and Koraput of Orissa. The Wainganga rises near Seoni town in Madhya Pradesh and flows a distance of about 240 km to join the Godavari in Maharashtra.

The river *Krishna* is the third largest in India and second largest in the Peninsula. It rises in the Mahabaleshwar Hills in Maharashtra and flows south and southeast. Its main tributaries are *Koyna, Bhima, Tungabhadra, Varna, Panchaganga, Dudhganga* and *Vedavati*. After traversing a length of 1400 km through the states of Maharastra, North Karnataka, and Andhra Pradesh, it drains into the Bay of Bengal forming a large delta near Vijayawada in Andhra Pradesh.

The river *Kauvery* originates at 1320 m on the eastern edge of the Western Ghats near Mercara in Karnataka. It flows East crossing the Ghats. There are several rapids and water falls in its course. At *Shivasamudram* it plunges from a height of 100 m forming the famous *Shivasamudram Falls*. Then it enters Tamil Nadu and reaches the Bay of Bengal by way of a large delta. The river travels 710 km of which 310 km are in Karnataka and 460 km in Tamil Nadu. It starts dividing near Srirangam. The river *Kollidam* is a well known distributary.

There are many other smaller rivers along the East coast. The well known are *Rushikulya, Burabalonga, Brahmani* and *Vaitarni* in the north, in Orissa ; in the far south the *Ponnaiyar, Palar, Vaigai, Chittar* and *Tamraparini* in Tamil Nadu. The river *Chittar* and its tributaries traversing the Courtallum region joins the *Thambraparni* river northeast of Tirunelveli. It takes southeasterly course of about 115 km to empty itself into Gulf of Mannar. The Chittar has several 'falls' at the descent to the plains of Tenkasi, known as *Courtallum Falls*.

Lakes and Swamps

Some depressions on the land surface which, when filled up with water, are described as *lakes*. Lakes commonly occur above the mean sea level and the basins always have their bottoms below the water table.

Fluvial erosion and deposition often cause the formation of lakes along river valleys. There are a number of such small lakes in the Gangetic delta of West Bengal and in Kashmir. In hilly tracts, some lakes are formed due to landslides along or across the course of rivers. Such lakes are known as *rock - fall basins.* Some smaller lakes in Central India and the *Golna lake* in Garhwal are said to have been formed due to landslides. Deposition of sand away from the seashore, some times cuts off a portion of the sea to form saline lakes. The lakes *Pulicat* and *Chilka,* along the eastern coast of India, are of such origin. Lakes are also formed due to glacial erosion and deposition. The moving ice masses often excavate the floor of their valleys and form a lake there during the postglacial period. Some of the lakes in Kashmir viz, *Alipather, Sheshnag, Kounsernag, Vishnusar, Tarsar* and *Gangabaler* are of glacial origin.

The comparatively smaller lakes are usually fed by underground water alone. The larger lakes are also fed by streams and rivers which drain in them.

In the humid climatic regions, lakes with inlet and outlet can maintain a regular circulation of water and continue to remain fresh all through. Such lakes are known as *freshwater lakes.* In warm and dry regions, the process of evaporation on the surface of water bodies may lead to complete or partial desiccation of the lakes and also brings about concentration of the dissolved minerals occuring within the water bodies. Such lakes become saline in nature, aud depending on the salts present are described as *salt lakes, alkaline lakes, bitter lakes, borax lakes* etc. Salt lakes contain a greater proportion of Sodium Chloride while alkaline lakes have a greater concentration of carbonates of Sodium and Potassium. Bitter lakes contain more Sodium sulphate.

Those lakes lying along the river valleys act as natural reservoirs and effectively control the discharge of water further downstream and floods. Comparatively larger lakes play some role in controlling the local climatic conditions and provide ideal habital for some specific groups of plants and their remains are preserved as fossils in the lake sediments.

India by its unique geographical position with varied terrain and climatic conditions ranging from the cold arid of Ladakh to the warm arid of Rajasthan has many lakes in addition to major river systems. Some important lakes of India are : *Pangong Tso, Tso Morari* (Ladakh) ; *Dal lake, Wullar* (Jammu & Kashmir) ; *Harike, Kanjli* (Punjab) ; *Sambahar, Pichola, Pachpadra, Lunkaransar* (Rajasthan) ; *Nalsarovar* (Gujarat) ; *Renuka* (Himachal Pradesh) ; *Nainital, Bhim Tal* (Uttar Pradesh) ; *Kabartal* (Bihar) ; *Bhoj* (Madhya Pradesh) ; *Lonar, Ujni* (Maharashtra) ; *Chilka* (Orissa) ; *Kolleru, Pulicat* (Andhra Pradesh) ; *Asthamudi Sasthamkotta, Vembanad* (Kerala) ; chho Lhamo, *Gurudongmar Chho* (Sikkim) and *Loktak* (Manipur). (Chatrath, 1992 ; W.W.F. India, 1992). Physical features of some important lakes are given below.

Wullar lake is the largest and deepest fresh water lake in the Jhelum Valley in Kashmir. It absorbs the flood waters of the river Jhelum. Its area is 173 sq km. *Dal* lake is another fresh water lake in Kashmir situated near Srinagar. It is about 12 sq km and has a catchment area of about 300 sq km. It is fed by Dachigam and Telbal streams.

Harike lake is a shallow reservoir located at the confluence of Beas and Sutlej rivers. It has an area of 28 sq km. The lake was developed (man made) due to construction of Harike barrage in Punjab.

Sambahar lake is the most important salt lake in Rajasthan. It has an area of 234 sq km. during rainy season with a depth of about 1 meter.

Lonar lake in Maharashtra is a saline deep crater lake in the district Buldana. The lake is about 100 meter depth and 2 km in diameter.

Vembanad lake in Alleppey is the largest brakish - water lake in Kerala. While *Asthamudi* lake is the deepest one. The *Sashthamkotta* lake is the only natural fresh water body in Kerala.

Chilka lake in Orissa is a salt water lake separated from sea by sand banks and is the largest salt water lake in India. Its maximum length is 64 kms and width 80 km. It is connected to the Bay of Bengal. It receives flood waters from river *Daya* and other rivulets.

Kolleru lake is a large fresh water lake situated near Gudivada in Andhra Pradesh. It extends over 900 sq km. It has a catchment area of about 4700 sq km. A number of rivulets flow in. The outlet into sea is called Upputeru.

Loktak lake is the largest natural lake in eastern India with an area of 289 sq km and occupies the southern part of Manipur Valley. Impal river and its tributaries flow water directly into Loktak.

Swamps are low lying lands where the water table has just reached the land surface. In swamps the land surface is always saturated with water. The depressions, actually contain water only during the rainy seasons, when the water table rises to some extent. Swamps commonly occur along flood - plains of rivers and in lowlying sea shores. The salt lake swampy areas in West Bengal lie within the flood - plain and delta of the Ganges. The vast tract of low land, lying along the western coast of India known as the *Rann of Kutch* in Gujarat and *Vedaranayam salt swamp* in Tamil Nadu constitute the best examples of *coastal swamps*. In swamps, vegetation grows in abundance and these are in the long run, converted into layers of partically carbonised plant remains known as *Peat*. Peat beds occur in swamps lying in the Gangetic delta are of low-land Peat, while those occurring in the Nilgiri hills (Western Ghats) are of high land.

Tidal marshes are shallow depressions along seashores, within which a thin sheet of saline water enters during the high tides. As soon as low tide sets in, sea water completely recedes from such depressions. The tidal marshes differ from coastal swamps since no inrush or recession of seawater takes place in coastal swamps, during high and low tides respectively. The best examples of the tidal marshes are Sunderbuns in West Bengal, Bitrakanika in Orissa, Coringa in Andhra Pradesh, Pichavaram and Point Calimere in Tamil Nadu, Rann of Kutch in Gujarat and some along the coast of Andaman and Nicobar Islands.

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2. GEOLOGY

(P. Venu, G. V. S. Murthy & M. Sanjappa)

In general geological history is mainly construed based on the study of interrelationships between different groups of rocks and the conditions responsible for their formation. Studies on the sedimentary rock formations include the order of the strata, lithology, fossil content and structural characters. While in igneous and metamorphic rocks, structural element, petrogenesis and geochronology form the important guidelines.

The rock formations constituting the earth crust are of three types and their basic features including origin are summarised before actual description of the geology of the country.

1. Igneous rocks :

Igneous rocks are the products of consolidation of magmas, the molten silicates which underlie the solid crust of the earth. The underlying magma after the formation of the crust tries to penetrate into the thin solid crust and thus enter the surface of the earth. In its effort to come out on the earth surface, some of the magma-masses may be stopped during their upward journey. The igneous rock-masses which were produced due to the consolidation of the magma upon the surface of the earth are known as extrusive bodies and the others which remain as injections within the country-rocks underneath the surface are known as intrusive bodies. Intrusive rock masses may consolidate either at very great or at moderate depths underneath the surface. They are classified into Plutonic rock bodies of deep seated origin and Hyp-abyssal rocks formed at shallow depths.

2. Metamorphic rocks :

A change in physico-chemical and tectonic conditions commonly upsets the stability of the pre-existing country rocks and the latter tend to reform themselves into new rocks stable under the new set of conditions. The change or reformation may be either in mineral composition or in texture or in both and under appropriate conditions, in chemical composition as well. The process which brings about this change is known as *metamorphism* and the ultimate products, formed due to operation of such processes are defined as the metamorphic rocks. Metamorphic rocks are, therefore, the products of metamorphism of pre - existing igneous, sedimentary or even metamorphic rocks which had lost their stability and hence reformed themselves in keeping with the new environment.

3. Sedimentary rocks :

The surface of the earth has evolved through natural agencies and these changes involved withering and erosion of high lands and consequent deposition of the resulting sediments in depressions of the earth surface. These natural agencies deposited enormous quantities of sediments giving rise to sedimentary rocks. These constitute nearly three fourths of the surface of the existing continents. These thick columns of sediments were built over years and sometimes these columns constitute entire height of the lofty mountains. In each column of these sedimentary rocks, the lower beds were deposited first and the overlaying ones in a later stage following a definite chronological order. The fossils contained in different layers of these rocks indicate the nature of the organisms existed during that period.

The lithological sequence also gives some information on the nature of environment and climate existed during that period. The entire investigation tries to read the detailed geological history of the earth from the study of rock belts. The smallest lithological unit is termed *bed* and beds of similar characteristics constitute *formation* Sometimes sedimentary columns get subjected to very severe *diastrophism*. In any column of sediments, constituent formations may be conformable with one another. Each formation should pass imperceptibly into the overlaying and the underlaying ones. In many cases the successive formations are found to be related unconformably.

Strategraphic Units

Different rock formations constituting the earth's crust may be classified into six major groups. a) Archaean or Azoic, b) Precambrian or Proterozoic or Algonkian, c) Primary or Palaeozoic, d) Secondary or Mesozoic, e) Tertiary or Cenozoic/Cainozoic, f) Quarternary or Recent. Of these, Archean group is the most ancient one and the Quarternary is the youngest.

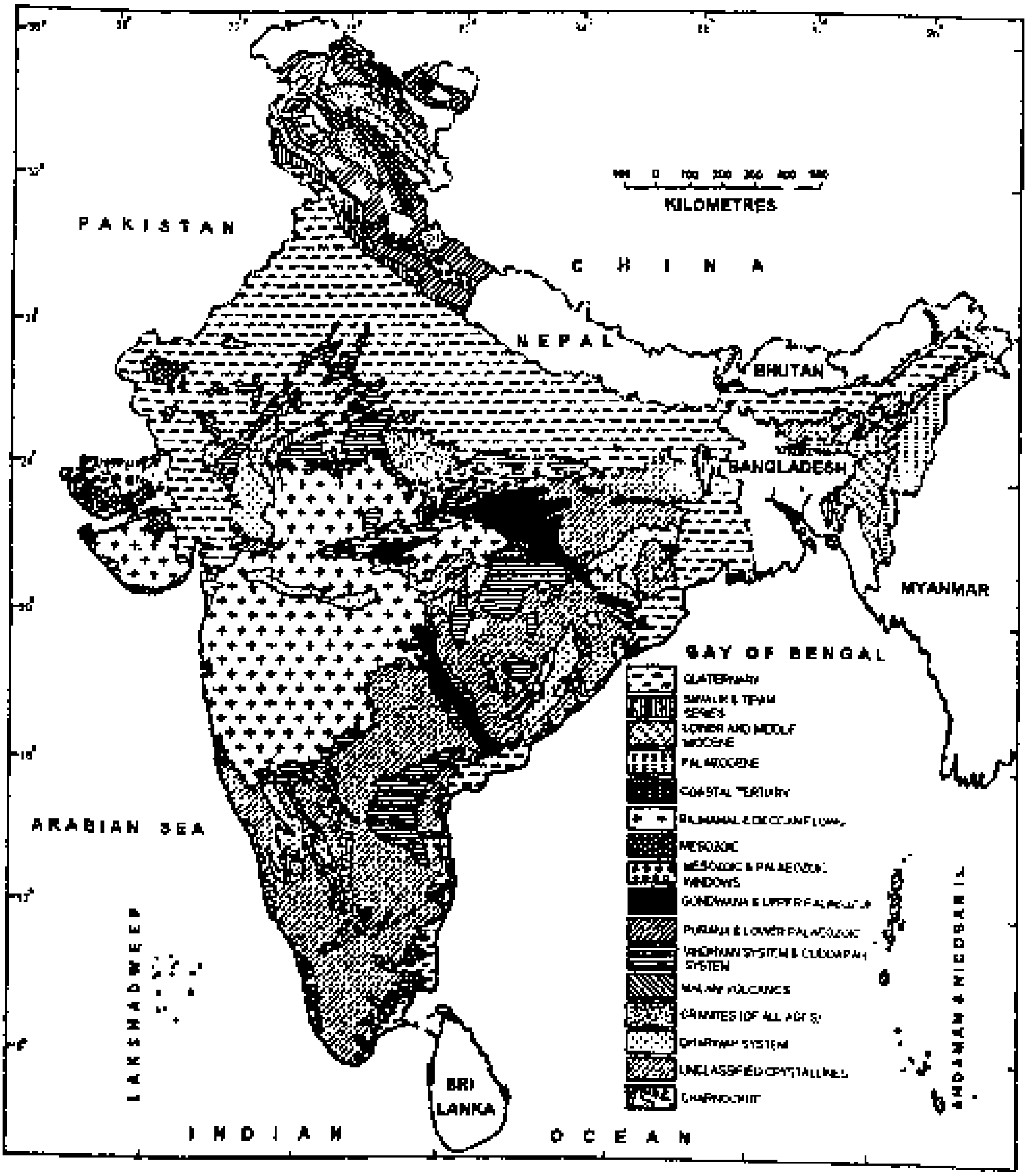
The major groups are divided into *systems* ; each system into *series* ; each series into *stages* and each stage into *zones*. Corresponding to these divisions of formations, there are divisions of geological time :

Formation		**Time**
Group	....	Era
System	....	Period
Series	....	Epoch
Stage	....	Age
Zone	....	—

STANDARD GEOLOGICAL TIME SCALE (Britannica, 1985)

Era	Period	Duration of each of the periods (In millions of years approx.)
Quaternary	Holocene or Recent	-
	Pleistocene	2.5
Cainozoic or	Pliocene	4.5
Tertiary	Miocene	19.00
Cenozoic or Tertiary	Oligocene	12.00
	Eocene	16.00
	Palaeocene	11.00
Mesozoic or Secondary	Cretaceous	71.00
	Jurassic	54.00
	Triassic	35.00
Palaeozoic or Primary	Permian	55.00
	Carboniferous	65.00
	Devonian	50.00
	Silurian	35.00
	Ordovician	70.00
	Cambrian	70.00
Proterozoic or Algonkian or Precambrian	Precambrian	1000.00
Azoic or Archaean	Archaean	3000.00

All the strategraphic groups and systems have been traced and studied from India and are given in Map 3.



Map 3. India - Geology.

(Source : India - *A Regional Geography*, R. L. Singh, 1971)

ARCHAEAN GROUP

The Archaean group refers to *gneisses, schists* and *granites,* which constitute the platform on which all sedimentary formations lie. The maximum age determined is about 3000 million years. The *schists and gneisses* were formed due to the metamorphism of pre-existing igneous and sedimentary rocks and are found to have been traversed by intrusive igneous bodies of acidic to ultrabasic composition. In some regions, the Archaeans are made up only of sedimentary metamorphites or of mixture of para or ortho schists. Such rocks are commonly described as *Dharwarian rocks.* The Archaean rocks are very complex and are devoid of fossils. In fact no life existed during the Archaean rock formation.

Occurrence and distribution :

The Archaean rocks are well developed in South India, Rajasthan, Madhya Pradesh, and in the Eastern India in Singhbhum - Gangpur area of Bihar and Orissa. This group of rocks also occurs in Eastern Ghat ranges. In the Extra Peninsula, the Archaean rocks occur along the whole length of Himalayan mountains.

In South India the Archaean rocks are best developed in Karnataka (carstwhile Mysore) and Maharashtra. Here they are commonly described as *Dharwar System.* It is made up mainly of schists, gneisses and granites. The metamorphosed sediments are older in age than the gneisses and granites of igneous origin. In South Maharashtra and parts of northern Karnataka these rocks exhibit the lower grade of metamorphism compared to those of southern Karnataka.

The rocks known as *Champion gneiss* developed along the eastern border of the Kolar Schist belt and are characterised by opalascent quartz grains with greyish tint. The rocks known as *Peninsular gneiss* are widely distributed in Karnataka and in other parts of South India. They are made of gneisses, granite, and granodiorites of varying composition, texture and structure. The *Charnockites* are widely distributed in parts of both Eastern and Western Ghat ranges. They exhibit the characters of both igneous and metamorphic rocks.

The *Colsepet granites (Bellary gneiss)* are younger in age than the *Charnockites.* They exhibit intrusive relationship with the pre-existing country rocks. These granites are coarse-grained with por-phyritic texture and are occasionally foliated.

In Central India, the Archaean rocks are developed in Bastar, Rajpur, Sambalpur, Bilaspur, Balaghat, Nagpur, Bhandara, Chhindwara, Jabalpur and adjacent areas. In Bastar, the Archaean rocks were made of schists and gneisses of both igneous and sedimentary origin and these were intruded by igneous bodies of acidic and basic composition. Mica schists quartzites, phyllites and banded haematic quartzites and the associated masses of granites and gneisses occupy a vast area in Rajpur.

In Sambalpur area, hornblende and biotite-schists and gneisses, quartz-schists, quartzites and igneous bodies of granite composition constitute the Archaean rocks.

In northern Balaghat area, the oldest rocks are described as the *Sonawani series*. This series is made up of manganese ores, calc. gneisses, crystalline limestones, quartzites and schists. The *Sonawani series* is overlaid by the *Chilpi ghat series*. It is made of trap rocks, grits, conglomerates, green stones etc. Either of these contains manganese bearing horizons.

In Bilaspur-Balaghat area, the *Sonawani* and the *Chilpi ghat series* are associated with granatic rock belonging to three distinct groups. They are made of schistose biotite gneisses, porphyritic and augen gneisses and granites respectively.

In Nagpur-Chindwara area, the Archaean rocks are highly metamorphosed and are known as *Sausar series*. The rocks of this series are granulites, marbles, schists etc., which exhibit a regional dip towards south of south-south east. The whole sequence of rock beds had undergone folding, faulting and shearing and contain important manganese deposits.

In Nagpur-Bhandara area, the metamorphic rocks of Archaean age are made up of quartzites, dolomites, amphibolites, schists, phyllites, conglomerates, ferruginous and manganiferous ores and dolerites of igneous origin.

In Jabalpur, the Archaean rocks are made up of marbles, mica-schists, phyllites, conglomerates and ferruginous and manganiferous ore bodies. In addition, there are some basic igneous rocks which are altered to a great extent.

The Archaean rocks of northern Singhbhum are separated from those of southern Singhbhum by a distinct thrust zone which is 125 km in length and runs approximately east-west. Towards the south of this thrust zone, there occurs a group of unmetamorphosed rocks like conglomerates, sandstones, limestones, shales, banded-haematite-quartzites etc., which are underlain by the older metamorphic rocks. The unmetamorphosed group of rocks is associated with basic lavas. The whole sequence of rocks in southern Singhbhum is traversed by younger igneous bodies of ultrabasic, basic and acidic composition. In the northern Singhbhum, the Archaean rocks are made of mica schists, chloriteschists and hornblende schists which contain minerals like garnet, staurolite and kyanite. The metamorphic rocks of northern Singhbhum are known as the Ironore series and are associated with younger granites and gneisses known as *Chota Nagpur granite gneiss*.

The Archaean rocks harbour major metalliferous deposits in India. The Kolar gold occurs within the Dharwarian schists ; important copper deposits occur in Bihar, Rajasthan and Tamil Nadu ; high grade iron enriched in the banded hematite-quartzites of Bihar. Orissa and Madhya Pradesh ; other deposits include those of manganese, chromite, lead-zinc, nickel and numerous metalliferous ores. Mica occurs within the pegmatites of Rajasthan, Bihar and Andhra Pradesh. Gem stones of Kashmir, Rajasthan and Tamil Nadu constitute a minor part of the mineral wealth of the Archaean group of rocks in India.

PRECAMBRIAN GROUP

The Archaean rocks after their formation were subjected to diastrophism, erosion and denudation resulting in what is known as *Eparchaean Unconformity*. The Precambrian rocks lie above this unconformity and are well represented in the Peninsula. In India, the Precambrian rocks have given rise to two distinct formations known as the *Cuddapah* and the *Vindhyan systems* of which the former is older in age and complicated in structure. These rocks are practically devoid of fossils.

The Cuddapah System :

The name of this system was derived from the Cuddapah basin in Andhra Pradesh, where it is best developed. In this area, the Cuddapah system is overlain by the *Kurnool system* of Vindhyan age. The huge Cuddapah basin is more or less crescentic in shape. This crescent is convex towards the west and concave in the east. The Western side of the basin exhibits an undisturbed sequence of Cuddapah rocks, made up of quartzites and shales. In the eastern half of the basin, the same rocks have been folded and slightly metamorphosed. The effect of diastrophism is most conspicuous along the concave eastern margin of the crescent, where the rock beds have been remarkably folded and even faulted.

Structurally, the Cuddapah system shows alternating layers of quartzites and shales and an unconformity between any two successive series of the system. Of the four series constituting the Cuddapah system, the oldest one is known as *Papaghni series* and is about 1500 m thick and lies unconformably upon the Archaean rocks. The *Cheyair series* is over 3300 m in thickness and its lower part (*Nagari or Pulivendla stage*) is made up of quartzites, sandstones, conglomerates which have been crushed along the eastern margin of Cuddapah basin. The upper part of the series (i.e. *Pullampet* or *Tadpatri stage*) is composed of shale beds which have become slaty due to metamorphism. There are some siliceous and calcareous bands and basic sills within the rocks of this stage. The *Nallamalai series* is over 1000 m in thickness and forms the Nallamalai hills. The Bairenkonda quartzites and Cumbum shales are two stages that constitute this series. The youngest series, named after *Kistna* overlaps all the older series and lies right over the Archaean rocks. It is made up of three distinct stages which constitute a total thickness of about 600 m.

The rocks of Cuddapah system also occur in different parts of the Peninsula and the Extra-Peninsula. Towards the southern side of Maharashtra, rocks of Cuddapah age are described as *Kaladgi series*, which is made up of quartzites, conglomerates, limestones and shales.

In Singhbhum the *Kolhan series* lies above the iron ore series and is made up of basal conglomerates, sandstones, shales and limestones which exhibit some amount of folding in them. This series is considered equivalent to Cuddapah system.

In Madhya Pradesh, the arenaceous rocks belonging to the *Chandrapur series* and the argillaceous calcareous rocks of the *Rajpur series* and the *Delhi system* of Rajasthan are equivalent in age to the Cuddapah system of Andhra Pradesh.

The rocks of Cuddapah age contain a number of important economic mineral deposits. In Andhra Pradesh, deposits of talc and asbestos occur at the contact of Vempalle limestone and the intrusive sills. Deposits of cobalt and copper ores are associated with the black slates of the *Delhi system* in Rajasthan. Veins of barites occur in *Vempalle limestones* of Andhra Pradesh and in the *Alwar quartzites* of Rajasthan.

The Vindhyan System :

The Vindhyan system (named after Vindhyan range) lies uncomformably above the older formations and constitutes an unmetamorphosed column of calcareous, arenaceous and argillaceous sediments. These cover 52,000 sq km in area with a maximum thickness of 4600 m. This group extends from the Eparchaean terrestrial period to a part of Cambrian. From the point of view of lithology and structure of constituent beds, the Vindhyan system has been divided into lower and upper subdivisions. The lower part is made of calcareous and argillaceous sediments, which were deposited under marine environment. The upper Vindhyans are made of undisturbed and more or less horizontal layers of arenaceous rocks. of esturine or fluviatile origin. They exhibit no sign of diastrophism and are devoid of fossils. The Vindhyan system is composed mainly of limestones, shales and conglomerates. This is a source of limestones and also some pyrite and diamond deposits.

PALAEOZOIC GROUP

Palaeozoic era includes rocks of Cambrian to Permian. The geological formations developed during this era contain some fossils. In this respect, these rocks radically differ from the unfossiliferous formations of Precambrian and Archaean ages. Palaeozoic rocks formed under marine environment contain distinct remains of organisms and are developed characteristically in the Extra-Peninsula. Those were studied especially in Spiti and Kashmir. In the Peninsula, the Palaeozoic group is represented by (a) *Talchir* and *Damuda* series of Permo-carboniferous age. (b) The marine lower Permian rocks near Umaria in Madhya Pradesh. (c) A portion of the upper Vindhyan sequence which is possibly of Cambrian age. A brief account of Palaeozoic sequence developed in Spiti, Kashmir, Kumaon and other Extra-Peninsular region is given below.

Spiti :

In the Spiti Valley and adjoining areas, a complete succession of folded marine Palaeozoic rocks exist in a large synclinal depression which has its axis running north-west to south-east.

In Spiti, the *Haimanta system* of Cambrian age is 1500 *m* thick with quartzites, slates and shales. It is underlain by highly metamorphosed rocks of *Vaikrita system*. This is followed by rocks of *Ordovician* age which are highly fossiliferous and contain quartzites, grits and sandstones of shallow water facies. The Ordovician rocks are overlain conformably by limestones and marls and included within the *Silurian system*. These are further overlain by an unfossiliferous column of quartzites and range in age from Upper Silurian to Devonian. This is followed by *Kanwar system* of carboniferous age, which is composed of quartzites, shales and limestones rich in fossil fauna belonging to *Lipak* and *Po series*. Over these, there is a thick boulder of conglomerate horizon and it represents the Permo-Carboniferous break. This is overlain by *Kuling system* consisting of shales and calcareous sandstones of the Permian age.

Kashmir :

Hundwara system of rocks, mainly composed of slates, greywackes and quartzites of early Cambrain age overlie the Dogra slates in many parts of Kashmir and Liddar valleys. The upper part of the Cambrian sequence is composed of blue clays with thin limestone bands and rich Trilobite fossils. As the arenaceous shales and limestones of Ordovician-Silurian part of Palaeozoic era is poorly developed in Eish makam and few other areas with restricted outcrops, muth quartzite of Devonian age is found to rest directly over the Cambrian sequence all over the Kashmir region. However, the succeeding Carboniferous system is well represented by *Syringothyris limestone* and *Fenestella shales*. During the Hercynian movement of Permo-Carboniferous time, land conditions prevailed in Kashmir region when the Panjal volcanics were erupted. The pyroclastics of Panjal volcanics including intercalated beds containing plant fossils and vertebrate remains are known as *Gangamopteris* and *Zewan beds*. Unfossiliferous Palaeozoic rocks made of quartzites, phyllites and quartz-schists occur in some parts of Kashmir. These rocks form *Tanawal series*.

Kumaon :

In the Kumaon Himalayas, *Garbyang series* comprising slatycalcareous sandstones and metamorphsed volcanic tuffts of about 5000 m thick contain fossils of Cambrian age. *Shiala series* contain characteristic ordovician fossils in its calcareous rocks. The overlying conspicuous red and green shales with thin limestone bands, known as *Variegated series* represent Silurian system. The lower 800 1000 m part of muth quartzite containing dolomitic limestone bands is also included within the Silurian. The rest of the muth quartzite represents Devonian system which is composed of limestones rich in fossil fauna. Over these, the *Kuling series* of Permian age lie unconformably.

In the eastern Himalayan region the Permian system is represented by marine deposits. The *Productus shales* continue eastwards up to Assam, known as *Subansiri beds.*

The fossil fauna of palaeozoic era are invertebrates like Brachiopods, Trilobites, Gratolites, Corals, Crinoids etc.

Gondwana sequence :

After the uplift of the Vindhyan rocks, the Peninsula during the Precambrian era witnessed no further deposition of sediments for a long time. During the Upper Carboniferous period, there is a new phase of deposition of sediments within the continental block, which continued up to the end of Jurassic period. The sediments exhibit all characters of having been formed under a shallow stretch of water in river and lake basins and constitute a total thickness of the order of 6 to 10,000 m. The enormous thickness of the sedimentary column may be ascribed to the gradual sinking of the basin alongwith the deposition of more of sediments. The aforesaid inland sediments of Upper Carboniferous to Jurassic age occupy a vast tract in the Peninsula and together constitute the Gondwana group. The Gondwana sediments contain enough of remains of plants and animals and are characterised by the presence of large number of coal seams.

During the period of deposition of Gondwana sediments, the configuration of the surface of the globe was quite different from what is now. The southern continents namely Australia, Southern part of Africa, Madagascar, South America, Antarctica and India were united together to form one continuous stretch of land known as Gondwana land. Thus the fluviatile and lacustrine deposits of Gondwana age occur not only in India but also in all the southern continents of the present day. The Gondwana rocks of India and of southern continents have similarities in lithological, floral and faunal characteristics.

On the basis of their floral content, Gondwana has been subdivided into two parts. The lower Gondwana rocks ranging in age from Upper Carboniferous to

Lower Triassic and are characterised by the presence of *Glossopteris* flora in which *Pteridosperms, Corditales, Equisetales* and *Sphenophyllales* are the dominating elements. The upper Gondwana rocks are marked by the advent of *Rajmahal flora (Ptilophyllum* flora) which exhibit the dominance of more advanced flora such as ferns, cycads and conifers.

The Gondwana rocks occur in a series of narrow faulted troughs which lie along the Damodar, Sone, Narmada, Godavari and Mahanadi valleys. In the Damodar, Sone and Narmada valleys, the trend of the troughs is approximately east-west. In the Godavari valley this trend changes over to north-west to south-east. They also occur in certain foot hill portions of Himalayas. In the eastern coast, the Gondwana rocks occur near Cuttack, Rajmundry, Vijayawada, Guntur, Madras, Trichirapalli and Ramanathapuram.

The advent of Gondwana period during the early Permian time was characterised by prolonged cold climate, as evidenced by glacial and fluvioglacial deposits of the *Talchir formation.* In most of the basins these deposits overlie, at places with intercalated marine sediments with marine Permian fauna, the basement complex with profound unconformity as the basal part of the Lower Gondwana sequence. Over these lie the thick sequence of sandstones, siltstones, shales and coal seams. Workable coal seams are restricted to two main horizons of which the lower coal measure is known as the *Barakar formation* and *Karharbari formation* (being developed in restricted fields) and the Upper one as *Raniganj formation* with a barren zone in between designated as the *Barren measures.* These two coal measures contain the major coal reserves of the country. Fire-clay, another economic mineral, is associated with these rocks. The coal measures roughly represent the middle and upper part of Permian and are rich in *Glossopteris* flora.

MESOZOIC GROUP

In India, the Mesozoic group of rocks generally lies conformably above the rocks of Palaeozoic age. This group occurs in the Extra-Peninsula as well as in some parts of the Peninsula. The era includes Triassic, Jurassic and Cretaceous. In the Extra-Peninsular region, the Triassic rocks are well developed in Spiti, Kumaon and Kashmir areas of the Himalaya. The rocks of Jurassic age developed in Kutch, Rajasthan, Kumaon, Spiti and Kashmir. The Cretaceous rocks occur in the eastern coast of South India.

Spiti :

In Spiti area, the Triassic is represented by *Lilang system* composed of limestone and shale interbands of about 1,200 m thickness. This is overlaid by the *Jurassic system* consisting of upper part of *Kioto limestone, Sulcacutus beds* and *Spiti shales* in order of succession. The Spiti shales are famous for Saligrams (with

Ammonite) and gradually pass upward into Cretaceous sequence consisting of *Glumal series* and *Chikkim series*. The former series is made up of sandstones and quartzites while the later is of fossiliferous grey and white limestone and folded unfossiliferous shales.

Kashmir :

A more or less complete sequence of Triassic is represented in Srinagar which is composed of limestones and shales of about 1000 m thickness. Jurassic is represented by *Kiota* (Megalodon) *limestones*. White limestones of Cretaceous age are found in Ladakh.

Kumaon :

Well developed sections of Triassic sequence are seen in Bambanag, Shalshal Cliffs, Painkhanda and Byans. In this region also the lower part of Megalodon limestone is included within the Upper Triassic and the rest in Jurassic. Rocks of this age are also developed in Mt. Everest region.

In Kumaon, Cretaceous rocks are represented by *Giumal sandstone* and volcanic breccia associated with exotic blocks. *Kampa system* in north Darjeeling is represented by rocks of Cretaceous and early Tertiary age.

Kutch :

Mesozoic rocks, from middle Jurassic to Lower Cretaceous are particularly well developed in Kutch, where they exhibit a complete succession with a total thickness of over 2000 m. The Jurassic succession in Kutch commences with *Patcham series* which is principally made up of limestone, sandstones and shales with about 300 m thickness. The series as a whole is rich in limestones. The lower beds are, however, somewhat arenaceous while the upper beds contain some shaly horizons. The Patcham basal limestones contain some shaly horizons and the characteristic fossil *Megateuthis*. The overlying shell limestones contain Pelecypods (*Trigonia* and *Corbula)* and ammonites *(Macrocephalites triangularis)*. The Patcham coral beds are characterised by the presence of remains of corals (*Stylina, Montlivaltia*, etc.) and ammonites (*Sivajiceras* and *Macrocephalites)*.

The *Chari series*, made up of five distinct stages, lies above the *Patcham series* and constitutes a thickness of about 400 m. The oldest stage of this series, known as the *Macrocephalus beds*, is made up of shales, calcareous bands and is characterised by the presence of *Macrocephalites macrocephalus* and a few other forms of ammonites. The overlying *Rehmanni beds* are composed of yellow limestones and contain remains of a number of ammonites (*Reineckeia rehmanni, Sivajiceras*, etc.). The *Anceps beds* lie above the *Rehmanni beds* and are made up of limestones and shales. This horizon contains *Perisphinctes anceps* and a few other remains of ammonites. The marls and gypseous shales occurring above the *Anceps beds* are known as the *Athleta beds*. These beds are characterised by the presence of fossils namely *Peltoceras athleta* (ammonite). The *Dhosa oolites*, made up of green and brown oolitic limestones, form the uppermost stage of the Chari series. This horizon is characterised by the presence of *Mayaites maya*, *Epimayaites polyphemus* and other important fossils.

The *Katrol series* lies above the *Chari series* and is made up of three stages with a total thickness of about 330 m. The Katrol stage has been found to contain a few plant remains. The *Gajansar beds* form the uppermost horizon of the *Katrol series* and are characterised by the presence of important fossils like *Belemnopsis gerardi* and *Phyllocera* sp.

The *Umia series*, which lies above the *Katrol series* is made up mainly of shales and sandstones and constitutes a total thickness of about 1000 m. This series has been subdivided into six stages which include (1) *Zamia shales*, (2) *Ammonite beds*, (3) *Trigonia beds*, (4) *Ukra beds*, (5) *Umia plant beds*, and (6) *Marine Sandstones*. These beds are characterised by different fossil members.

The Jurassic and Lower Cretaceous rocks in Kutch are overlain in some places by the Deccan Trap lava-flows. In certain regions, they are overlain unconformably by younger rocks of Tertiary age.

South India :

In the Peninsula after the Vindhyan period, only a few patches of sedimentary rocks were deposited along the coastal tracts. However, there occurs no complete succession of mesozoic rocks along the eastern coast and exist only three patches of rocks of Cretaceous age. These patches rest upon a basement of *Archaean gneisses* and *Charnockites* and are sometimes fringed, along their western margins by the strips of rocks of Upper Gondwana age. Of these three patches the largest patch occurs in the Trichinopoly district (Tamil Nadu) while the smallest one is located near Pondicherry. The other patch exists near Cuddalore and Vriddhachalam.

The Cretaceous succession in Trichinopoly commences with the *Uttatur stage* which is made up of limestones, clays and arenaceous rocks. In general, the rock-beds of this stage exhibit an average seaward dip of about 10°. The *Uttatur stage* constitutes a thickness of about 600 m and its upper part appears to have been deposited during a period of desiccation of the Cretaceous sea.

The *Uttatur stage* is overlain by sandstones, grits, clays and shell limestones belonging to the *Trichinopoly stage*. Its constituent rock-beds appear to have been deposited under a shallow stretch of marine water.

The overlying *Ariyalur stage* is composed of grey, light brown and white sandstones and argillaceous horizons with a thickness of about 330 m. The white sandstones forming the upper beds are unfossiliferous. The *Ariyalur beds* exhibit a gentle seaward dip of about 3° to 5°, and are overlain by brown and grey sandstones, shales and arenaceous limestones, which together constitute the *Niniyur stage*. This stage is characterised by the absence of remains of ammonites in its constituent rock-beds.

The Deccan Traps :

In the Peninsula, the end of the Mesozoic era was characterised by the pouring out of extensive lava-flows, which were erupted mostly through fissures and occupy a major portion of the Deccan plateau. These lava-flows generally occur in the form of horizontal sheets, ranging in thickness up to 30 m and cover an area of about 3,38,000 sq km The successive lava-flows are separated from one another by sedimentary beds formed under water and are known as the *intertrappeans*. The total thickness of the column of lava-flows and intertrappeans varies, in different localities from 60 to 2300 m. Although most of the flows were erupted througth fissures, there are a few areas like the Girnar Hill and some other localities in Gujarat and Maharashtra where they appear to have been poured out through localised vents. These extensive lava-flows gave rise to flat topped mountains and plateaus with step-like terraces. They are described appropriately as the trap rocks and the formation as a whole is known as the *Deccan Traps.*

The Deccan Traps occur in Maharashtra, Gujarat (Kutch, Kathiawar), Madhya Pradesh and in some parts of southern India. In the geologic past these rocks occupied a much larger area and in course of time, the constant erosion through natural agencies totally removed them from many localities. Some portion of the lava-flows appears to have been faulted down the Arabian sea in Western Coast. The Deccan Trap formation has been classified broadly into three parts. Upper flows 500 m thick ; Middle flows 1330 m thick ; and Lower flows 160 m thick.

The upper flows are developed characteristically in Bombay and Kathiawar. They are about 500 m thick and contain intertrappean horizons and ash beds. The middle flows are well developed in Madhya Pradesh and are associated with some ash beds. Intertrappean horizons are extremely rare. The lower flows occur in Madhya Pradesh and further eastwards. They are about 160 m thick and contain a number of intertrappean horizons. Layers of volcanic ash occur rarely in association with the lower flows.

The Deccan Traps are made up principally of basic volcanic rocks of basaltic composition. In few localities, however, there occur a few other rock-types which were formed as a result of localised differentiation of the basaltic magma.

The Deccan Traps are used commonly as excellent road metals. Those of lighter colour are sometimes utilised as building stones. The lateritised tops of the lava yielded workable deposits of high grade bauxite in Belgaum, Jabalpur, Katni and other areas. The iron rich laterites are used as building stones. The vesicular traps contain enough of agate, chalcedony, amethyst and other semiprecious stones that are used in the manufacture of ring stones, beads etc. The black soil of the Deccan suited for cotton cultivation was derived from the trap-rocks. The vesicular and highly jointed lava-flows serve as suitable aquifers from which a steady supply of ground water can be obtained in some parts of the Deccan Trap country.

TERTIARY GROUP

The Tertiary (or Cainozoic) era witnessed some significant changes in the physiographic, environmental, faunal and floral characteristics on the surface of the globe. The ancient Gondwana land was broken down into a number of fragments and these drifted gradually to form the modern southern continents. The great orogenic movement was in operation during the Tertiary era and the Himalaya mountains attained their present configuration in a series of five remarkable phases of uplift. Along with the rise of the Himalaya, the geosynclinal basin (i.e. the Tethys) became progressively shallower. As a consequence, the initial marine environment of the Tethyan sea gradually changed over to estuarine and, after the principal phase of the Himalayan upheaval in Middle-Miocene, fresh water environment prevailed in the resulting inland basins. Along with the aforesaid changes in physiography and environment, the older life forms failed to adapt themselves to the new set up and in their place new plants and animals were brought into being and these continued to develop and flourish during the Tertiary era. Ferns, Cycads and Conifers which dominated during the Mesozoic era became much less important and were replaced by the angiosperms. The mighty reptiles of the Mesozoic era became extinct and, in their place the mammals grew as dominating group. The ammonites which occurred in abundance in the Mesozoic seas disappeared just before the advent of the Tertiary era.

In India, Tertiary rocks are particularly well developed in the Extra-Peninsula where they occur practically all along the length of the Himalayan ranges. Characteristic geological successions of Tertiary rocks have been studied in Jammu and the Himachal Pradesh Himalayas, Assam and the Andaman & Nicobar Islands in the south. In the Peninsula, small patches of Tertiary rocks occur in Rajasthan, Gujarat (Kutch) and along the eastern coast in West Bengal, Orissa, and Tamil Nadu. In the early stage, it is marked by rocks of marine facies which in the later periods, through estaurine condition, became a fresh water one in the Siwalik time. It is also the major constituent of the Indo-Gangetic plains including the Bengal Basin.

In Gujarat and Rajasthan, the Lower and Middle Eocene are well represented by equivalents of *Ranikot* and *Laki series*. Over these the *Murree series* of

Lower Miocene age lie unconformably which again is overlain by the *Siwalik system* of rocks composed of limestones, shales and sandstones ranging in age from Miocene to Pliocene. In other parts of Himalaya, Hill limestone and *Chharat Stage* represent the Eocene rocks over which the *Murrees* and *Siwaliks* rest unconformably. In the eastern extremity the Tertiary rocks are well developed in the Assam region by *Jaintia series* of Eocene age. Over this the *Barail series* were deposited during the Oligocene time. *Surma, Tipam, Dupitila* and *Dihing series* were laid successively up to the Plio-Pleistocene. These are rich in oil and coal. The Siwaliks are famous for their spectacular vertebrate fossil wealth.

QUATERNARY GROUP

With the advent of Quaternary Period, the Northern Hemisphere witnessed a widespread glaciation. Throughout this period cold climate recurred five times interspacing with four interglacial warmer periods. Spells of Ice-age caused extinction of the major parts of the previous flora and fauna. However, some of the existing life migrated to other parts.

In the Extra-Peninsula in the Himalayan region, it is marked by glacial tillites. Bain boulder beds of Trans-Indus region are an example. Karewa deposits of Kashmir composed of sands, clays, loams, breccian beds were laid down in large lakes in the Himalayan region. Fossil assemblages of land plants and animals were reported from these deposits.

In the Peninsular region warmer climatic condition prevailed during this time. The vast Indo-Gangetic plain constituting the thick deposits of sands, clays, gravels, pebbles and peat beds formed during this period. The older alluvium contains remains of Pleistocene mammals.The younger beds consisting of sands and gravels, known as the newer alluvium, merges into the recent alluvial deposits. The fluviatile and deltaic deposits of Bengal and of other major rivers are included within this. The Pleistocene deposits are found in Narmada, Godavari, and Krishna valleys. Some of these contain fossils of Palaeolithic and Neolithic implements of ancient man. Rajasthan desert, coastal beach sands and limestone deposits of the Eastern and Western Coasts of the Peninsula, and lacustrine deposits of Kodaikanal, and Chilka were formed duirng this time.

SOILS

Soils that sustain the vegetation are actually the altered product of rocks of a particular area. Composition of soil is governed by the mineralogical components of the parent rocks. As there exists a great variety of rocks in India in different parts, an equal diversity in the soil types are observed.

Soil is defined as the part of earth crust in which humus is present. According to Daubenmire (1968) soil is a weathered superficial layer of earth crust with which are mingled living organisms and products of their decay. According to Wadia (1953), soil is the topmost layer of earth crust capping the rock. The soil is made up of five components which include mineral particles, dead organic matter, soil atmosphere, soil water and biological system or soil micro-organisms.

Depending upon the mode of origin, soils are classified into two main groups : Sedimentary soils and Transported soils. Sedimentary soils formed from the disintegrated rocky material and remains at the same place where they are formed. Transported soils are brought from the place of their origin to another by various agencies. They are different types basing on the transporting agency. Illuvial soils are moved due to gravitational influence. While alluvial soils are transported by river courses. Glacial soils are shifted by glaciers and aeolian soils by wind.

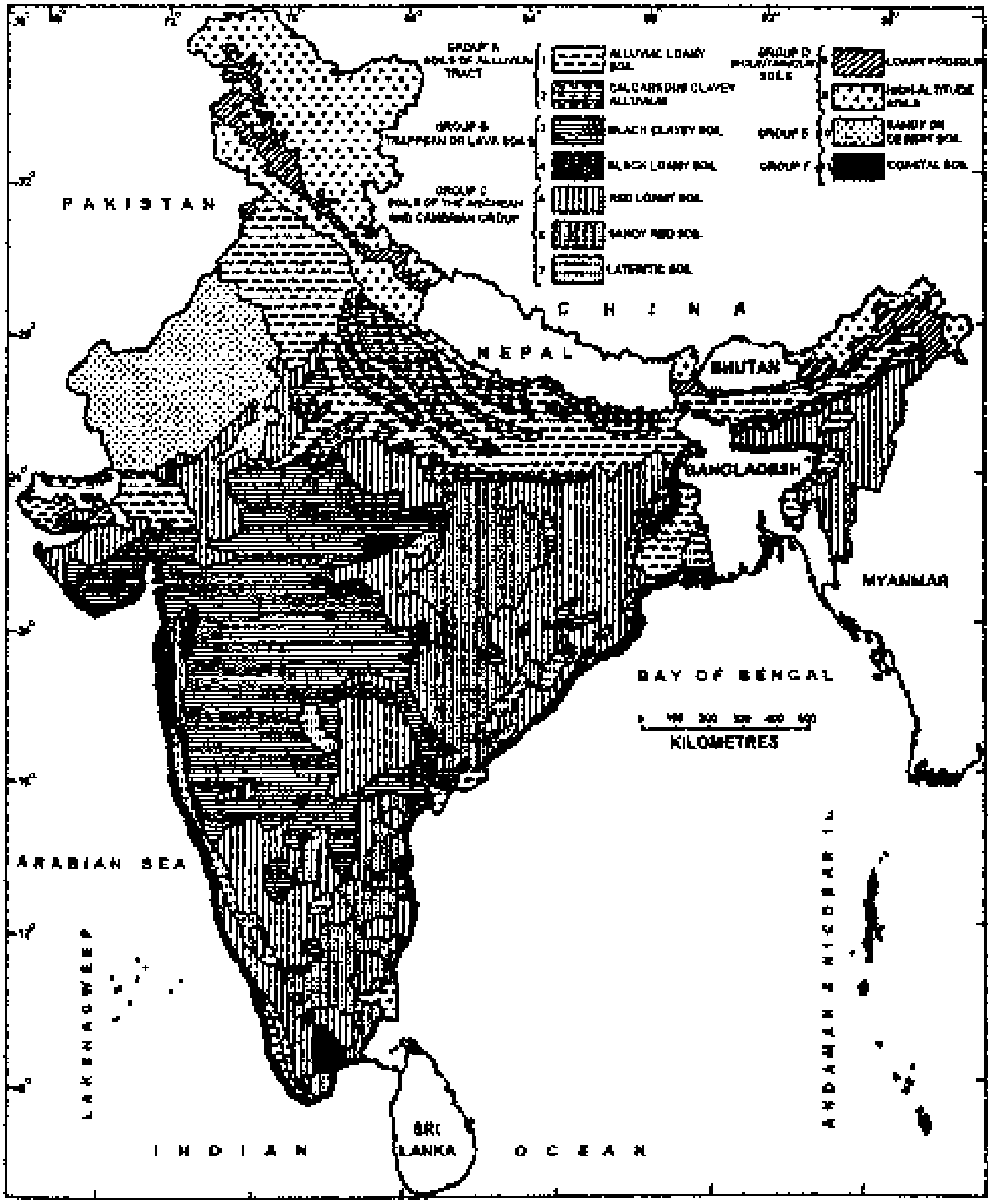
Geographically soils of India are divided into three groups (i) Mature soils of Peninsular India (Red, Black and Lateritic soils), (ii) Alluvial soils of Indo-Gangetic Plains, (iii) Scanty soils of Himalayas. Some generalised soil maps were prepared under the auspices of International Society of Soil Science, Geological Survey of India and Indian Agricultural Research Institute. The soil types of India are presented in Map 4.

Presently, soils are grouped into 8 categories for a comprehensive description that occur in this country. They include 1. Laterite or Lateritic soils, 2. Black cotton soils, 3. Red soils, 4. Alluvial soils, 5. Alkali soils and saline soils, 6. Peaty and other organic soils, 7. Desert soils and 8. Scanty soils of mountains.

1. Laterite or Lateritic soils

Lateritic soils are generally reddish or yellowish-red and turn black on exposure to sun. This group of soils occurs in parts of Rajasthan, Madhya Pradesh, Bihar, West Bengal, Assam, Orissa, Tamil Nadu and in Eastern and Western Ghats. These cover an area of 2,48,000 sq km and are majorly composed of hydrated oxides of aluminium and iron with minor quantities of manganese and titanium oxides. The rocks rich in aluminium such as gneisses, sandstone, basaltic rocks and granites produce lateritic soils. These soils are formed in regions having alternate wet and dry seasons. Alkali and silica are lost in the leaching process and the residual compounds of rocks rich in aluminium and iron oxides form such soils. Laterites are well developed on hill tops and are characterised by low levels of lime, magnesia and nitrogen. There is higher content of humus.

In Tamil Nadu, laterites occur at different altitudes from a variety of rock materials under specific climatic and weather conditions. They occur along the West coast and in some parts of the East coast. Paddy is grown on the laterites at lower elevation while those at higher elevation support plantations of tea, cinchona, rubber and coffee. The soils are rich in nutrients and contain 10 to 20 per cent



Map 4. India - Soil Types.

(Source : *India - A Regional Geography*, R. L. Singh, 1971) organic matter. The pH is generally low around 4.0 in the soils under tea plantations and at higher elevations.

In Kerala, at lower elevations the laterites show poor nutrient status and paddy is grown. Laterites at higher altitudes support plantation crops such as tea, rubber, cinchona, arecanut etc. The soils are generally poor in nitrogen, phosphorus, potassium and organic matter with pH ranging between 4.5 and 6.0.

The laterite soils in Karnataka occur in the western parts of the districts of Shimoga, Hassan, Chikkamagalur and Mysore. These soils are comparable to the laterites found in Tamil Nadu. In Kodagu (Coorg), laterites appear sporadically almost all over the country.

The soils of Uttara Kannada and Dakshina Kannada districts (North & South Kanara districts) are coarse, poor in lime and phosphorus but fairly good in organic matter. Laterites are found only in Ratnagiri and Konkan in Maharashtra. In the soils of Ratnagiri, coarse materials are found in large quantities.

In West Bengal, the area between the Damodar and the Bhagirathi is interspersed with some basaltic and granitic hills with laterite capping.

In Bihar, laterite occurs principally as a cap on the higher plateaus but is also found in fair thickness in some valleys.

The laterites of Orissa are found largely capping hills and plateaus occasionally in considerable thickness. Large areas in Khurda are occupied by laterites.

2. Black cotton soils or Regur *(Regada = Black)*

These are black soils and best suited for cotton cultivation. Black soils are locally known as 'regur' in some states and are distributed in Tamil Nadu (Ramnad and Tirunelveli (Tinnavelly) districts), parts of Karnataka, Andhra Pradesh, southern districts of Orissa, Maharashtra, Bundelkhand region of Uttar Pradesh, Western Madhya Pradesh, some districts of Rajasthan and Gujarat. It covers a total area of 5,46,000 sq km.

The black soils are derived by the decomposition of trap rocks and its black colour is due to presence of superficial iron in the rocks. The surface fraction consists of small transparent or semitransparent grains cemented together by dark coloured matrix which is a double hydrated ferrous and aluminium silicate.

The colour of black soil varies from place to place. *Regur* soils are mostly dark grey to black in colour. The soil is clayey (clay content 40 - 60%) or loamy. They are highly argillaceous, fine grained and contain a high proportion of calcium and magnesium carbonates. They are very tenacious to moisture and exceedingly sticky when wet. Owing to considerable contraction on drying, large and deep cracks are formed. The soil is poor in phosphorus and rich in nitrogen and organic matter.

Black soils have a high base status and high base-exchange capacity (40 to 60 m eq.). Clay fractions contain 13% iron content. Oxides of calcium and magnesium contents are high. Cotton is the best suited crop. Other crops suited to black soils are wheat, millet, gram. Black soils are categorised into different groups based upon the depth of their formation. These groups are :

(i) *Shallow black soils (Depth ranges from 30 to 50 cm)* : These soils are derived from basalts of Deccan trap.

(ii) *Medium black soils (Depth ranges from 50 to 120 cm)* : They are derived from a variety of rocks including basaltic trap, Dharwar schists, basic granites, gneisses, hornblende and chlorite schists.

(iii) *Deep black soil (Depth ranges from 120 to 200 cm)* : These are derived from basaltic traps in Deccan plateau and are commonly identified as *regur soils*. Distribution of irregular nodules of lime (Kankar) throughout is a regular feature of this subgroup of black soil.

Soils derived from the Deccan trap occupy quite a large area. On the uplands and on the slopes, soils are light coloured, thin and poor. On the lowlands and in the valleys, deep and relatively clayey black soils are found. Along the ghats, the soils are very coarse and gravelly. In the valley of the Tapti, the Narmada, the Godavari and the Krishna rivers, heavy black soil is often 6 m deep. The subsoil contains a good deal of lime. Outside the Deccan trap area, the black cotton soil predominates in parts of Gujarat. Twelve distinct types, named alphabetically from A to L, have been distinguished in Maharashtra. In Tamil Nadu, black soils are either deep or shallow and may or may not contain gypsum in their profiles and accordingly four types are distinguished : (i) shallow with gypsum, (ii) shallow without gypsum, (iii) deep with gypsum and (iv) deep without gypsum. The black soils of Karnataka are fairly heavy with high salt concentration. Black cotton soils of Andhra Pradesh are the results of accumulation of products of decomposition of rocks in combination with the humic material. The group of black clay soils, popularly known as *karail*, occur in the lower Gangetic basin in Uttar Pradesh. These soils are distinct from their zonal associates developed under similar environments on the Gangetic alluvium and show greater resemblance to the *mar* of Bundelkhand or *regur* of Central India. Their parent material is similar to that of the black cotton soils.

Black soils of Madhya Pradesh, developed on different parent materials. Although these soils do not reveal any difference in outward appearance, the differences of parent rocks are reflected in the physical and chemical composition of the soils as well as clay fractions separated from them. Two distinct kinds of black soils are found in Madhya Pradesh, viz. (i) deep heavy black soil covering the Narmada valley and (ii) shallow black soil in Saugar and Jabalpur.

3. Red Soil including Red loam, and Yellow earth

These soils are distributed mainly in the peninsular regions. The soils occur mainly in Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh and Orissa covering a total area of about 3,50,000 sq km Red soils are also found in some parts of Bihar, Uttar Pradesh and Rajasthan. The ancient crystalline and metamorphic rocks on weathering gave rise to red soils. The red soils of valleys and plains are dark and fertile. These are composed of silica and aluminium with free quartz or sands. Soils are low in bases and base exchange capacity. These soils are characterised by absence of lime nodules (Kankars). Humus and other organic nutrients are low. Ferrous oxide is precipitated after evaporation of water from the soil. They are neutral to acidic in their reaction. Soils are generally rich in potash but nitrogen content is low. The red soils are light, friable and porous. The water absorbing capacity is very low.

Relative to black soils, these soils are poorer in lime, potash and ironoxide and are also uniformly low in their phosphorus content. Many of the so-called red soils of South India exhibit no red colour. On the other hand, some red soils are of lateritic origin and are of quite different nature.

The clay fraction of the red soil is rich in Kyanite (Aluminium and Silica bearing). Red soils are also found under forest vegetation. The yellow soils show yellow colour due to a higher degree of hydration of the ferric oxide.

The red soils of Tamil Nadu constitute nearly two-thirds of the cultivated area. The soils are rather shallow, open in texture, have a pH range from 6.6 to 8.0. The red soils predominate in the districts of Bangalore, Kolar, Mysore, Tumkur and Mandya in Karnataka. They vary in depth from a few centimetre to several metres. There are shades of red and these pass on to yellow. Loamy red soils are predominant in the districts covering Western Ghats.

In the Telangana division of Andhra Pradesh, where the predominating geological formation is grantite, gneissic complex, both red and black soils predominate.

South Bihar, particularly Ranchi, Hazaribagh, Santhal Parganas, Manbhum and Singhbhum districts exhibit red soils with lower pH varying from 5.0 to 6.8. These Soils exhibit high percentage of acid soluble Ferric oxide (Fe_2O_3) compared to Aluminium oxide (Al_2O_3).

In West Bengal, the red soils are the transported from the hills of Chhota Nagpur plateau.

A part of Jhansi district in Uttar Pradesh comprises red soils. There are two types, locally known as *parwa* and *rakar*. The *parwa* is a brownish grey soil varying from loam to sandy or clay loam. The *rakar* is the true red soil which is generally not useful for cultivation. The soils of Varanasi (Banaras) and Mirzapur, developed on the Vindhyan parent materials were also red loams.

4. Alluvial Soils

This is by far the largest and the most important soil group of India, contributing the largest share to the agricultural wealth of the country. These soils cover 15,00,000 sq km area and occupy the most populous portions of India. This soil is distributed in parts of Rajasthan, Punjab, Uttar Pradesh, Bihar, West Bengal, Orissa and Assam. In this vast tract, though a great deal of minor variations exist, the main features of the soils are derived from the silt laid by the numerous tributaries of the Indus, the Ganges and the Brahmaputra systems. These river systems draining the Himalayas bring with them the products of weathering of the rocks in various degrees of fineness and deposit them as they traverse through the plains. The various kinds of alluvial soils have same origin. The soils are found in the valleys of Brahmaputra in Assam ; Narmada and Tapti rivers in Madhya Pradesh, Godavari, Krishna and Kauveri in the peninsular states ; Yamuna, Ganga and their tributaries ; Gandak, Gomati, Ghagra and others in Uttar Pradesh, West Bengal and Bihar.

Geologically, the alluvium is divided into newer alluvium of sandy, generally light coloured and less kankary composition, i.e. *Khadar* and older alluvium of more clayey composition, generally of dark colour and full of kankar known as *Bhangar*. 'Bhangar', are the soils of uplands and are in the process of denudation.

In dry regions of India, alluvial soils contain excess of Potassium nitrate (KNO_3) and alkali. The deltaic soils of Ganga and Brahmaputra are rich in humus and are loamy and fertile. But by floods, surface soils are removed and also replaced by fresh silty soils. This reduces the soil fertility. Alluvial soils of peninsular regions including those in Narmada and Tapti valleys are very fertile. In Eastern ghats, the deltaic soils of Godavari, Krishna and Kauveri rivers are black, humid and sandy. The soils of Orissa are sandy and swampy with fine texture. They are rich in potash.

The alluvial soils of Gujarat, locally known as *Goradu*, consist of brown clay and Kankars. These are poor in organic content and nitrogen but rich in potash. Such soils are very common in north Gujarat and Ahmedabad. Yellow and red alluvial soils of Madhya Pradesh are found in the basin of Mahanadi river covering Balaghat, Durgapur, Raipur and Bilaspur districts. These soils are grouped as *Bhata*, *Matasi, Dorsa* and *Kanhar* as these are found at different altitudes. *Bhata* is barren soil consisting of red gravels and sands and is found on uplands. While *Matasi* is yellow loamy clay soil and *Dorsa* is dark coloured clay soil of slopes. *Kanhar* is darker and heavier than *Matasi* and *Dorsa* and is deposited in low lying areas.

The alluvial soils of Uttar Pradesh are divided into four groups basing on texture. These include (a) Alluvial soil of West and North Uttar Pradesh (light texture), (b) Alluvial soil of East Uttar Pradesh (heavy texture), (c) Alluvial soil of Central region consisting of old alluvium which is neither too light nor too heavy (intermediate texture.) and (d) Alluvial soil of north-east Uttar Pradesh which contains calcium carbonate ($CaCO_3$) and other salts and shows alkaline reaction.

The alluvial soils of Bihar may be divided into (a) the alluvium north of the Ganges and (b) the alluvium south of the Ganges.

In West Bengal, parts of Murshidabad, Bankura, whole of Burdwan, and the western half of Midnapur are composed mainly of the old alluvium. There is hardly any regularity in the manner of deposition of the river borne materials. Some of the early deposits have naturally been subjected to the climatic and other influences leading to soils which is different from others in texture, colour, profile, chemical composition and mechanical and other physical properties. Soils of the Murshidabad district are of two types : the Vindhyan alluvium and the Ganga alluvium. The coastal soils of West Bengal vary from pure sands to heavy clays.

In Assam the old alluvium and hills are the most acidic soils whereas the new alluvial soils along the river banks are less acidic, often neutral or even alkaline. Soils of the Brahmaputra valley are of sandy type ; available and total potash contents are fairly good, the percentage of organic matter and nitrogen are fairly moderate.

On the Orissa coast there are stretches of sand and sand dunes alternating with deltaic swamps. Behind this coastal belt is an area of cultivated alluvial and lateritic formations.

The soils of the Punjab plains belong to the same class of alluvial soil that is typical of the Gangetic Plains. The majority of the soils are loam or sandy loams consisting of a soil crust at varying depths.

In Kerala, the coastal alluviums are sandy having a low water holding capacity and low nutrient status. The alluviums on the banks of rivers are fertile.

5. Alkali and Saline Soils

These soils with higher percentage of salts are distributed in Kanpur, Lucknow, Unnao, Raibareli, Azamgarh of Uttar Pradesh, parts of Punjab, West Bengal, Bihar, Orissa, Maharashtra, Tamil Nadu covering an area of 70,000 sq km. Some soils are salty mainly due to presence of alkali salts in them. In some soils, salts other than alkali are present and are commonly referred to as saline soils.

6. Peaty and other Organic Soils

Peaty soils are characterised by excessive organic matter accumulated in poorly decomposed conditions. They occur in low lying submerged areas and are peculiarly coloured due to presence of free aluminium ferrous compounds. Peaty soils are distributed in coastal tracts of Orissa, West Bengal , South-eastern Tamil Nadu and Kerala covering an area of 150 sq km.

7. Desert Soils or Arid Soils

Desert soils occur on arid and semi-arid zones of the country particularly north-western Rajasthan and south Punjab covering a total area of 1,42,000 sq km. The soils in these areas are coarse textured regosols and wind moved sand and sand dunes. These soils are salty and they contain good amount of alkalies.

8. Scanty Soils of Hills and Mountains

Mountain soils are distributed from north-west to eastern part of the country up to 4000 m altitude. Entire soil surface is covered with snow in higher altitudes. Mountain soils are lose and are young or immature. In these soils 'A' horizon is formed on the surface of rocks directly. Soil particles are loosely aggregated in soft sandy beds.

The Himalayan soils can be divided into the following soil groups on the basis of distribution and types of vegetation.

(i) Terai soil : It is distributed near the foothills. Soil is fertile, clayey in composition and has got high water retaining capacity and humus content.

(ii) Tea soil : These are found in Assam, Dehra Dun and Darjeeling. Soils are light loamy with low lime content. Soils are suited for the plantation of tea.

(iii) Igneous soil : This soil is derived from granite rocks.

(iv) Soils of older rocks : These soils are found in Nainital. They are rich in clay and iron content thus suitable for cultivation of certain crops and vegetables.

(v) Lime stone soil : It occurs near Mussoorie. Rice is the main crop of this hill soil.

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3. C L I M A T E

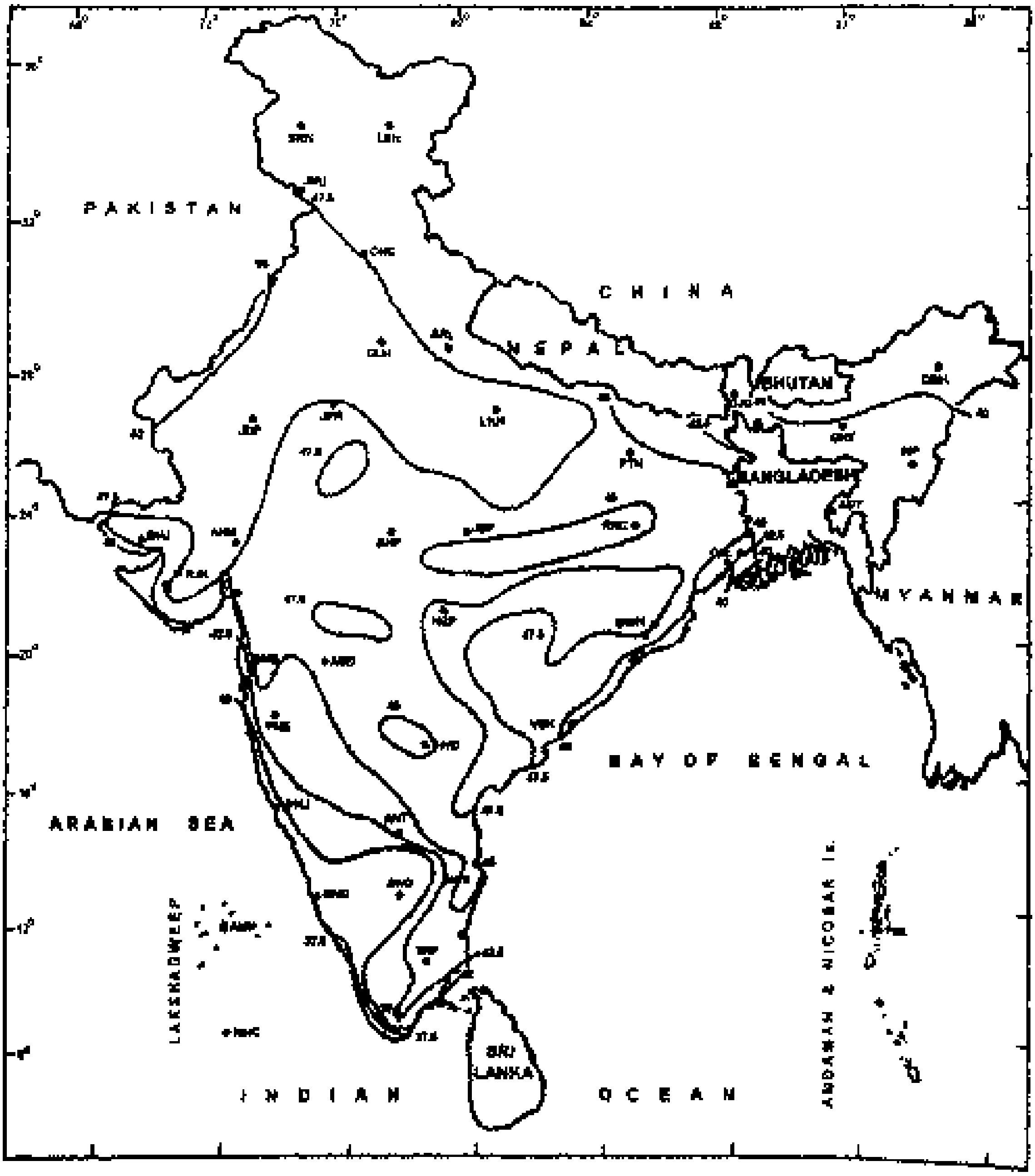
(G.V.S. Murthy, P. Venu & M. Sanjappa)

A brief account on the salient features of the weather and climatic patterns in India, specially behaviour of monsoon, seasonal and regional distribution of the rainfall, temperature and humidity have been discussed in this chapter.

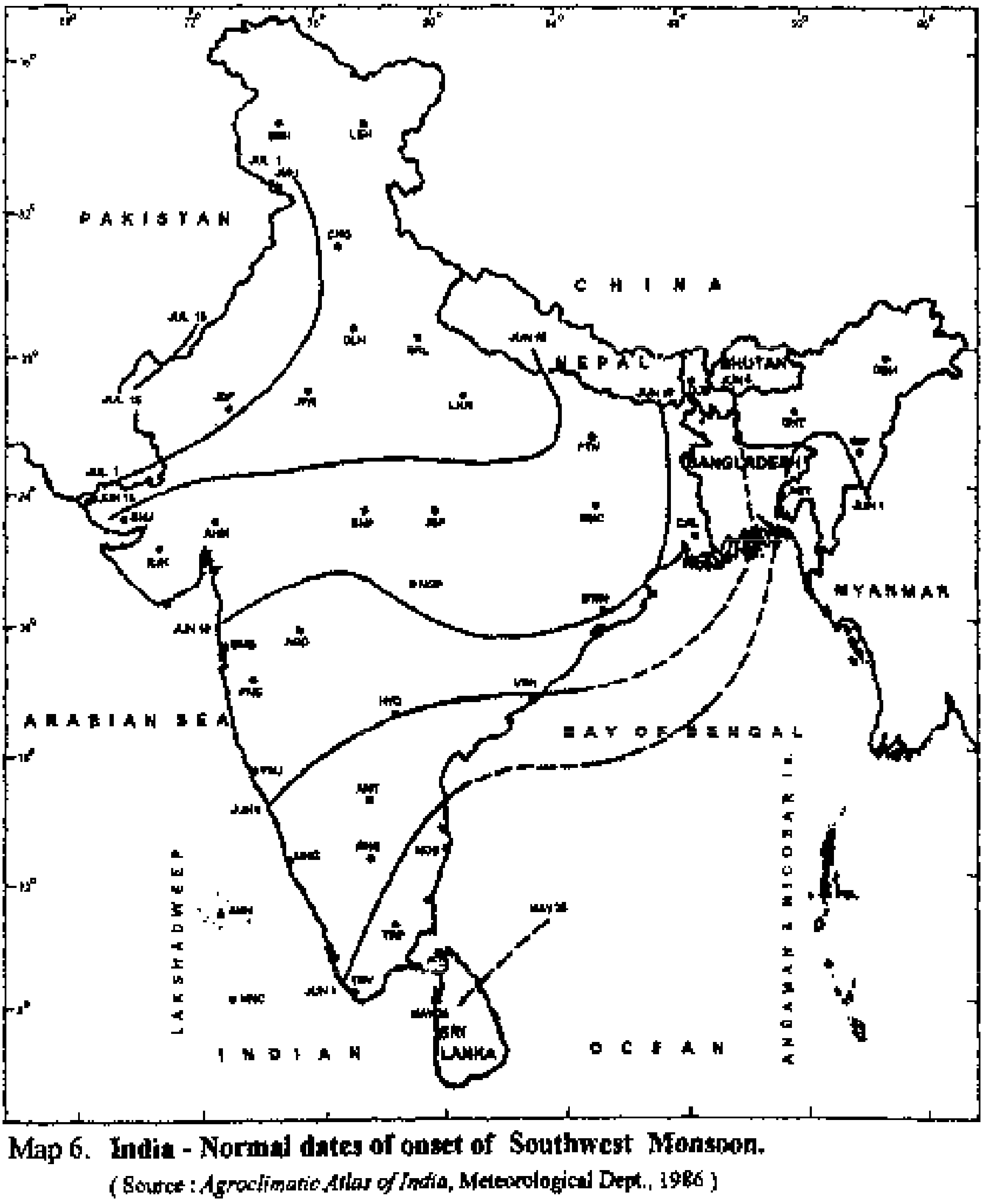
Climate is one of the basic elements in the natural environment. It effects landforms, soils and vegetation. Climate is generally defined as the average state of weather over long periods. To study the climate or weather conditions of a place, the elements to be considered are temperature, rainfall, winds, air pressure, humidity, sun shine etc. The systematic recording of daily observations of these factors is done by the network of meterological stations in India. These observatories record the wind velocity, temperature and humidity of the atmosphere up to sixteen kilometers or more above the earth's surface (Troposphere) (Anonymous, 1983, 1986). The estimates of climate based on these observations represent the general or macroclimate. Microclimate deals with the large vertical gradients of temperature, wind, humidity etc. of the layer of air, close to the ground up to 2 m high where life thrives. Both climate and weather are controlled by latitude, altitude, distribution of land and water bodies, direction of mountain ranges and ocean currents, (Ramdas, 1974).

India is a large country stretching from latitude 8^0 north to 37^0 north, covering a distance of about 3,200 km. The country has the highest and the most extensive mountain system, the Himalayas, as its northern boundary. The Himalayan ranges act as a great climatic divide. They obstruct the south-west monsoon winds to shed their moisture as heavy rainfall along the submontane areas, north of the Indo-Gangetic Plains, and as snowfall on the mountains further north. The Himalayan ranges also obstruct the direct entry of extreme continental winds from Tibet plateau into India, so that up to 30^0 north, the plains experience warmer climate in winter, whereas other parts of the world at the same latitude experience cold winters. The Peninsular India is flanked by the Bay of Bengal on the east, the Arabian sea on the west and the Indian Ocean on the south. The Peninsula is also flanked by the Western Ghats along the West Coast and by the Eastern Ghats along the East Coast. These two mountain ranges play a significant role in ensuring rains on their windward slopes.

India's climate is affected by two seasonal winds, the South-West Monsoon and North-East Monsoon. The South-West Monsoon commonly known as summer monsoon blows from the sea to land after crossing the Indian Ocean, whereas the North-East Monsoon known as winter monsoon blows from land to sea.



Map 5. India - Annual Highest Maximum Air Temperature in degree celsius.
(Source : *Agroclimatic Atlas of India*, Meteorological Dept., 1986)



Map 6. **India - Normal dates of onset of Southwest Monsoon.**

(Source : *Agroclimatic Atlas of India*, Meteorological Dept., 1986)

Though India is often referred to as a "tropical country", half of it is in the tropics and half in the North temperate zone. However, there is some form of unity in the climatic conditions. This is largely due to the influence of Himalayas and the monsoons. The climate of India may be broadly described as tropical monsoon type. The Meteorological Department of India recognizes four seasons. 1. Summer (Pre-monsoon), March to May, 2. Monsoon, June to September, 3. Post-monsoon, October to November and 4. Winter, December to February.

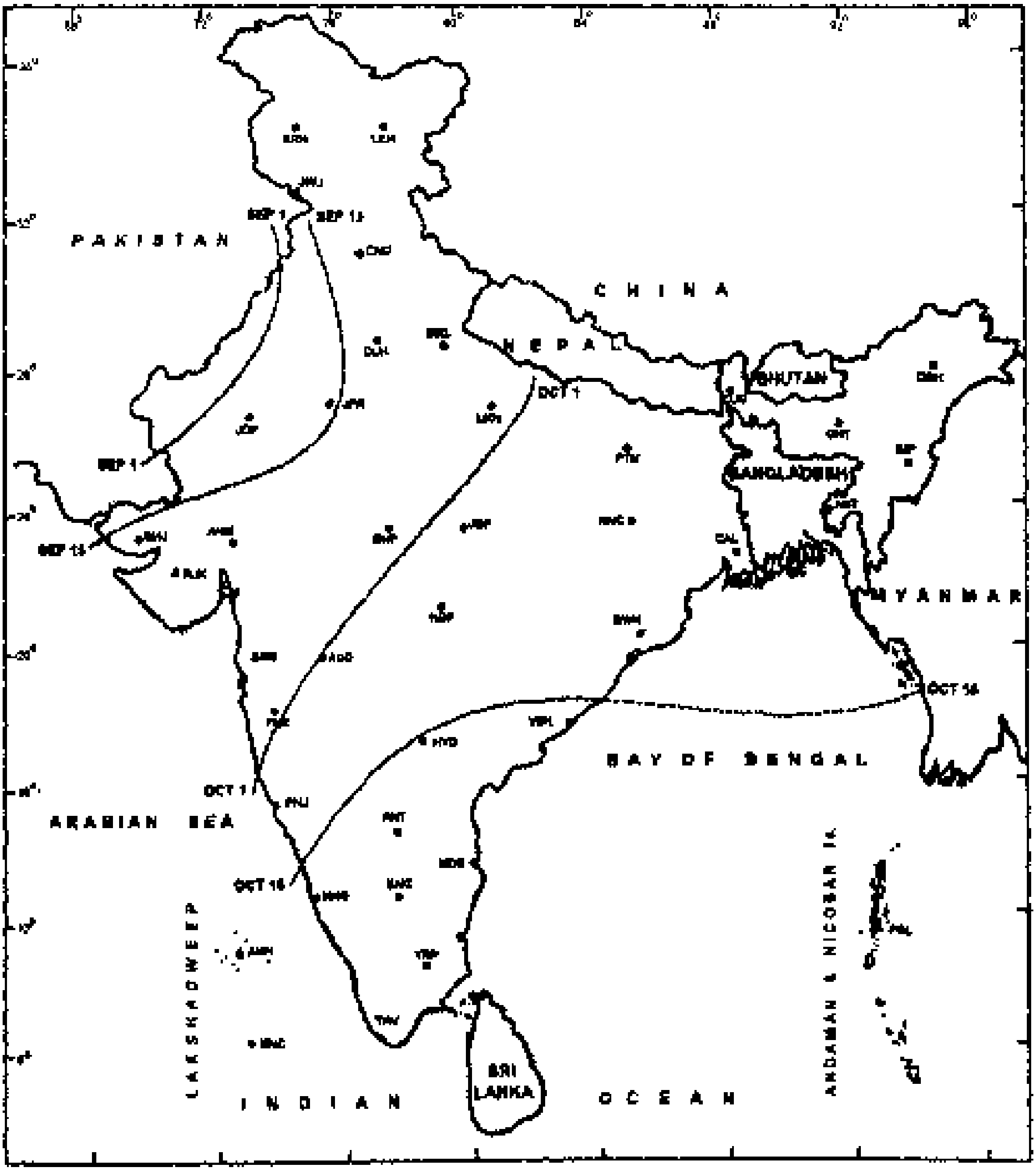
1. Summer season : It starts from March onwards and the whole country experiences great heat. In April and May the average temperatures all over the country raise to the maximum (Map 5). The highest average temperatures are 40°C in South Deccan, 40 - 45°C in Madhya Pradesh and 50°C in Rajasthan and parts of Punjab. During this season, most of the lakes and rivers in the Peninsular India either dry up or shrink.

2. Monsoon season : The South West Monsoon winds enter the South Indian seas towards the end of May or the beginning of June (Map 6). These monsoon winds coming from the Indian Ocean get bifurcated due to the topography/relief of Sri Lanka and South India and advance towards North India. The winds from Bay of Bengal strike against the slopes of Assam. Meghalaya and Chittagong Hills (of Bangladesh) which receive heavy rains. The remaining winds are deflected by the Eastern Himalayan ranges and move westerly direction towards the Gangetic plain. Thus, the foot-hills of the Eastern Himalayas and the whole basin of the Ganga receive heavy rainfall. The winds from the Arabian Sea move over the Western Ghats, Deccan, Central India, Gujarat and Rajasthan. It gives heavy rains in the Coastal and the Western Ghats, moderate rain in the Aravalli Hills and very little in the West Rajasthan. On reaching Punjab, these winds meet the deflected winds from Bay of Bengal and give moderate to heavy rains in the foot hills of Western Himalayas, eastern Punjab and north-east Rajasthan. The heaviest rains are recorded in July and August. Along the West Coast it is 250 cm but diminishes eastward. In the North-Assam Valley it is over 250 cm, but diminishes steadily westward and is barely 15 cm in the Indus Valley.

During this season, cloudy skies cause temperatures to fall a little, but humidity rises to its maximum for the year.

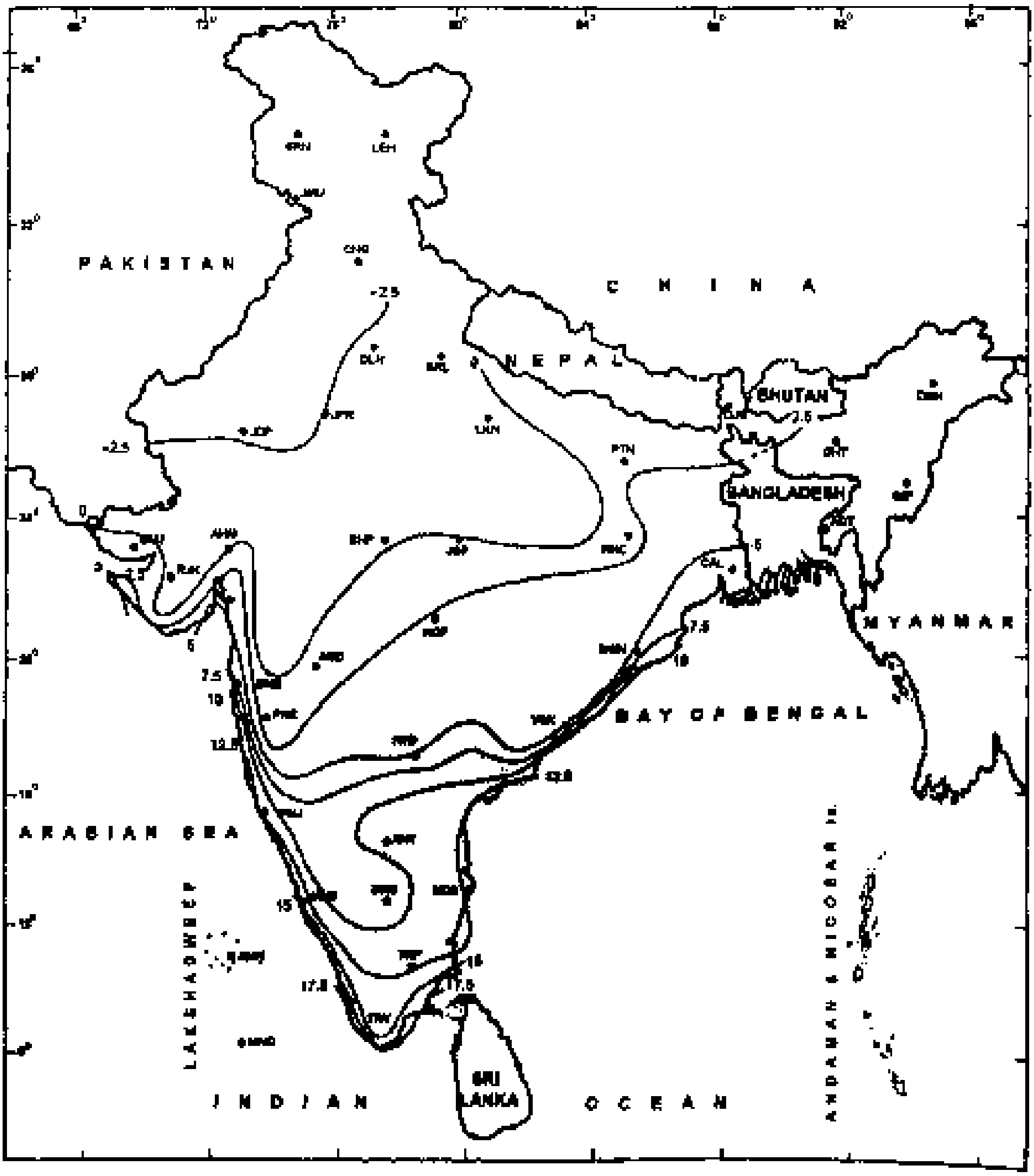
3. Post-Monsoon season : The South West Monsoon begins to withdraw from India by the first week of October (Map 7). The retreating South West Monsoon winds are replaced by North-East Monsoon winds. The North-East Monsoon or winter monsoon blows from land to sea, and a good part of the annual rain is received in the Kashmir and in the South-Eastern parts of Tamil Nadu during this period.

4. Winter season : Winter commences more or less by the end of November and continues till the end of February. The cold continental winds blowing North-



Map 7. India - Normal dates of withdrawal of Southwest Monsoon.

(Source : *Agroclimatic Atlas of India*, Meteorological Dept., 1986)



Map 8. India - Annual Lowest Minimum Air Temperature in degree celsius.
(Source : *Agroclimatic Atlas of India*, Meteorological Dept., 1986)

Easterly into India cause rainfall, hail stroms and snow fall during winter. The average temperature all over the country fall to the minimum (Map 8). The winter temperature in Kashmir and adjoining parts of Himachal Pradesh fall below 0^0 C.

In Eastern Himalaya the ordinary winter limits of snow is 2000 m altitude and it never lies for many days even at 2300 m. In Kumaon, on the west, it usually reaches down to 1600 m level and occasionally to 800 m. At Leh and on the Passes between 5600 and 6300 m altitude, the snow fall is hardly 1 m but on the Central Himalayan Passes the snow fall is heavier. The snow line or the level to which snow recedes in the course of the year, ranges from 5000 - 5300 m on the southern exposures of the Himalaya between Sikkim and Kashmir. These zones above this altitude carry perpetual snow.

Temperature :

Temperature is the most important factor of climate. It is the term used to express the intensity or degree of heat. The heat generated at the earth's surface by the sun rays, warms the air by radiation, conduction and convection which gradually escape back into space. The differences in the elevation of the sun cause differences in the heating of the earth's surface. High mid-day sun altitudes cause high temperatures, whereas low mid-day sun altitudes cause low temperatures. India situated between 8^0 37^0 North latitudes receives its maximum amount of solar radiation during May June and minimum amount during December-January (Map 5 and 8). In general temperatures decrease from the equator to the Poles, forming four zones viz. Tropical, Sub-tropical, Temperate and Arctic. The mean annual temperature exceeds 24^0 C over the whole country, except hilly areas and extreme north-west (cf. Climatological Atlas and Climatological Tables of Observatories). In the Indo-Gangetic Plain there is roughly a fall of 0.75^0 C for each 1^0 latitude. The mean maximum isotherms then run very fairly directly East and West over the northern half of the country. The range of temperatures (difference between maximum and minimum temperatures) over the country as a whole is about 10^0 C in January and July, but 20^0 C in April and October increasing in a north-west direction from the east coast. On the basis of temperature, India may be divided into following zones:

Zone	Mean annual Temperature	Mean January Temperature	Winter
Tropical	over 24^0 C	over 18^0 C	None : No frost.
Sub Tropical	17 24^0 C	10 18^0 C	Definite but not severe ; frost rare.
Temperate	7 17^0 C	1 10^0	Pronounced, with frost and some snow.
Alpine	under 7^0 C	below 1^0 C	Severe, with much snow.

The temperate and alpine zones occur in India in the higher hills.

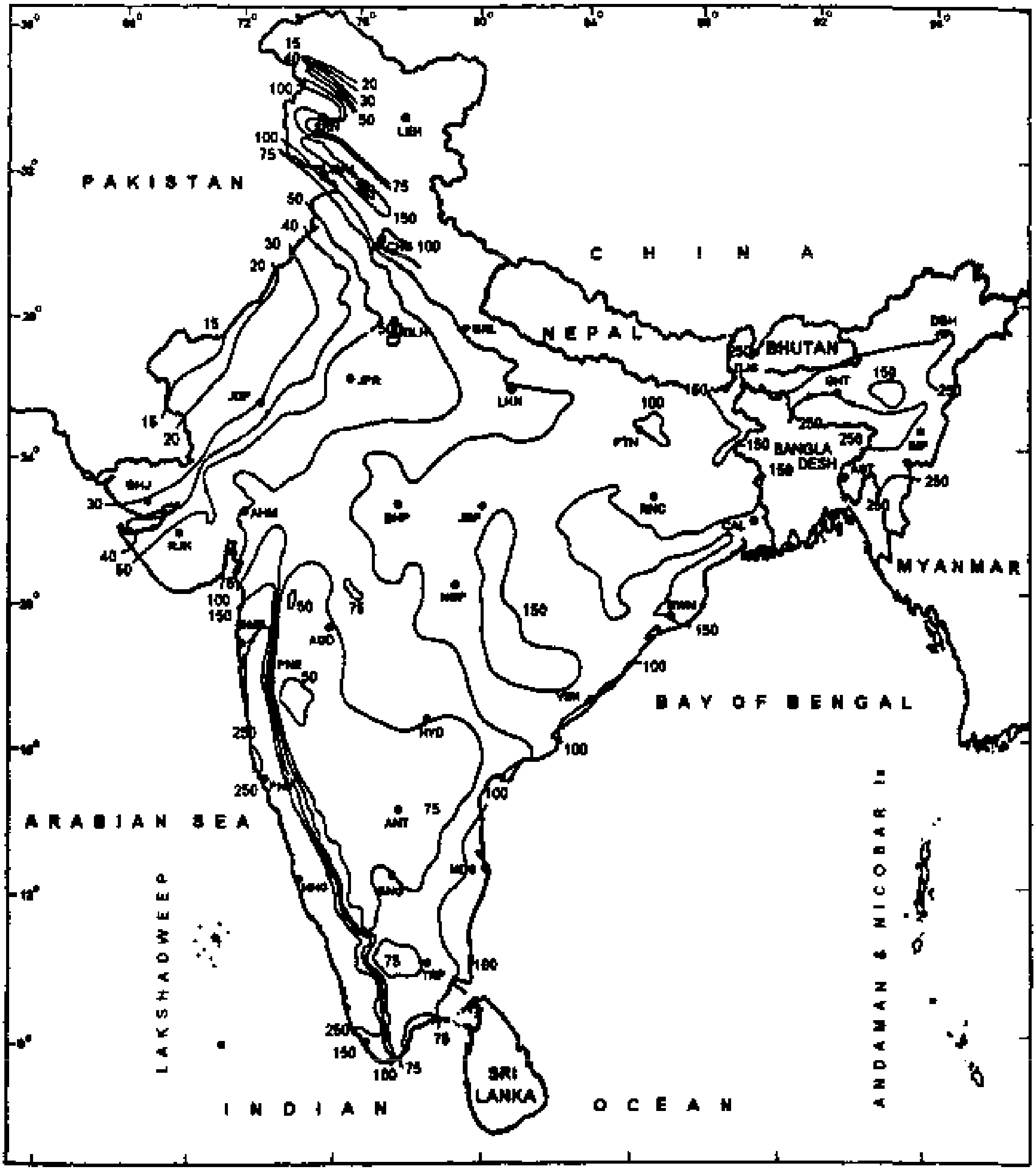
The factors such as latitude, altitude, humidity, winds etc. have influcnce on the temperature. The effect of altitude varies with conditions, a rise in the hills of 1000 m, there is roughly a fall of 6°C in temperature. In general, this fall is more pronounced on the leeward side of hills than on the windward side ; thus it is reported to be 1°C for 100 m rise on the west side and 122 m on the east side of the Nilgiris. Hill stations, coastal areas and plateau regions have differing temperature conditions. In India the hill stations like Darjeeling, Simla have the lowest temperatures averaging between 15.7°C and 16.9°C. In coastal areas, Bombay on the West Coast has an average temperature of 30.5°C, while Madras on the East Coast goes up to 33.4°C. In the plateau, Nagpur registers an average of 35.5°C.

Rainfall :

The South - West Monsoon and the North East Monsoon bring good rains into India. The South-West Monsoon brings most of the rainfall during the year in the country. This rainy season varies in duration with a general increase from North - West to East and South of India, so that upper Assam experiences the short dry period and the North - West the longest dry period. The South East of Peninsula gets relatively less rain during the usual South - West Monsoon (June to Septemper), but more rain from North East Monsoon in October-November. The combined effect of both rainy periods is felt in the Nilgiris and the Eastern Ghats, by prolonging the moist season.

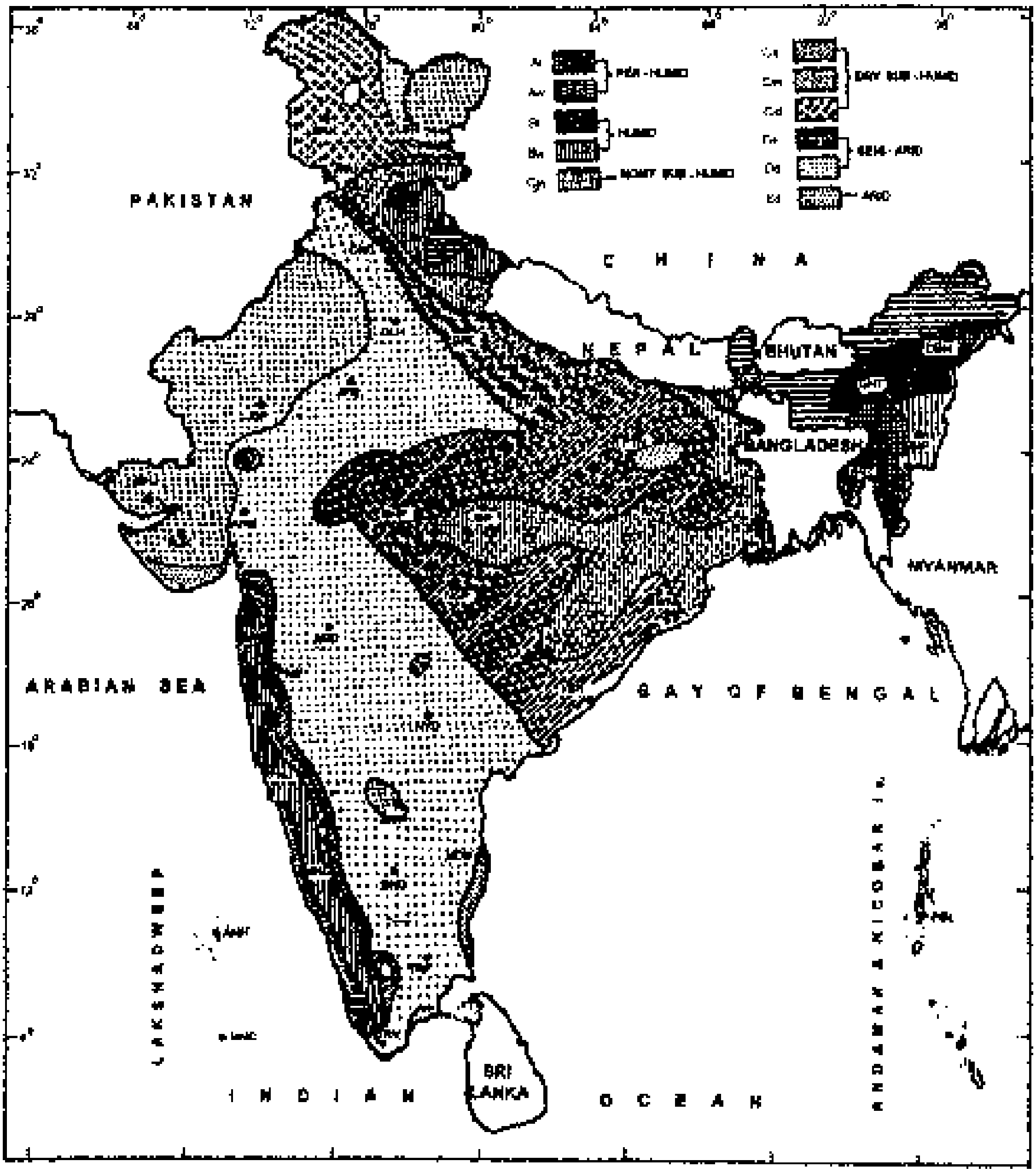
In India rainfall is uneven and ill distributed. It varies from place to place and from time to time. The general pattern of distribution of normal annual rainfall is shown in Map 9. There are four broad climatic regions based on rainfall. Areas like the West Coast lying at the foot hills of the Western Ghats, Bengal, Assam get the heaviest rainfall over 200 cm annually ; places like Maharashtra, Madhya Pradesh and Bihar along the Vindhyan mountains receive 100 200 cm rainfall; South coastal plains, North Western Deccan and Upper Gangetic Plain have 50 - 100 cm rainfall. The Rajasthan desert, extending to Kutch, the high Ladak plateau in Kashmir constituting the aridzone receive only nominal rainfall of 15 cm annually.

The direction of mountain ranges greatly influence the distribution of rainfall in the country. The windward slopes of Western Ghats receive over 200 cm of rain, while the leeward side has less than 75 cm of rainfall. The wind-ward submontane tracts of the Himalayas receive as high as 287.5 cm of rainfall. These areas are the water sheds, from which the major rivers of India arise. Cherrapunji and surroundings in Meghalaya, facing the South West Monsoon receives 1143 cm rainfall annually, the largest amount recorded in Asia and the second largest in the World.



Map 9. India - Annual Rainfall in cm.

(Source : *Agroclimatic Atlas of India*, Meteorological Dept., 1986)



Map 10. India - Agroclimatic Classification.

(Source : *Agroclimatic Atlas of India*, Meteorological Dept., 1986)

Thus, in India about 30% of the country receives 15 80 cm, 40% area gets 80 120 cm, 20% area gets 120 200 cm and only 10% area receives over 200 cm of annual rainfall.

Cyclones

Cyclones are a periodic feature of India. They form during the South West Monsoon i.e. April to December. Cyclones form both in the Bay of Bengal and the Arabian Sea, but more frequently in Bay of Bengal. They cause heavy damage to the coastal areas.

Humidity

Humidity is another important climatic factors and referes to the amount of water vapour in the air. The amount of water vapour present in the atmosphere depends on temperature and increases with increase in temperature. When the temperature falls, the excess water vapour then condenses into water droplets which form either clouds, rain, mist or fog, known as *precipitation*. The primary source of atmospheric humidity is the oceans. The water is evoporated from these water bodies by winds and diffusion method. The secondary sources are the moist land surfaces, the vegetation cover and the minor water bodies. So, there is always a constant turnover in the atmosphere's water vapour, addition through *evapotranspiration* and loss by *condensation* and *precipitation*. Data on the evaporation are scanty and unreliable. The ratio between the actual amount of vapour in the air and the amount of vapour the air could hold at a particular temperature is called the *Relative Humidity* (R.H.) and is expressed in terms of percentages.

Thronthwaite (1933) distinguished five humidity zones on the basis of P/E Index i.e., the sum of twelve monthly P/E ratios (P = total monthly precipitation and E= total monthly evaporation). Each of these zones is associated with a characteristic vegetation type. A. Perhumid (P/E index 128 and above), B. Humid (64 - 127), C. Subhumid (32 63), D. Semiarid (16 - 31) and E. Arid (under 16). These five principal humidity provinces are further divided into four subtypes based upon seasonal concentration of precipitation : r = rainfall abundant at all seasons, s = rainfall deficient in summer, w = rainfall deficient in winter, and d = rainfall deficient in all seasons (Trewartha, 1954). The distribution of these climatic zones in India are shown in Map 10. Assam and some parts of Western Ghats are extremely damp, whereas the Rajasthan desert and Ladak in Kashmir fall under arid zone. Thus humidity in combination with rainfall and temparature determines the distribution of vegetational types in the country.

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4. BOTANICAL HISTORY

(N.C. Nair, V. J. Nair & P. Daniel)

INTRODUCTION

The Flora of British India in seven volumes by J.D. Hooker and his associates (1872-1897), is the only standard reference work on which botanists in India relied to study the flora of the country. Since then several underexplored areas were intensively surveyed and a large number of specimens were collected. Many new taxa have been described, circumscription of many texa has changed and some genera were split or merged. The names of many species have been altered by the application of International Code of Botanical nomenclature. The area covered by the Hooker's work has undergone political transformation with end of colonial period. Hence, the Botanical Survey of India is bringing out a National Flora of the country incorporating all the above mentioned changes.

A flora is written based on plant collections and their study. Information about collectors and herbaria where they are located from the historic part of any area. Although, it is ideal to include the collections and collectors of all group of plants at one place, only those pertaining to flowering plants are dealt here. Collectors and collections of other group of plants will be treated separately.

Introductions in old floras and monographs are very valuable sources of information on botanical history. I.H. Burkill's *Chapters on the history of botany in India*, which appeared in parts in *J. Bombay Nat. Hist. Soc.* 1963 and was published in book form by the Botanical Survey of India, is the only comprehensive account available on the history of botanical explorations in India. Burkill ended the history at 1900 A.D. A good number of bibliographies are also available on Indian botany which will furnish a great deal of information. The bibliographies consulted for the present account which cover the period up to 1990 are listed below:

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THE BEGINNINGS OF BOTANY IN INDIA

India has been inhabited by man almost since prehistoric times and from that very early period he has sought to acquire knowledge of his immediate surroundings, partly for his survival and partly because of his inborn curiosity. Gradually this led him to undertake the study of his country and record his impressions on the biota around, plants being one of them very intimately associated, thereby evolving one of the earliest known civilizations when many parts of the world were still inhabited by savages. Indians were the first to weave cloth (Hill, 1952), a very early sign of civilization indeed. In the 5th century B. C. Herodotus gave a number of details about India, reference to the voyage of Scylax and testimony that India has trees which bear fleece as their fruit "surpassing in beauty and quality the wool of sheep". A curious myth prevailed among the Greeks of ancient days that certain trees in India bore fruits which burst to produce little lambs whose soft white fleece was used to weave the finest cloth. Sophocles (505-495 B. C.) mentioned rice, sandalwood etc. specifically as Indian products which were known to the Greeks only by their Tamil names.

Very early studies on plants of India were particularly with reference to their uses. Archaeological findings, the Vedas and Upanishads, Indian epics, Puranas, Samhitas, Materia Medica and ancient classical literature give some indications of plants growing in this country, their uses and legends attributed to them (Dutt, 1893). The pictorial records which ancient men left for the posterity are clear indications that man began to be fully aware of plants and to consider them in a way that marks the first step to scientific study. The excavated seals of the Indus Valley civilization (c. 2400-1700 B.C.) from some parts of India indicate the presence of *Ficus religiosa* (seal no. 387), *Acacia nilotica* var. *indica* (seal nos. 356, 357), *Ziziphus mauritiana* (seal nos. 353, 357) etc., which were used in one form or the other. Remains of that civilization also reveal that rice, wheat, cotton barley, pea, sesame etc. were already in cultivation in that remote period.

Many other plants yielding food, timber, wood and fibre were known. Many others were known for their curative properties (Dixit, 1939). Among the flowers used for worship the sacred lotus (*Nelumbo nucifera*) was the most popular used to wreath over the head of the sun-god.

Plants were classified into those which were wholesome to eat and others which were unwholesome or injurious. Engravings of cultivated pea on potteries show that they were known to them (Vats, 1940, 1958). The finds of lemon leaf-shaped pendant, polychrome vases in the shape of a coconut, melon seeds etc. suggest that these ancient Indians were familiar with these and made critical observations (Mackay, 1938). A motif of unusual interest is the incense burner which shows that incense was used in that early period of Indian history. They also defied trees (Marshal, 1931; Cumming, 1939; Wheeler, 1953). Sesame was the most important oil.

In the Vedas, there are references to palasa *(Butea monosperma)*, salmali *(Bombax ceiba)*, soma (*Sarcostemma acidum*), kushta (*Saussurea costus*), apamarga (*Achyranthes aspera*), arka (*Calotropis gigantea)*, hastikarna (*Ricinus communis*) and several other plants. In the Rig Veda, there is a mention of yevana *(Avena)* which possibly indicates an early introduction of this cereal to India and possible contact outside.

Like today's Hindus ancient Indians considered tulasi *(Ocimum sanctum)* as sacred being named after Tulasi, a nymph beloved to Lord Krishna. In Vishnupurana, parijathaka *(Nyctanthes arbor-tristis)* was brought by Krishna from elsewhere for his beloved spouse Satya Bhama. In Manusmriti, the tree sahakara *(Mangifera indica)* is referred to be the transformation of Prajapathi. Legends of this genus are many in Puranas and epics.

Many plants were considered sacred. *Ficus benghalensis* and *Ficus religiosa* belong to this category, so also the grasses durbha, kusa and ama *(Cynodon dactylon, Desmostachya bipinnata* and *Saccharum spontaneum*). Panchavati is named after the five trees, asoka or vanjula *(Saraca asoca)*, ashwata *(Ficus religiosa)*, vata or vada *(Ficus benghalensis)*, bilva *(Aegle marmelos)* and amlaki *(Phyllanthus emblica)*.

In the Ramayana (c. 1300-1000 B.C.) several plants are mentioned in addition to the vivid description of the flora of the Chitrakuta hills, Agasthya's hermitage, Panchavati and Pampa. In the *Mahabharata* also there are many references to trees and shrubs growing in Indraprastha, Gandhamardhana forest, Dwaithavana etc.

Charaka Samhita (c. 800 B.C.) classified plants as medicinal plants, dye yielding plants, pulses, timber yielding plants and other useful plants. Charaka also emphasised on some botanical characters such as habit (tree, herb, grass-like, creeping etc.), presence or absence of flowers (indicating the presence or absence of petaloid parts), whether withering after fruiting and the mode of propagation (seed, cutting, root etc). Special mention may be made of his treatment of manjishta, kusumbha, kesari etc. (dye yielding plants), masura *(Lens esculenta)* tuvara *(Cajanus cajan)* etc. (pulses), shala *(Shorea robusta)*, sissoo. *(Dalbergia sissoo.)*, parusaka *(Grewia asiatica)* etc. (timber yielding plants), babul *(Acacia nilotica var. indica)*, bimba *(Coccinia grandis)*, dhupdamara *(Vateria indica)*, harida *(Curcuma domestica)*, pipli *(Piper longum)* etc. (medicinal and other useful plants). Roy and Gupta (1965) gave a detailed account of the plants of the *Charaka Samhita.*

Evidence of systematic knowledge of plants is found in *Susrutha Samhita.* Suśrutha's system flourished at Varanasi (Benares) around 560-480 B.C. when Gautama Buddha was alive. The *Samhita* embodies information from older material. It also shows that Indian medical men had a large armoury of materia medica. More than 700 plants are named in 37 groups depending on the disease and the condition to be treated. Food plants are classified according to the parts to be used and also according to the taste.

Vatsayana (c. 100 B.C.) described pleasure gardens (pushpa vatika) associated with palaces of kings and mansions of the rich and plants suitable for such gardens. Among the trees were asoka *(Saraca asoca)*, cadamba *(Anthocephalus chinensis)* etc., and among the climbers were madhavi lata *(Hiptage benghalensis)*, jotsna *(Jasminum sp.)* etc.

Brihat Samhita of Varaha Mihira (c. 500 A.D.) gave lists of plants on ecological basis as well as on the basis of indicators of underground water *etc.* (Kern, *1865)*. Amrataki *(Spondias pinnata)*, arjuna *(Terminalia arjuna)*, bhallataka *(Semecarpus anacardium)*, jambu *(Syzygium cumini)* and three score and ten others are mentioned as indicators of groundwater. Mihira also recommended plants for villages, tanks, canal banks, courtyards etc. It is also mentioned that kataka *(Strychnos potatorum)* can be used for clearing turbid water. In this Samhita there are also references to various types of toothpicks of plant origin, hair oils, perfumes, recipes for dyeing hair etc.

Kalidasa's *Ritusamhara* and *Meghadoota* (c. 5th century A.D.) give names of several trees, shrubs, climbers and herbs, graphical and vivid descriptions of the six seasons and the associated sylvan splendour as well as seasonal changes in the flora.

It may be evident from the very brief review presented above that in ancient India plants were studied from various angles. The science of arboriculture, horticulture and silviculture were also developed in ancient India. Methods of propagation of plants by seeds, cuttings, layering, grafting and budding were prevalent and find mention in the *Vedas*, *Artha Sashtra* and *Brihat Samhita.* Treatments against diseases of plants of Sarngarava was part of the curriculum in seats of learning in ancient India. To a small extent, there was also the scientific study of plants irrespective of economic values. Branches analogous to present day morphology, nomenclature etc. were also developed; for example, male plants of *Pandanus fascicularis (Pandanus odoratissimus)* were called ketakiviphala or dhulipushpika (meaning plants which produce only pollen grains or which do not produce fruits), the female as swanaketaki (those which produce fruits) and the male and female together as ketakidwayam (meaning *Pandanus* couple). There are also evidences that plants were being closely observed; several varieties of sugarcane are named in *Susruta Samhita*. Incidentally it may be mentioned that four classes of fungi such as those which grow on stacks of straw or bamboo, sugarcane, earth and dung were recognized. Plants were classified also on the basis of external morphology, medicinal properties and environmental associations. A legend has it that around 500 B.C. Bhikshu Atreya, a famous teacher at the University of Taxila, asked one of his pupils named Jeevaka (who later became the court physician of King Bimbisara of Magadha, a contemporary of Buddha and Mahavira, and whose empire was the most extensive in ancient India) to collect, identify and describe the properties of all plants growing within a radius of four yojanas from Taxila (Maheshwari *et al.*, 1965). This is possibly the oldest floristic study in the world. A binomial system of nomenclature was also followed; for example, Bala is the modern genus *Sida* and the specific names are suffixed to the generic name. In Sanskrit, on the other hand, the specific name is prefixed to the generic name: Ati bala = *Sida rhombifolia*, Maha bala = *Sida rhomboidea*, Naga bala = *Sida spinosa* etc. The remarks of Sir William Jones (1790), the great orientalist and botanist, that Linnaeus himself would have adopted the Sanskrit system of nomenclature had he known and learnt this ancient language of India which is rich in plant names, on scientific basis.

Plants also featured in personal adornments and beautifactions. Chewing 'tambula' (leaves of *Piper betel*, nut of *Areca catechu*, lime and spices) was in common use to sweeten breath. The practice is followed even today. Women folk adorned their hair with flowers of champaka *(Michelia champaca)*, jotsna *(Jasminum spp.)* etc. They also wore garlands of many kinds of flowers. Sandal paste *(Santalum album)* was used by both men and women. The devotees used rudraksha (the stone of *Elaeocarpus ganitrus)* or the wood of tulasi. Lac dyes were used to redden lips, soles of feet etc. Mehndi or henna *(Lawsonia inermis)* is a later introduction to India by Muslims.

India had contact with the East in plants and plant products. Most of the wild habitats of rice *(Oryza spp.)* are in peninsular India and therefore this region is believed to be the original home of this cereal. It is possible that it went across the Himalayas to China earlier than 3000 B.C. Besides, in *Artha Sashtra*, there are references to China, in the *Mahabharata* and the *Manusmriti* suggesting intercourse between the two countries through the present Bangladesh, Assam, Manipur, Burma etc. Deep sea voyages also took Indians to for East.

Economic plant products of India like cardamom, black pepper, ginger, cinnamom, sugarcane, sandalwood, rosewood, teak, damars, gums, resins, elemi, Himalayan spikenard, cotton, turmeric, indigo, myrobalan nuts, vetiver, medicinal plants etc. were known in various parts of the Western world as Oriental luxury several centuries before the birth of Christ. The first traders in these articles were probably the Arabs who brought them from India by caravan to Arabia and thence to other parts of the Western world (*vide* also Piggot, 1950; Pusalkar, 1958). It is now known that *Sorghum* reached Egypt prior to 2200 B.C. and ginger from India was brought to Asia Minor by caravan even before the time of Rome. There is also a reference to ebony *(Diospyros ebenum)* in the 5th dynasty of Egypt (c. 2500 B.C.). This plant is a native of southern India and Sri Lanka (Ceylon). Theophrastus in his *Historia plantarum* (4,4,6) described ebony from India (*vide* Leucas, A. 1934. *Ancient Egyptian materials and industries).* Logs of Indian teak have been found in the temple of moon at Mughar (Ur of the Chaldees) and in the palace of Nebuchadnezzar, both of 6th century B.C. Big trade in teak, ebony, sandalwood, black wood etc. flourished till the 2nd century A.D. Many articles mentioned in the Jewish annals bear names which can be traced to Indian originals. Thus Hebrew almug (sandalwood, probably from Sanskrit valgu), sadin (cotton cloth, Arabic satin, Greek sindon, all from Sindhu meaning cotton cloth), Hebrew karpas and Greek karpasos (cotton from Sanskrit karpasa) etc. are referable to their Indian roots (Pusalkar, 1958). The early Arab traders tried their best to keep the sources as a secret and they could do so for a long time. The esteem and high price of Indian produce were the cheif incentives which lured adventurers of the Western world to search for a sea route to India. Possibly knowing from the Arabs, the Phoenicians are believed to have visited India even before 1000 B.C. by sea when Hiram ruled Tyre. This was about the same time that Solomon, the wise king of Israel, in partnership with Hiram, fitted out a commercial fleet of ocean going vessels manned by Phoenicians. Some of these ships sailed from Ezjongeber, a port in the Gulf of Aqaba, close to the modern Israeli port of Elath. These vessels made three year voyages to Ophir to buy plant products, ivory, monkeys etc. (*vide* also Menon, 1962; Snaith, 1971). According to Nagam Aiya (1906) Ophir is Puvar in Neyyatinkara taluk on the Kerala coast.

The companions of Alexander the Great of Macedonia during his campaign to India, Omesikritos, Nearchos and Aristobulos in their diaries gave some floristic information about India. Afterwards these were incorporated by Theophrastus (also known as Tyratamus, 372-287 B.C.), a native of Erasus in Lesbos, a pupil of Plato and successor of Aristotle in the Peripatetic School, in his important contribution to botany, *Historia plantarum* (*vide* also Moldenke & Moldenke, 1952).

Megasthanese, the Greek ambassador from Seleucas I, visited India in the 4th century B.C. When Sandrocothus (Chandra Gupta), the founder of the Maurya dynasty, was ruling Magadha with Pataliputra as his capital (present day Patna was known to the Greeks as Palibothra). The emissary who travelled the whole of northern India wrote an account in which he mentioned important produces of India (Mac Crindle, 1877).

Bindusara, the Maurya emperor and father of Asoka, ruled India between 300 and 273 B.C. At that time an ambassodor from Syria lived in Pataliputra and made notes. A geographer and official from Greece also came to make nature-study.

Egyptian tombs yield information on the earliest dyes known to the Western world from India. Among these, indigo or anil, the brilliant blue and king of dyestuffs with its natural fastness to both light and water, was the popular dye for about 4000 years (Schery, 1954). The tombs also contained sandalwood, ebony, tamarind etc. of Indian origin. Mummies were wrapped in Indian muslin.

The Roman emperor Augustus (Octavius, 63 B.C. - 14 A.D.) sent his emissary to the Pandya king who ruled over Madurai, Tinneveli (Tirunelveli) and closeby regions for various plant products. The anonymous author of the *Periplus of the Erythraean sea,* a work written by a Greek settled down in Egypt in the first century A.D., made reference to several products of plant origin from the Malabar Coast. In about 45 A.D. Hippalus after learning from the Arabs of the regular seasonal changes of the monsoons made these winds serve him as the means of establishing a trade route between the Red Sea and India. He found that the distance between Aden and Ganganore could be covered in forty days. This opened up a new chapter in the trade of plant products between India and Rome. Pliny (Gaius Plinius Secundus, 23 B.C. 79 A.D.) who gave an accurate description of the sea route to India and of the land of Malabar in his *Historia naturalis* also mentioned the main articles of plant origin in trade from Caelobothras (Kerala, Putram), Kottanara (Kottarakara), Modura (Madurai) etc.

There are several words of Indian origin as plant names in Greek; for example arisi and vettiver in Tamil became *Oryza* and *Vetiveria* respectively. Injiver and elathari in Malayalam became *Zingiber* and *Elattaria* respectively. Sandanam *(Chandanam)* and sarkara became *Santalum* and *Saccharum* respectively.

The Byzantine monk Cosmos Indicopleustus who visited the West Coast in 522 A.D. and Rabbi Benjamin of Tudela who travelled in the East between 1159 and 1173 A.D. wrote about pepper, ginger, turmeric, indigo etc. Al-Kazwini (1263-1275) who compiled an account of India from the works of others recorded several plant products. Marcopolo (13th century), Friar Jordanus (1324), Nicolo Conti (1441), Ludovico Varthema (1510) and Durate Barbosa (1514) are other chief Western travellers who wrote about Indian plants before the Portuguese, French, Dutch and the English came to India.

THE PORTUGUESE TAKE THE LEAD

The quest for India by sea was very dominated among the Portuguese. In 1487 Barthalomew Diaz, the explorer, sailed around the Cape of Storms (now known as the Cape of Good Hope) and opened the way for Europe to start trade with India.

Later Vasco da Gama also rounded the Cape of Good Hope and anchored off Calicut (Kozhikode) on 20 May, 1498, the voyage from Lisbon having taken 10 months and 12 days. He established friendly relations with the Zamorin, but Pedro Alvares Cabral, the leader of the second expedition which reached India in 1500 fell out with the king and sought trading concessions from the Zamorin's rival, the Rajah of Cochin. Cochin with its excellent port became the first trading headquarters of the Portuguese in India. The first viceroy was Francisco de Almeida (1505-1509) who defeated the Arab-Egyptian fleet in 1509 and gained command of the Indian waters. In addition to the interest in spices and other luxury items from India, the shortage of wood on the shores of the Red Sea also was another important factor for the growth of Portuguese power in India Realising the importance of a fortified base on land, Alffonso d'Albuquerque (1509-1515) captured Goa which became the capital of Portuguese possessions in India and remained so till December 1961 when it was annexed to the Indian Union.

To Goa came a physician and pharmacist named Garcia de Orta (1490-1570) from Elvas. With his 30 year contact with Ayurvedic physicians, study of native drugs and their uses published a book entitled *Coloquios dos simples* in 1563 from Goa. In it, a detailed account of 57 more commonly used Indian medicinal plants are given. A Latin translation was published from Antwerp in 1567 by Charles de l'Escluse (Carolus Clusius) entitled *Aromatum et simplicium Aliquot medicamentorum apud Indo nascentium historia.* This publication made the Coloquios familiar in Europe and this Latin translation ran into six editions between 1567 and 1595. Simultaneously an Italian translation was made by Annibale Briganti and published it from Venice in 1576 followed by three more editions during 1582-1616. A French translation by Antoine Colin appeared in 1609 at Zyons and another edition in 1619. These translations were from the Latin translation of Clusius. Annotated edition of the *Coloquios* in 2 volumes was published by Count de Ficalho in 1895 at Lisbon and this edition was translated into English by Clements Markham in 1913. This work embodies several mistakes.

The *Coloquios* chiefly gives information on the drugs of the East about which the West had no information. The work also includes an account on the local fruits, betel quid, narcotics from hemp, *Datura* etc.

A little later, Jan Hughes van Linschoten (1596) gave an account of life in Goa which has some botanical notes including cultivation of pepper and a description of it by his friend Bernard Paludanus.

With the arrival of the more powerful Dutch, French and English fleets during the first half of the 17th century Portuguese power rapidly declined and lost its monopoly in Indian waters.

THE DUTCH

Towards the end of the 16th century Lisbon was closed to the Dutch vessels and this adversely affected their carrying on trade in spices and prompted them to have direct access to the spice growing regions. The Dutch were the real successors of the Portuguese and they established themselves in the Coromandel Coast, Gujarat and Bengal. However, their main centre of activity was the Malabar Coast. In 1661 most of the Portuguese stations such as Quilon (Kollam), Cranganore, Cochin and Canannore (Kannoor) on the West Coast fell to the Dutch and as a result the Dutch had the monopoly in the trade of spices and other produces of India. In 1667 Hendrik Adriaan van Rheede tot Draakestein (1636-1691) was made the governer of the Dutch possessions in Malabar. He was stationed at Cochin. Between 1663 and 1669 Rheede travelled over most of the coastal regions from Goa to Tuticorin and made notes on plants (*vide* Heniger, 1980). His love for Malabar and respect for the people of the region enabled him to organize the preparation of an illustrated account of the floristic resources of the area for the exploitation and benefit of all. In this endeavour he sought the help of the native physicians as well as people from all walks of life in Malabar and people from Europe. Among them special mention may be made of Itti Achutan, Ranga Bhatt, Vinayaka Pandit, Appu Bhatt, Father Mathew, Johannes Casearius, Emmanuel Carneiro and H. C. de Donep. Live plants from Cochin and its neighbourhood were brought, illustrated and described. The accounts were finally translated into Latin. The manuscript was prepared at Cochin and sent to the Netherlands. The first volume of this great collaborative work was published in 1678 (Warner, 1920), edited by Arnold Seyen, at Amsterdam under the title *Hortus Indicus Malabaricus.* The next 11 volumes were also published from Amsterdam, the last volume in 1703, 12 years after the death of Rheede on board his ship and burial at Surat (Heniger, 1979). In these volumes are 794 excellent illustrations covering about 780 species. The specimens on which Rheede based his descriptions are not known to exist (Raizada, 1954a; Johnston, 1970) although he forwarded some plants to the "Hortus Medicus" at Amsterdam (Manilal, 1980). Recently 660 plants described and illustrated by him have been re-collected (Nicolson *et al.*, 1988).

Linnaeus (1740) gave van Rheede the same status as that of renowned botanists like Dillenius, Clusius and the Bauhins and established about 265 species from *Hortus Malabaricus* (Linnaeus, 1753, 1754). Adanson (1763), Jussieu (1789), Dennstedt (1818), Hasskarl (1867) and many later botanists also used *Hortus Malabaricus* to name new taxa treating the illustrations as types. Van Rheede's name is commemorated in the genus *Rheedia* L. (Guttiferae). *Hortus Malabaricus* has attracted the attention of several recent botanists (*vide* Manilal, 1980; Nicolson *et al.*, 1988). No work on Indian botany of a similar nature has surpassed the *Hortus Malabaricus* in its importance in botanical literature. Today more than 63 species stand dedicated to Rheede e.g., *Bruguiera rheedei, Croton rheedei, Impatiens rheedei, Allophylus rheedei* etc. Even his fellow workers' names were used as generic names *e.g., Achudemia, Casearia, Mathaea* etc. Many original Malabarian plant names have remained even today valuable generic names covering more than 1,000 species (*cf.* Vaczy, 1980) e.g., Basela = *Basella* L., Canavalia = *Canavalia* DC., Cansjera = *Cansjera* A. L. Juss., Canti = *Canthium* Lam. etc.

THE ENGLISH

On 31 December, 1600 a "Company of Merchants of London Trading with the East Indies" was formed and their ships reached India for trade. In March 1615 one of Downton's ships, the Hope, left India and it was the first English vessel to return to England with a cargo of spices and other plant products from India. By 1619 English trading posts had been established at Surat, Ahmedabad, Broach, Masulipatnam and Madras. In 1640 Fort St. George was built by Francis Day which developed into the headquarters of the English in India on the East Coast. Bombay replaced Surat in 1687 as their headquarters on the West Coast. In 1690 Charnock laid the foundations of Calcutta and renamed it as Fort William in honour of William III. All these places are intimately connected with the history of botany in India.

The demand for spices was gradually coming down in Europe. This was occasioned by the increasing use of sweets in preference to spiced dishes and by the use of winter fodder for cattle to ensure supply of meat throughout the year. Therefore, the English Company's important trade was in cotton, cotton yarn, silk piece goods and raw silk.

While van Rheede was organizing the work on *Hortus Malabaricus* 'the English had very good relations with the Dutch and possibly inspired by the latter' the English also began collecting plants in the Madras coast through captains of ships and others connected with the East India Company. Among those English collectors special mention may be made of James Petiver (c. 1658-1718), an apothecary, and Charles Du Bois (1656-1740), an official of the East India Company. Due to the impetus given by these men Richard Sambach and Samuel Browne, both surgeons, collected plants from Madras coast particularly near about Fort St. George. Browne sent a packet of dried plants, *Hortus Siccus*, to London.

Like Browne, another official of the East India Company, Edward Bulkley (c. 1651-1714) also sent dried plants to London along with information regarding uses and names in Tamil. This collection of herbarium specimens with labels made of bamboo strips with tamil names in China ink by Tamilian Pandits has been returned to Calcutta herbarium by Sir Hooker along with numerous gift specimens. In addition there was a ship's surgeon, Alexander Brown, who also collected. None of them were botanists. The plants sent to London were studied by Petiver and Du Bois. Wagenitz (1978) unearthed 12 sets of herbarium specimens from India kept under the title "Plantae Malabaricae" in the herbarium of the Systematisch Geobotanisches Institut der Universitat Gottingen. These were principally of Ch. Th. Walther (1699-1744) who collected them in the surroundings of Tranquebar (Tharangampadi). The specimens were annotated with Tamil names and notes on their uses. As pointed out by Wagenitz *(l.c.)* the term Malabar in those days meant not only the Kerala coast but also other parts of southern India.

In 1697, Leonard Plukenet (1641-1707) began to publish copper-plate illustrations of plants under the title *Phytographia*. Petiver also began publishing reports on plants *(Philos. Trans.* 20: 313-353. 1699). The observations of both of them were based on plants of India chiefly supplied by Browne and Du Bois. The plants possessed by Petiver and Plukenet ultimately reached the British Museum. The pre-Linnaean inquiry into the flora of India ended with Petiver.

POST LINNAEAN PERIOD

Tamil Nadu

In the 17th and early half of the 18th century there were no generally accepted rules for naming plants and every botanist had his own way of naming plants. Linnaeus' *Species Plantarum* (1753) and *Genera Plantarum* (1754, 5th ed.) marked a new epoch in botanical history. In *Species Plantarum* he consistently used the binomial system of nomenclature and this publication is taken as the starting point of modern nomenclature. The descriptions of genera in *Genera Plantarum* are accepted to validate generic names.

Johann Gerhard Koenig (1728-1789), an illustrious student of Linnaeus and a missionary of the Royal Danish Mission, surgeon and naturalist, brought the Linnaean system of naming to India. He was stationed at Tranquebar (Tharangampadi) and began to study the flora of the Madras coast in 1768. Koeing was accompanied by patrick Russell and W. Roxburgh in local tours to places like Nagari hills, Tirupati Kakinada, Madgol hill etc. in Eastern ghats. Koenig died at Kakinada near Samal cottar and described *Roxburgh gloriosoides* in presence of his friend and desciple W. Roxburgh. G. King (1890) aptly named koenig as 'Guru' Koenig sent dried specimens to Joseph Banks (1743-1820) in

England as well as to Anders Johan Retzius (1742-1821), Professor at the University of Lund, Sweden. The specimens received by Linnaeus have been recorded in *Savage's Catalouge of the Linnaean herbarium* (1948) and that of Retzius are listed by Fischer *(Bull. Misc. Inform.* 1932: 49-76). Koenig also sent seeds and live plants (Rendle, 1933).

Koenig left the Tranquebar Mission after ten years and joined the Arcot Nawab's services wherefrom after four years he was absorbed by the East India Company till his death (*cf.* Burkill, 1965). From Madras he along with George Campbell, a surgeon, botanized Pulicat situated a little to the north of the city of Madras. *Koenigia* Retz (Polygonaceae) *Murraya koenigii* Spreng., *Chionachne koenegii* Thw. were dedicated to this pioneer botanist and explorer on special mission to East Indies.

There were also other missionaries working in the Tranquebar Mission and studying plants. Among them may be mentioned Johann Gottfried Klein (1766-1821), Johan Peter Rottler (1749-1837), Christopher Samuel John (1747-1813) and Benjamin Heyne (1770-1819) (*cf.* Mueller, 1955; Stansfield, 1957; Mabberley, 1980; Stewart, 1982 b). There was also a botanical garden at Tranquebar around 1768.

Moravian brothers contracted to sell dried plants to Joseph Banks and carried out their promise from 1775 to 1778. It was from this transaction that an idea of starting a learned society at Madras and a society of botanists by name " United Brothers" was formed in 1775 (Chakravarty, 1972).

Rottler joined the Tranquebar Mission in 1776. He was already a botanist and collected plants chiefly in the coastal regions. Except for a brief spell in Sri Lanka he remained in India till his death. Rottler not only exchanged and distributed plants with Heyne and the younger Klein of the Tranquebar Mission but also with Roxburgh, Schreber, Vahl and Willdenow in Calcutta, Erlangen, Copenhagen and Berlin respectively (Stansfield, 1957). However, much of his collection seems to have reached Kew via King's College, London. How Rottler's collections reached King's College could not be ascertained (Anon., 1926). Although Rottler published many papers on south Indian botany, the very first being the account on the Indian gooseberry, "Der nellicaimaram, *Phyllanthus emblica* Linn." published in 1787 (Christensen, 1924-1926). Names of 3 genera and 68 species of flowering plants were validly published by Rottler and Willdenow separately in 1803 (Daniel, 1991). Rottler's dictionary in three volumes is an important work equating for the first time Tamil plant names with botanical names.

Heyne joined the Tranquebar Mission in 1777 and passed into the services of the East India Company in 1793 and joined Samalcottah (following the transfer of Roxburgh to Calcutta) where he was to supervise and direct works on the introduction of pepper, sapan, tobacco and cardamom. He was not a botanist but became one. In 1813 when he went on leave to England he took along with him duplicates of his collections. In London he got access also to Bank's possessions from India to name them. He submitted the worked over collections to Albrecht Wilhelm Roth (1737-1834), a physician turned botanist of repute. Roth published his account on new plants from India in 1821. As remarked by Burkill (1965), "with Roth's book appeared the first approach to a flora of any considerable part of India; but, one adds, 430 species amount to little more than a sampling" The Pondicherry based French botanists also made extensive plant collections and enriched the herbarium at Paris. Among them mention may be made first to Pierre Sonnerat (1745-1814) who collected at Pondicherry, Mahe and Surat. Next is Louis Theodore Leschenault de la Tour (1773-1826). He reached Pondicherry in 1816 as a Research Officer in natural objects, travelled and collected widely. He sent a part of his collections to Wallich. Leschenault also published a couple of papers on Madras flora. The third was Francois Louis Busseuil, surgeon of a ship. He reached Pondicherry in 1824. The fourth was Charles Belanger who arrived in India in 1825 and collected at Mahe, Pondicherry and Chandernagore. In 1829 he returned to Paris with a large collection and published an account, *Voyage aux Indes Orientalis* in 1834. A. A. M. Reynaud was another surgeon and he collected at similar places. George Samul Perrottet (1793-1870) also travelled widely and collected. His collection was very large and ran to 1,500 species. Some plants were also named after him e.g., *Aeschynanthus perrottetii* A. DC. In 1834 Alphonse Delessert travelled with Perrottet. Though his main interest was collecting animals, he collected plants in Gingee, the Nilgiris and Pondicherry.

Patrick Russel also collected plants from the East Coast including Vizagpatnam between 1785 and 1793. A portion of Russel's collection went to Banks. He carried specimens and the first part of the paintings of Coromandel plants from Kakinada. He also described Sea fishes and snakes of India.

Roxburgh (1751-1815) arrived at Madras in 1776 and along with Koenig he studied the flora of the Madras coast. Roxburgh was sent to Samalcottah in 1785 from where he was ordered to proceed to Calcutta to succeed Kyd in 1793 in the Company's Garden and he left India in 1814. During his stay in India he collected and published several works particularly the plants of the Coromandal and 'Flora India' of great importance to Indian botany and also worked on plant introduction which made him Father of Indian Botany.

While at Samalcottah he not only explored the region but also found wild pepper and established an experimental plantation where a trial was made of pepper, cardamom, sapan wood, indigo and other possible crops. He had got made drawings by native artists of most of the species described by him. There are more than 2500 of them (CAL, K). Under the auspices of the Board of Directors of the East India Company and direction of Banks a selection of 300 of these drawings were published as *Plants of the Coromandel coast* comprising 3 volumes with 4 parts each; the first part appeared in 1795 and the last in 1820. About 400 of the plates in Robert Wight's *Icones plantarum Indiae orientalis* were copied from Roxburgh drawings. Roxburgh distributed specimens freely but does not appear to have kept a set for himself and it would seem that nowhere is there a complete set of his plants whose identity with species described by him is beyond question (Sealy, 1957). According to Clarke (Roxb., *Fl. Ind.* facs. ed. 1874:v) these drawings are of particular value since they can be connected with certainty with Roxburgh's description. Roxburgh's name will appear at several places in this account.

Bernhard Schmid (1787-1857) was a missionary and botanist. He arrived at Madras in 1817 and travelled the Coromandel coast collecting plants for the preparation of a Tamil-English dictionary. He also collected in the Nilgiris and Tinneveli. In all he sent over 1000 specimens to William Jackson Hooker at Kew. Some specimens from him were received at Calcutta. He also supplied material to Hohenacker.

Another collector was Frederick Adam, Governor of Madras from 1823 to 1837. During almost the same period two missionaries, Thomas Foulkes and Weigle studied the plants of the Nilgiris. They sent their specimens to W. J. Hooker. Karl Alexander A. F. Huegel (1795-1870) enriched the Vienna Herbarium with specimens from the Nilgiris, Bombay etc. in 1831. R. Baike (1857) published a guide book on the Nilgiris. In this Huegel assisted him by supplying notes on climate and vegetation while Schmid provided a list of 471 species in the Appendix. On his return to Europe in 1837, Schmid presented his dried plants to Jonathan Carl Zenker (1799-1837), Professor of Natural History in Jena, who published *Plantae Indicae: Decas* 1(1835), *Decas* 2(1836) (Stafleu & Cowan, 1988).

An indefatigable and a zealous worker that he was Robert Wight (1798-1872), the greatest accumulator of material of all (Burkill, 1965), arrived in India in 1819 at Samalcottah as a medical man of the East India Company. He was not a botanist when he came. During his spare time he studied plants and soon began sending collectors out to bring plants beyond his jurisdiction. A lithographed catalogue of plants distributed from Wight's herbarium was produced by Wight in the handwriting of Walker Arnott, a classmate and later Professor of Botany at Glasgow. The first parts of this untitled work appeared before their excellent *Prodromus* (1834) such that many of their new names were authenticated by valid publication in this catalogue (Mabberley, 1980). Many names in this catalogue are validly published although two are superfluous new names. During his 35 years of stay in India Wight described 38 new genera and more than 3000 species. His contributions include 28 publications among which *Illustrations of Indian botany* (1831-1832, 1840 & 1850), *Contributions to the botany of India* (1834), *Icones plantarum Indiae orientalis* (1838-1853) and *Spicilegium Neigherrense* (1846-1851) are very frequently consulted by botanists. By 1838 Madras had a botanical garden and Wight looked after it for some time. Wight's areas of collection were Madras, Vellore, Samalcottah, Rajamundry, Nagapatnam, Nagari hills, Sriharí Kota, Tanjore, Bellary, Coimbatore, Nilgiris, Palni hills and to the very south of the Indian peninsula. His specimens went to many like W. J. Hooker at Glasgow, Delessert in Geneva, Walker Arnott in Glasgow, and Wallich in Calcutta which like the collections of some of his predecessors like Rottler and others also sent into the making of his *Numerical list* (1828-1849). In appreciation of his work several species were named in his honour by various botanists.

Thomas Caverhill Jerdon (1811-1872) a reputed zoologist and an ornithologist in particular also collected plants in several parts of the Presidency of Madras and maintained his collections untill his death after which they were presented to Kew. The genus *Jerdonia* was named in his honour by Wight.

Among those who joined Wight was Hugh Francis Clarke Cleghorn (1820-1895) who became Professor of Botany and Materia Medica at the Madras Medical college in 1851, Conservator of Forests in 1857 and Inspector General of Forests in 1867. He collected mostly in the Madras Presidency and his specimens enriched the herbaria at Edinburgh and Calcutta. A few of his collections are also in Madras Herbarium at Coimbatore. Cleghorn's cheif interest was towards the preparation of a catalogue of indigenous and naturalized plants of the Agri-Horticultural Society's Garden at Madras, sand-binding plants of the beach at Madras, and forests and gardens of south India.

Contemporary workers of Cleghorn were many. Among them the works of J. Allardyce (1836) on the Nilgiris, B. S. Ward (1837) on the survey of the Pulney hills and Gardner (1845) on the botanical visit to Madras, Coimbatore and the Nilgiris are noteworthy.

George Bentham obtained the collections of J. F. Metz (1819-1886) from the Nilgiris through Hohenacker and furnished a list of plants belonging to the Leguminosae (1851a) and Acanthaceae (1851b). Robert N. Brown, a horticulturist, published a handbook of 968 trees and shrubs and herbaceous plants growing in the Madras Agri-Horticultural Society's Garden in 1862. Though a guide book it went into a second edition edited by John Joseph Wood (1828-1867). Jameson (1869) published a list of timber trees of the Nilgiris and Bidie (1874) dealt with the loranthaceous parasites.

Col. Richard Henry Beddome (1830-1911) joined the Madras Forest Service in 1856. He was principally a botanist and began working on the plants of the Palni hills where he was first posted. While collecting he also illustrated plants by the use of lithography. In addition to Palni he collected in the Nilgiris, Anamalais and Tirunelveli. He was a specialist in ferns and angiosperms. His prolific writing began in (1858a) with the flora and vegetable products of the Palni hills followed by the flora of the Nilgiris (1876, 1880). In addition to these, his illustrations with descriptions like *The flora sylvatica for southern India* (1869-1874) and *Icones plantarum Indiae orientalis* (1868-1874) are very important works. His other contributions on angiosperms include *Impatiens* (1858b), *Contributions to the botany of southern India* (1861-1862) etc. The genus *Beddomea* was dedicated to him by J.D. Hooker. Beddome described several new genera like *Utleria*, *Poeciloneuron*, *Octotropis* etc.

Captain Frederick Cotton, an engineer, visited the Anamalais in 1850 and was in charge of the teak plantations. He was succeded by James Michael, another army officer, who continued till 1856.

Cinchona plantation had already been established in the Nilgiris under the charge of W.G. Mc Ivor. Cleghorn was associated in the selection of the land. C.B. Clarke who visited the plantation in 1869 also made some collections. Nelson's account (1868) on the flora of Madura (in the Madura country manual) has a list of plant names supplied by Turnbull. Bidie (1880) gave a list of useful plants of the Nilgiris in *Grigg's Manual of Nilgiri* district.

James Matthew Gleason, Superintendent of the Madras Botanic Garden, gave a lengthy account (1884) of the plants grown in the garden. In 1882 Malmaduke Alexander Lawson (1840-1896), Director of the *Cinchona* undertaking at Ootacamund collected not only in the Nilgiris but also in Nagercoil, Kanyakumari and Thadikarakonum (Lawson, 1894). His specimens are in Calcutta and Madras Herbarium. Lawson later became the first Director of the Botanical Survey of India at Madras and began cataloguing the plants growing in the Presidency of Madras which included 3,295 species. The catalogue was later completed by A. G. Bourne in 1897. In 1886 Hunter briefly described the flora of Madras.

James Sykes Gamble (1847-1925) reached India in 1871 after qualifying in forestry in France. From Bengal where he was Conservator of Forests, he was sent to Madras in the same official position. He had already published *A list of the trees and shrubs found in the Darjeeling district* (1878, rev. ed., 1896) and *A manual of Indian timbers* (1881, new & rev. ed., 1902). After reaching Madras he toured extensively in the presidency and collected; the collections he maintained as a private herbarium ultimately reached Kew. A set is also present at Madras Herbarium. Gamble described several new species and some new genera like *Meteoromyrtus*, *Pseudoglochidion* etc. Several species are dedicated to him. The frist part of Gamble's *Flora of the Presidency of Madras* was published in November 1915. This included the account of Ranunculaceae to Opiliaceae consisting of 200 pages of which the first 132 pages were written by S.T. Dunn. Subsequent 7 parts of the flora were published by Gamble himself which ended with the Euphorbiaceae. The remaining 4 parts were completed by C. E. C. Fischer of the Indian Forest Service in the Presidency of Madras. The flora is acclaimed as the best regional flora of India. It was reprinted by the Botanical Survey of India in three volumes in 1957 and again in 1967. It was reprinted with original pagination by Bishen Singh and Mahendrapal Singh of Dehra Dun in 1979.

P.M. Lushington (1900) published an account on the sandal trees of southern India (also *vide* Narayanaswami, 1965). A.W. Lushington (1902) brought out an account on the flora of north Coimbatore (also *vide* Narayanaswami, 1965). He also publised a *Vernacular list of trees, shrubs and woody plants of the Presidency of Madras* in 1915. Another valuable contribution by him is *Nature and uses of Madras timbers* (1919).

Bonnier collected and published a comparison of the flora and vegetation of the Nilgiris with that of Paris (1905 a, b).

Charles Alfred Barber (1861-1933) was a great specialist on sugarcane. He became the Government Botanist and Director of the Botanical Survey of southern India in 1898. It was during his period that the Madras Herbarium was transferred from Ooty to Coimbatore where Barber was the head of the Agricultural Department as Government Sugarcane Expert. He travelled widely in the Madras Presidency and procured specimens numbering over 20,000 now housed in Madras Herbarium. He published an account of the botany of Madras in 1908.

A. Sauliere published an account of the plants of Palni (1914). He along with the other staff of the Sacred Heart College, Shenbaganur, made extensive collections in Kodaikanal.

Cecil Ernest Claude Fischer (1874-1950), entering service in India in 1895 at Madras remained in the presidency except for a brief period of teaching at the Forest College, Dehra Dun. Wight had not left any collection from the Anamalais and there is no information as to whether he collected any. Therefore, Fischer undertook a study in this area and published an account of the flora of this region in 1921. Earlier he collected in north Coimbatore and published an account in 1906. After retirement he worked at Kew (1925-1937) and completed Gamble's unfinished work of the flora of the Presidency of Madras.

E. Blatter from Bombay along with E. Hallberg studied the High Wavy mountain of Madurai district in 1917. Blatter published an account of the Orchidaceae of the area in 1928; *Chrysoglossum hallbergii* was named after Prof. Hallberg from this collection by Blatter and Mc Cann.

Butterworth (1911), Thurston (1913) and Mudaliar (1915) published accounts of the Madras flora. P. F. Fyson, Professor of Botany, Presidency College, Madras, also published an account of the Madras flora in 1918. Fyson also collected in various parts of the presidency. *Rotala fysonii* Blatt. & Hallb. was named after him. Mayurananthan (1926) recorded some weeds introduced into Madras and also published an account of the flowering plants of Madras and its neighbourhood in 1929. Viswanathan (1931) published *A handbook of systematic botany for Madras*. E. Barnes (1938) of the Madras Christian College also gave a list of additional plants of Madras city and neighbourhood. He also collected in Mettur in 1935.

The Palni hills attracted the attention of several botanists. Sauliere's work has already been mentioned. Fyson's work (1915, 1921) in this connection is very significant. Bowen (1932) and Pallithanam (1957) made observations on the Kodaikanal flora. Gupta (1960 a, b, 1962 a, b, c) in addition to the ecology of the area gave a systematic enumeration of the plants. K.M. Matthew collected in Kodaikanal for a long time. His work on the flora of Kodaikanal (1959, 1962, 1965, 1969 a) are important contributions. Matthew *et al.* (1975) gave another account on Kodaikanal and dealt with the successional aspect of the vegetation and the biological changes brought about during recent years. Information on the pine plantations at Kodaikanal was furnished by Bhadran (1962). Krishnaswamy (1950) and Wyckoff (1951) also gave information on Kodaikanal. A. Anglade, E. Bombert, G. Foreau, S. Muench, C. Montaud, R. Rodrigues etc. also collected here. Their specimens were mostly sent to Kew and elsewhere. Anglade's paintings of about 8000 plants along with useful notes are preserved at the Sacred Heart College, Shenbaganur.

In Bourdillon's *The forest trees of Travancore* (1908) and Rama Rao's *Flowering plants of Travancore* (1914), an appreciable number of plants from Kanniyakumari and Tirunelveli districts are mentioned. Rangachari (1919) brought to light the rich floristic wealth of Tirunelveli district. Mudaliar and Sunderaraj also collected in Tirunelveli district and published a paper in 1954.

The status of grasslands and sholas of the state was studied by Bor (1938) and Ranganathan (1938). Jacob (1940) collected in North and South Arcot districts and enumerated the grasses.

The flora of Annamalainagar received the attention of Pillai (1941) and Venkatesan (1951). Later, Venkatesan (1966) also studied the mangroves of Madras state. Earlier the mangroves of Pichavaram was studied by Rajagopalan (1952). Thirumalraj (1957) also dealt with the mangroves of Thanjavur district. Iyengar (1927) and S. N. Chandrasekharan *et al.* (1946) collected in the Krusadi Islands. S. N. Chandrasekaran and Lakshmanan (1950) gave an account of the trees around Coimbatore. Chandrasekharan *et al.* (1951) brought out the wild flora of the Nilgiris and its bearing on humanity. Krishnamurthy (1953) dealt with the horticultural and economic plants of the Nilgiris. Lakshmanan collected the hydrophytes of Annamalainagar and its environs around 1953. K. A. Shankarnarayan and M.Y. Dabholkar (1958, 1959) studied the flora of Pondicherry and scrub jungles of Madras State. Shankarnarayan and R. K. Gupta reported 215 species from Coimbatore district in 1959.

With the establishment of the Southern Circle of the Botanical Survey of India at Coimbatore, after its reorganization in 1955, floristic studies under its jurisdiction were intensified. N. C. Nair *et al.* (1983) highlighted some of the significant contributions from the Circle (*vide* also Nair & Nair, 1983). A bibliography and resume of the work done at the Circle after 1955 was published by Basak (1983). Over 325 research papers dealing with about 75 new taxa and 360 additional records for the area under its jurisdiction have appeared.

Subramanyam, Sebastine and their colleagues made intensive explorations in several parts such as the Vellingiri hills, Maruthamalai, Boluvampatti, Kanniyakumari, Alagar hills, Pakasura hills, Nilgiris, Singampatti, Madurai, Coimbatore, Eastern Ghats, North Arcot, Kudiramoli, Cumbum Valley, Siruvani, Parambikulam etc. (*vide* Subramanyam, 1959; Sebastine, 1959; Nayar, 1959; Subramanyam & Henry, 1959). Ramamurthy (1963) furnished an account of the vegetation of the Kudiramoli Teri in the Tirunelveli plains. Vedaranyam was explored by Sebastine and Ellis (1967), Javadi hills by Subramanyam and Henry (1967), Dharmapuri by Vajravelu and Joseph (1971) and Chandrabose from 1977 to 1979; Agastyamalai by Henry and Subramanyam (1983), and Henry and Subramanyam (1981a, b) and Mahendragiri by Sharma *et al.* (1976) and the Kalakkadu hills by Vajravelu *et al.* (1987).

Nilgiri district was intensively explored and this enabled Sharma *et al.* (1977) to bring out a comprehensive check list. Mudumalai Wildlife Sanctuary was also studied by Sharma *et al.* (1978). Collections were made in the Shevaroys by Karthikeyan in 1978. Kanniyakumari district was explored by Henry and Swaminathan (1978) and South Arcot by Ramamurthy (1978). Collections from Pareli forest were made by Vajravelu and Chandrasekharan (1978). Shetty and Vivekananthan collected in the Kundah Range towards 1970 and published an account on the endemic, primitive and relict elements in 1981. Henry and Swaminathan studied the flora of Vedanthangal Waterbird Sanctuary and Kargil Waterfowl Refuge (1981). N. C. Nair and Srinivasan made collections from Ramanathapuram district during 1977-1981 and Srinivasan continued. Joseph (1982) brought out the orchid wealth of the Nilgiris. Intensive collection of plants was made by Chandrabose from 1964 to 1970 in Coimbatore and based on this as well as of other earleir collections, *Flora of Coimbatore* was published (Chandrabose & Nair, 1988).

Scientists from other units of the Botanical Survey of India, particularly from Calcutta, also collected in Tamil Nadu during the period. K. S. Srinivasan (1960 a) from the Industrial Section of the Indian Museum studied the plants of the Hare and Church Islands. T.A. Rao and his colleagues from the Ecology Unit collected plants of the coastal region of Tamil Nadu and also of the Krusadi and Rameswaram Islands (*vide* Rao, 1971; Rao *et al.*, 1963 a, b, c). Rao (1964) reported *Ipomoea tuba* from Rameswaram and Rao *et al.* (1974) added a few unrecorded taxa from the Kanniyakumari shore.

Courtallum (Kuttalam) was a centre of attraction of botanists including Wight, Beddome, Thomson. Anderson, Stocks, Bourdillon etc. K. K. N. Nair from the Central National Herbarium, Calcutta, collected from 1973 to 1977. Based on this as well as material procured by earlier workers like Gideon Thomson (1850), T. Anderson, Stocks, Barber, Bourdillon, D. Hooper, C. C. Calder, M. S. Ramaswamy, M. Rama Rao, Venkaba Rao etc. during the first half of the 19th century, and Subramanyam during 1957-1958, K. K. N. Nair and M. P. Nayar published Flora of Courtallum in two volumes in 1986 and 1987.

Nair and Henry edited the first volume of *Flora of Tamil Nadu* in 1983 followed by two more volumes edited by Henry, Kumari and Chithra (1987) and Henry, Chithra and Balakrishnan (1989). Daniel (1980) and his associates (Daniel *et al.*, 1983, 1988; Daniel & Rajendran 1989, 1992) made a detailed study of some rare plants.

Workers other than those of the Botanical Survey of India were also engaged in floristic work during the same period. Kasinathan (1956) studied the vegetation of the fresh water swamp of Uthangal in South Arcot district. Govindarajulu continued the work of Fyson in Presidency College. His chief interest was Cyperaceae and described several new taxa in the family. Swamy and Govindarajulu (1956) worked on the flora of Courtallam. Govindarajulu and Swamy (1956, 1958) collected in Mundanthurai. Sakharam Rao (1957a) Sugarcane Breeding Institute, Coimbatore, collected in Adayar. He also procured grasses from Coimbatore district (1957 b).

The flora of Maruthuvamalai was worked out by Lawrence (1959, 1960). The Hare and Chruch Islands were explored by Sunderaraj and Nagarajan (1964). They also surveyed some other parts (1966, 1969) of south India. Subramanian (1966 a) of the Forest College, Coimbatore, collected in Boluvampatti and Subramanian and Kalyani (1977) in the Bhimbam Ghats. A pictorial flora of Courtallam was published by Arachi (1968) of St. Xavier's College, Palayankottai. Workers of the French Institute, Pondicherry have been studying various aspects of the vegetation of peninsular India under the leadership of Meher-Homji and Blasco. Their approach is chiefly ecological (Meher-Homji, 1969, 1975; Blasco, 1971).

Balasubramanian (1972) recorded some noteworthy plants of the Nilgiris and Palni hills. Samaraj dealt with the trees of the Nilgiris. Krishnamurthy *et al.* (1978) collected in Theerthamalai.

A centre of intensive activity is the Rapinat Herbarium, Tiruchirapally. Fr. K. M. Matthew and his colleagues have added much to our knowledge of the plants of this part of Tamil Nadu. They explored the districts of Dharmapuri, Pudukkottai, Salem, South Arcot and Tiruchirapally from 1975 to 1981 and Matthew brought out *Materials for a flora of Tamilnadu Carnatic (1981), Illustrations on the flora of the Tamilnadu Carnatic (1982), Flora of Tamilnadu*

Carnatic (1983) and *Further illustrations on the flora of Tamilnadu Carnatic* (1988).

Senthilkumar and Krishnamurthy (1989) of the Bharathidasan University, Tiruchirapally explored and studied the floristic ecology of the Shevaroys.

Kerala

As pointed out earlier Kerala was known outside India right from very ancient times. In addition to the plant products already mentioned, teak was another important item from the coast of Malabar carried to the Euphrates at least as early as 800 B.C. How did it reach there?. Must have been by ships and ship building flourished on the West Coast till the end of the 18th century A.D.

Mention has already been made of van Rheede and his *Hortus Indicus Malabaricus*. After the stimulating study of van Rheede and his fellow workers, there was a lull in the study of plants of the Kerala coast for a long time possibly due to something wrong in the attraction of the utility of plants. Paul Hermann (1646-1695) of Leiden had contacts with van Rheede. He visited Kollam (Quilon) and Kochi (Cochin) in 1675. It is probable that Linnaeus also received Hermann's specimens.

Francis Buchanan-Hamilton (1672-1829) after his mission in Burma was sent to make an economic survey of south India in 1800 to report on agriculture, cattle farms, the natural resources like cotton, pepper, sandalwood, cardamom, vegetables etc. In this connection he visited Malabar in 1801 and published his report in three volumes in 1803. He also collected plants. Buchanan-Hamilton was a good field botanist. He described 12 new genera. The genus *Buchanania* Spreng. and several species like *Clematis buchanania* were named in his honour.

Robert Wight collected in Kollam and Thiruvananthapuram (Trivandrum) districts towards middle of the 19th century. He also procured material from Palakkad (Palghat) district, sporadically between 1844 and 1848. General William Cullen who was residing in Travancore also collected at about the same time. The genus *Cullenia* was named by Wight after him. Cullen's collections formed the basis for the publication of Drury (1858, 1866). Cleghorn collected in Palghat distirct from 1852 to 1859. Alfred Augustus Davidson collected in Kerala and presented his specimens to Kew in 1883. Rev. E. Johnson was a resident in Travancore. He published a list of orchids (*Madras J. Lit. Sci.* 19: 215-220, 1858). Beddome collected in Kollam, Idukki and Palakkad districts in 1864, 1865 and 1873. M.A. Lawson from Madras made a brief visit to Travancore and collected in 1893. He also collected in Palakkad and Wynaad. T. F. Bourdillon was the first Conservator of Forests, Travancore. He was earlier planting coffee. He collected extensively from 1871 onwards and published his book entitled *The forest trees of Travancore* in 1908. His specimens were sent to Kew and Calcutta. Part of his collection is also preserved at the University College and Tropical Botanic Garden and Research Institute, Thiruvananthapuram and Madras Herbarium, Coimbatore. M. Rama Rao succeeded Bourdillon as Conservator of Forests, Travancore and he collected from 1908 onwards. His book on the *Flowering plants of Travancore* published in 1914 is based on these collections as well as those of Bourdillon. Rama Rao listed 3535 plants in his book. C. A. Barber collected in Travancore in 1895 and 1904. He also procured specimens from Malabar. Venkoba Rao collected From variuos parts of Kerala from 1913 to 1915. C. E. C. Fischer collected Palakkad district from 1914 to 1916. Raju and Ratnavelu collected in Palakkad district in 1929. Aiyar (1932) described the sholas of Palakkad. V. Narayanaswami from Calcutta collected in certain parts of Kerala at about the same time.

The "surpassingly grand and incomparably beautiful" (Hamilton, 1892) High Range of Kerala was intensively explored by Barnes of the Madras Christian College in 1933 and published an account of the Geraniaceae of the area (Barnes, 1939). He observed that 12 species of *Impatiens* are endemic to the High Range. The botanical richness of the tract is very clear from the fact that based on Barnes' collection 7 new species were described such as *Habenaria flabelliformis* Summerh., *Impatiens anaimudica* C. E. C. Fischer, *I. coelotropis* C. E. C. Fischer, *I. pandata* Barnes, *I. platyadena* C. E. C. Fischer, *Isachne fischeri* Bor and *Sonerila nemakadensis* C. E. C. Fischer. Subsequently new taxa were discovered from the area by Shetty and Vivekananthan (1968, 1969, 1970, 1973, 1975) and Sharma *et al.* (1974). K. C. Jacob, Gopal Rao and Rangachari, all from the Madras Herbarium, collected in various parts of Kerala. At the time of the reorganization of the Botanical Survey of India and establishment of the Western Circle at Pune in 1956 Kerala was under the jurisdiction of that Circle. G. S. Puri and his colleagues from this Circle procured plants between 1956 and 1959 (*vide* also Puri *et al.*, 1959). Kammathy while working on the Commelinaceae of India made collections in Kerala.

Several workers from the Southern Circle (after Kerala was attached to the Circle) collected in the southern and central parts of Kerala and published several papers (*vide* Basak, 1983). During 1965-1967 J. L. Ellis made a survey of some portions of north Kerala (Ellis *et al.*, 1968). This was followed by V. S. Ramachandran's collection in the entire present Kannoor (Cannanore) district till 1985 and Ramachandran and V. J. Nair (1988) published the *Flora of Cannanore.* Vajravelu, Joseph and Chandrasekharan explored Palakkaad district from 1965 onwards (Vajravelu *et al.*, 1968) and Vajravelu (1990) published the *Flora of Palghat* which also includes the Silent Valley National Park. The Silent Valley was also explored by N. C. Nair accompained by Bhargavan from 1978 to 1983 and they published a note on rare and little known plants from the area in 1982. V. J. Nair also collected in the Silent Valley. Bhargavan and C. N. Mohanan discovered a new orchid, *Porpax chandrasekharanii* (*Curr. Sci.* 51: 1. 1982) which was named after N. C. Nair. V. J. Nair *et al.* (1982) described a new primitive genus *Silentvalleya*. Vajravelu *et al.* discovered a new species, *Hedyotis silentvalleyensis*, in 1988. R. Ansari collected in Kasargod district from 1978 to 1984 and the flora of this district is being brought out. Joseph also collected in the Silent Valley and Joseph *et al.* (1979) recorded *Burmannia championii* Thw. Joseph and V. Chandrasekharan explored Bonacord and the Neyyar Wildlife Sanctuary and neighbourhood and discovered a new genus *Janakia* which was named after E. K. Janaki Ammal (1978). They also (1973) discovered some other new taxa.

Sreekumar explored extensively for grasses. Based on his collections as well as those of earlier workers Sreekumar and V. J. Nair (1991) published the grass flora. Several new species of grasses (N. C. Nair, Sreekumar & V. J. Nair, 1984 ; N. C. Nair & Sreekumar, 1985; Sreekumar, V. J. Nair & N. C. Nair, 1983 a, b, c ; Sreekumar, V. J. Nair & N. C. Nair, 1985 a, b) have been described. V. J. Nair and Sreekumar also described a new genus *Chandrasekharania* in honour of N. C. Nair.

K. Ramamurthy and R. Rajan explored Trichur district and described some new taxa. N. C. Nair, C. N. Mohanan, A. G. Pandurangan and V. S. Raju made intensive collections in the Idukki Hydro-electric Project area and its neighbourhood and rediscovered several threatened plants (Mohanan *et al.*, 1984; Pandurangan *et al.*, 1985). N. C. Nair, Sreekumar and V. J. Nair reported eight rare species from Kottayam and Alleppey districts. T. A. Rao from Calcutta studied the maritime flora of Kerala in 1971.

Workers from other institutions also collected in various parts of Kerala. Thomas (1962, 1976) surveyed Veli and studied the aquatic vegetation of Thiruvananthapuram. V. Nair of Victoria College, Palakkad, collected in several places. N. Ravi of S. N. College, Kollam, collected in Ponmudi and places round about Kollam. Stray collections from various parts of Kerala by students are housed in the herbarium of the University College, Thiruvananthapuram. Abraham and Vatsala collected orchids (1981). Fr. Kadavil and Antony of S. B. College, Changanacherry, collected in Kottayam district from 1984 to 1988. A duplicate set of their collection is present at MH. They collected *Annona glabra* L. and *Cordia cylindristachya* Roem. & Schult., both new records to India.

The members of the staff of the Calicut University have taken up the collection of plants in the northern parts of Kerala. Manilal and Sivarajan published the *Flora of Calicut* (1982) covering the western sectors of Calicut and Malappuram districts. P. Mathew and A. Abu also collected in Malappuram district from 1977 to 1990. Manilal (1988) published the *Flora of Silent Valley*. Sivadasan and Balakrishnan collected in Wynaad district from 1984 to 1987. Sivarajan and

Ahmed Kunju have been collecting in Ernakulam district since 1970. Suresh collected in the areas covered by van Rheede in *Hortus Malabaricus*. Swarupanandan collected members of the Asclepiadaceae from several parts of Kerala.

The Kerala Forest Research Institute, Peechi, has been another centre of activity. V. P. K. Nambiar, N. Sasidharan, N. G. Nair, K. K. N. Nair, K. Balasubramanyan and Mukteshkumar collected in various places. Renuka concentrated on *Calamus*.

Scientists attached to the Tropical Botanical Garden and Research Institute, Thiruvananthapuram, have also been making collections. N. Mohanan and C. Satishkumar obtained material from Agasthyamalai.

Lakshadweep (Laccadives) and Minicoy

D. Prain (1890) published a list of plants of the Lakshadweep. This was followed by a few natural history notes (1892-1894). Willis (1901) published a note on the flora of Minicoy. Srinivasan of the Indian Museum collected in the Lakshadweep and Minicoy. Later, Wadhwa of the Botanical Survey of India, Western Circle, Pune, also collected in these islands and published a paper in 1961. Sivadasan and K. T. Joseph from the Calicut University collected in the Lakshadweep in 1978.

Karnataka

Towards the close of the 18th century Rottler obtained some plants from Coorg through some collector. Benjamin Heyne arrived at the Danish settlement of Tharangampadi in the company of John Gotfreid Klein and held the post vacated by Koenig till 1819. He travelled extensively and collected. In 1800 Heyne took charge of the Lal Bagh Gardens in Bangalore. He procured plants from the southern parts of interior Karnataka up to 1812 when he returned to Europe. Heyne published an account of his travels in 1814. His collections formed a major part in Roth's *Novae plantarum species* (1821). Of the 430 species enumerated by Roth 200 have the names given by Heyne and 104 of these are for plants from Karnataka. Heyne returned to Karnataka and resumed collecting about 1816. Roxburgh named the genus *Heynea* in his honour. Heyne's specimens are a part of "Herbarium Rottlerianum", formerly at King's College, London, and now at Kew, also at B-W and LIV.

Buchanan-Hamilton's report on his tour to southern India has already been mentioned under Kerala. He visited parts of Canara, Kodagu (Coorg) and Mysore during 1800-1801. His specimens were lost in transit. Some specimens which could be salvaged were handed over to James Edward Smith who made some use of them in his *Exotic Botany* (1804-1805). David White, a surgeon, published an account of cardamom cultivated along the Western Ghats in 1811 (*Trans. Linn. Soc., Bot.* 10: 228).

Rudolph Friedrich Hohenacker (1798-1874) wanted someone to collect in the area where van Rheede's specimens were obtained for *Hortus Malabaricus*. In this connection he contacted a missionary F. Metz of the Basal Mission and resident of Mangalore who instead of collecting in Cochin and surrounding areas collected in south Karnataka including Mercara (Coorg). Hohenacker distributed Metz's specimens from 1847 to 1858.

William Munro (1818-1880), an army captain who later became a general, began collecting in Kodagu in 1834. While returning to London he took with him the large collection of plants for critical study with the help of Bentham. He also sent specimens to Wight and Griffith. Wight named *Clematis munroana* and *Impatiens munronii* after this general. With Munro was collecting George Stevens Gough. Another was Thomas Lobb, an employee of the horticultural firm of Veitch who procured showy plants from the Western Ghats and Mysore.

The northern parts of Karnataka, formerly in the Presidency of Bombay, were explored by botanists stationed at Bombay. David Ritchie collected in north Karnataka and Belgaum from 1850 to 1853. J. S. Law and J. E. Stocks also collected in these areas as well as the Bababudan Range. Another collector of the Bababudan Range and north Karnataka was W. A. Talbot. The material procured by him from 1882 to 1896 are at Pune and Kew. Cooke's flora (1901-1908) as well as W. A. Talbot's forest flora (1909-1911) covered the northern districts of Karnataka including Belgaum, Dharwar and Bijapur. Northern Karnataka was also covered in Talbot's account published in 1902.

J. Cameron who was superintendent of the botanical garden published a catalogue of plants of the Bangalore Botanical Garden and its vicinity in 1880. He also brought out the *Forest flora of Mysore and Coorg* in 1894. Earlier, van Someran gave a list of *Forest trees of Mysore and Coorg* in 1879 and E. P. Lovery prepared a *Catalogue of forest trees of Shimoga district* in 1888. Bellary, South Canara and Coorg were part of the erstwhile Presidency of Madras and British botanists attached to the presidency such as Beddome, Lawson and Gamble made collections in these districts towards the close of the 19th century and most of the material was reported in Hooker's Flora of British India and Gamble's Flora of the Pesidensy of Madras.

C. A. Barber of the Botanical Survey of India (of southern India) made several collection trips to South Canara, Hassan and Coorg districts. His specimens are at Coimbatore and Kew. A. Meebold, an Austrian botanist, visited the Bababudan hills, Hassan and Coorg in 1908 and 1909. He gave an account of Mysore plants in 1909. Several interesting taxa were described from Meebold's collections. The only specimen of *Viscum mysorense* Gamble was collected by Meebold near Arsikere. Meebold's specimens in part are at Kew and they served Hooker in his study of the genus *Impatiens*. C. E. C. Fischer collected in the Biligirirangan hills from 1905 to 1907. E. J. Blatter reported on Fischer's material (*J. Bombay Nat. Hist. Soc.* 18: 390-429. 1908) as a contribution to the flora of north Coimbatore. Biligirirangan hills was also explored by E. Barnes in 1939-1943 and he published a paper in 1944. Thirumalachar *et al.* (1949) explored the Nandi hills.

B. A. Razi made collections in Mysore and published an account of its flora in 1946. This was followed by a number of papers published during a span of more than three decades. Ramaswamy (1965) explored Ramagiri and enumerated 340 species. Ramaswamy and Razi (1973) published the *Flora of Bangalore district*. R. R. Rao collected in the Chamundi hills, and Rao and Razi (1973-1974) enumerated 459 species. Rao and Razi also (1981) published *Synoptic flora of Mysore district*. Yoganarasimhan, Subramanyam and Razi (1988) published *Flora of Chikmagalur*. Bhaskar collected *Impatiens* from various parts and Bhaskar and Razi published a few papers (1978 a, b). Raizada, Arora and Wadhwa published the botany of Chickmagalur (*Indian J. For.* 2: 336-349. 1979). Arora, Wadhwa and Raizada also published a booklet, *The botany of South Canara district* (1981). Arora collected in Coorg and North Canara in the 1960s and published several papers (*vide* Karthikeyan *et al.* 1981) which have been given due importance by Champion and Seth (1968). Khan's (1953) *Forest flora of Hyderabad state* included part of Karnataka.

Saldanha and his assoiates at Bangalore collected in Hassan district from 1965 to 1971 which formed the basis for the *Flora of Hassan district* (Saldanha & Nicolson, 1976). Saldanha (1984) also published *Flora of Karnataka*. Yoganarasimhan *et al.* (1982) made medico-botanical collections from Tumkur district.

After the reorganization of the Botancial Survey of India the Western Circle at Pune is in charge of Karnataka. Scientists from this Circle collected in various parts of Karnataka. G. S. Puri, S. K. Jain, R. S. Rao and A. S. Rao took the lead. A. S. Rao collected in Coorg and Jain in Konkan. Naithani (1966) surveyed the flora of Bandipur. Based on the collections of Barnes, K. N. Subramanian (1966 b) published an interesting paper on the flora of the Biligirirangan hills. R.S. Rao and Sastry studied the flora of Devarayadurga forest. R. S. Raghavan made extensive collections in Agumbe and Thirthahalli areas of Shimoga district. Singh *et al.* (1976) gave an account of the Poaceae of

Karnataka. Singh also collected in eastern Karnata districts such as Bidar, Gulburga, Bijapur, Raichur, Bellary, Chitradurg, Tumkur and Kolar and published in two volumes *Flora of eastern Karnataka* in 1988 comprising 1265 species.

Andhra Pradesh

Roxburgh pioneered a survey of the Coast of Coromandel and gave a vivid account of the plants of Rajamundry, Samalcottah, Tuni and Visakhapatnam in his *Plants of the Coast of Coromandel*. When he moved over to Calcutta, Heyne took over the work of Roxburgh at Samalcottah in directing the experimental station. Heyne travelled widely in search of plants. As mentioned earlier, after 20 years of collecting he returned to London with duplicates of his specimens where he had access to Bank's collections to compare with. Ultimately Heyne's specimens reached A.W. Roth. In Roth's *Novae plantarum species* Heyne's collections from Andhra Pradesh are also included. R. Wight also collected about Samalcottah, Rajamundry etc. John Campbell, an army officer, collected in some parts of Andhra Pradesh particularly in the Circars and Hyderabad during 1835-1837 and sent the material to Wight. Another collector was T. C. Jerdon (1811-1872). He was mainly a zoologist who collected plants also. Jerdon's collections are at Kew.

The East India Company realizing the importance of educating the public organized an exhibition for the first time in India at Madras. One of the results of the exhibition was *Flora Andhrica* by W. Elliot (1859) who was stationed at Visakhapatnam. In this work both botanical and vernacular names are incorporated. Elliot's work is mainly based on that of Roxburgh.

Other important collectors were Beddome, Barber, Calder, Fischer, Gamble, Jacob, Lushington, Narayanaswami, Ramaswamy, Rangachari, Tadulinga Mudaliar etc. E. A. Patridge (1911) published the *Forest flora of Nizam's Dominion*. Sayeed-ud-Din from Hyderabad collected in the former Hyderabad state and published a few papers (1935, 1938, 1941). Venkateswarlu (1944) explored the estuarial flora of Godavari and listed 25 species. He also collected in the estuary of Kristna (1946) and enumerated 21 species, their uses and vernacular names. Suxena collected in Hyderabad state and published an account of some grasses in 1946. R. S. Rao visited Rupma and the Gudem Agency in 1947 and 1949 and published an account in 1958 and listed some new records in 1964. Wagh explored some parts of Andhra Pradesh from 1956 to 1961. Shareefuddin (1951) published a *Forest flora of Hyderabad state*. Khan (1953) published another Forest flora of Hyderabad as an enlarged edition of Patridge's Forest flora and enumerated 557 species. Naidu *et al.* explored the Tirupathi hills and published a few papers (1967, 1969, 1971). Subba Rao and Kumari collected in Karimnagar and published a paper (1967a). S. L. Kapoor and L. D. Kapoor (1973) also explored Karimnagar district and added 66 taxa to the list of Subba Rao and Kumari. Seshavatharam (1974) studied the aquatic flora of West Godavari. C. Ramachandran *et al.* (1976) also studied the aquatic flora and vegetation. V. S. Raju, P. N. Rao, S. Sudhakar, B. Suryanarayana, T. Pulliah and his associates, N. Ramayya, T. Rajagopal, M. R. Uppuluri and Satyavathi, all from universities and associated colleges explored some parts of Andhra Pradesh. P. N. Rao, Raju and R. S. Rao (1981) reviewed the floristic research in Andhra Pradesh. Venkateswarlu, Bhairavamurthi and P. N. Rao collected in Visakhapatnam and published a flora in 1972. Pulliah and Yesoda (1989) published the *Flora of Anantapur district*. The floras of Adilabad by Pulliah *et al.* and Nizamabad by Pulliah and B. R. P. Rao are in press.

The work of Subba Rao and Kumari of the Southern Circle of the Botanical Survey of India in Karimnagar district has already been mentioned. Others from the Circle have also undertaken collection tours to various parts. Sebastine, Thothathri and Balakrishnan (1960) gave an account of the flora of Narsapur and listed 268 species. Thothathri collected in Nagarjunakonda and published a paper in 1964. Balakrishnan explored the Tirupathi hills, and Subramaniam and Balakrishnan (1960) described *Pimpinella tirupatiensis*. Balakrishnan and Hajra also explored the Araku area in 1960-61 and described *Argyria arakuensis* (1961). Sebastine and Henry (1966) collected in Warangal district. Ellis explored Seshachalam (1966) and Nallamalai (1968). He also published a book on the *Flora of Nallamalais* (1987, 1990). Subba Rao collected in Visakhapatnam and East Godavari districts and reported (1967 b, 1972) several new records. Ramamurthy collected seagrasses along the Andhra coast in 1989. D. C. S. Raju collected in the Polavaram Agency tracts (1966 a), Papihill (1966 b) and Simhachalam (1966 c). He also collected in the Godavari region. T. A. Rao and Sastry collected in the coastal regions.

Goa, Diu, Daman, Dadra and Nagarhaveli

Garcia de Orta's *Coloquios* has been already mentioned. After its publication not much work was done in any of the Portuguese colonies till Manoel Galvavo da Silva began collecting. In 1862 he published *Observacoes Solre a historia natural de Goa* from Nova-Goa (Panaji) which provides a list of 163 species. In 1894 D. G. Dalgado published from Bombay *Classificacao botanica das plantas e drogas descriptas nos Coloquios da India de Garcia d'Orta*. His *Flora de Goa e Savantvadi* was published in Lisbon in 1898. Murmugao was explored by Cooke, Talbot, Kanitkar, Bhide and Bhiwa. Their collections are at Pune. Bhide's specimens from Daman are also there. R.S. Rao collected in the former Portuguese colonies from 1962 onwards. His specimens are also at Pune. He studied all available earlier collections as well as his own and published the *Flora of Goa* in 1985. Raghavan, Singh, Kanodia and Cherian are other recent collectors who procured plants from Goa. M.Y. Ansari collected in Nagarhaveli.

T. A. Rao and K. R. Agarwal from Calcutta collected in the Diu Island (1964).

Maharashtra

The British East India Company got permission from Emperor Jahangir to establish a factory in Surat which remained their headquarters till 1672 when it was transferred to Bombay. Initially the presidency was confined to the island of Bombay. But later during the time of Marquess of Hastings paramountcy of the British was established over the entire Maratha empire which came to be known as the Presidency of Bombay which also included the Province of Sind, now in Pakistan. The predominantly Marathi speaking state came into being in 1960.

Joseph Nimmo was a clerk in Surat in 1819 and later came to Bombay to join the Agri-horticultural Society. He was managing the botanical garden at Bombay. Nimmo collected specimens and sent them to W. J. Hooker.

In 1825 Alexander Gibson was appointed a vaccinator of Bombay who in 1847 became the Conservator of Forests. He was a good collector and had close contact with John Graham (1805-1839) who wanted to prepare a flora of Bombay. He moved to Pune (Poona) and took charge of the botanical garden at Dapuri from where he published a report on teak (*Trans. Bombay Agri-Hort. Soc.* 1840) which was followed by reports on senna and tobacco.

In 1826 John Sutherland Law (1810-1885) came to Bombay in the administrative service. He collected plants in Bombay, Belgaum and Dharwar.

Graham joined as Deputy Postmaster of Bombay. He collected in Khandala and other regions of the ghats and procured about 1500 species. Part of his collections went to Oxford and the rest to Kew.

Charles Lush (1797-1845), a surgeon, had a botanical garden at Pune. Another botanically minded medical man was Heddle of Bombay. It was through the collaboration of all who have been mentioned above that Graham and Nimmo could publish *A catalouge of plants growing in Bombay and its vicinity* (1839). This work mostly depended on Wight and Arnott's *Prodromus*.

William Henry Sykes (1790-1872), an army officer and a zoologist, collected plants in Pune from 1824 to 1831 and sent them to the Linnaean Society at London. These specimens were consulted by Gibson. They ultimately reached von Heuckx at Antwerp.

The specimens collected by P. J. Noton in Bombay reached Wallich. Jacquemont reached Pune from Delhi in 1832 and then to Salsette and Bombay. Along the way he collected extensively and his specimens are now at Paris. Jacquemont's collections were not included in the list of Graham and Nimmo.

An officer of the Austrian army Karl Alexander A. F. von Huegel (1795-1870) and his companion Polydore Rouxe from Marseilles procured specimens from botanists at Bombay besides collecting by themselves. Their material is now at Vienna.

When Graham was the Conservator of Forests, he got the assistance of Nicol Alexander Dalzell (1817-1878). Dalzell came to Bombay in 1841 and on appointment in the Custom House began collecting plants. Later he joined the forest department when he prepared short descriptions of the plants in Graham's *Catalouge* and thus came out the *Flora of Bombay* by Dalzell and Gibson in 1861. Gibson's herbarium was given to Calcutta. John Ellerton Stocks (1822-1854) came to Bombay in 1847 as a vaccinator. In 1852 he acted as the Conservator of Forests and collected plants which he took to Kew in 1853 for further study. He died in 1854 before working out his material. A set of his specimens was sent to Boissier at Geneva who was working on his *Flora Orientalis* (1867-1884). He described Stock's plants.

When Gibson retired in 1860, Dalzell became the Conservator of Forests and he was succeeded by Ere Champion de Crepigny (1821-1896). He was also the Superintendent of the Dapuri Garden and collected in the adjoining areas of Pune. His collections are at Manchester.

Another collector was a surgeon of Bombay D. Richtie (1809-1866) who collected in south Maharashtra, Bombay, central India and the Punjab during 1831 to 1866. His herbarium of large number of plants was passed on to the Royal Botanic Garden, Edinburgh. Almost at the same time two others also collected plants. The first was Herbert John Giraud, a teacher at the Grand Medical College. He reached India in 1842. The second was Bernard Kasper Kamphooven, a Danish botanist, who visited the Bombay Presidency in 1845. The latter's specimens are at Copenhagen with duplicates at Kiel.

George Christopher Molesworth Birdwood (1832-1917), a medical man and secretary of the Agri-Horticultural Society of Bombay, played a leading part in the making of a museum in the Victoria Park. He has to his credit a *Catalouge of economic products of Bombay* (1862). Herbert Mills Birdwood (1837-1907) was his younger brother who reached Bombay in 1858 and became a judge. *Flora of Matheran and Mahabaleshwar* was written by him.

Theodore Cooke (1836-1910) arrived in India in 1860 as a railway engineer and later became the Principal of the Civil Engineering College at Pune. He was also attached to the Agricultural College from where he studied the plants of the Bombay Presidency. He could also examine the collections of D. Ritchie, G. M. Woodrow, J. E. Stocks, J. S. Law, N. A. Dalzell, A. Gibson, P. S. Kanilkar, L. D. Garade etc. which had been deposited in his college. In 1891 Cooke established a Botanical Survey of Bombay as a part of the large Botanical Survey of India. Cooke published the first volume of The *flora of Presidency of Bombay* in 1901 and the second volume in 1908. These volumes were reprinted with some corrections in 1958 by the Botanical Survey of India. Cooke's flora also covered Sind, Gujarat and north Karnataka.

A. K. Nairne collected in Concan and the Deccan. His specimens went to Kew. In 1894, Nairne published *The flowering plants of western India.*

When Cooke retired in 1893 George Marshals Woodrow (1846-1911) who was in charge of the Gheneshkind Experimental Garden became the Director of the local chapter of the Botanical Survey and continued till 1899. He collected widely and published a series of papers on the flora of western India from 1897 to 1903 (*vide* Narayanaswami, 1965).

Contemporaneously William Alexander Talbot (1847-1917) who spent his whole life in the presidency after reaching India in 1875 collected largely in the southern part of the presidency. He published *Systematic list of the trees, shrubs and woody climbers of the Bombay Presidency* (1894), and followed it by a richly illustrated work entitled *Forest flora of the Bombay Presidency and Sind* in two volumes (1901, 1911). Like Cooke's flora Talbot's work also covered areas now in Pakistan.

I. H. Burkill (1910) made some observations on flora of the erstwhile Central Provinces and Berar. D. C. Witt (1908, 1916) and Haines (1912-1914) prepared lists of trees shrubs and other plants of economic importance of the former Central Provinces. R. J. D. Graham (1911) collected in Nagpur and Telinkheri. He also visited Ramtek in 1913. According to him the area furnished the meeting place of the western Indian flora and the eastern Indian or Bengal flora. Graham (1931) also published a list of grasses and sedges of Nagpur and Telinkheri farms. George Alexander Gammie (1864-1935) who was posted in Pune as Economic Botanist collected in this region.

The next botanical period in Maharashtra was led by Rev. Ethelbert Blatter (1877-1934), a Swiss, who did a great deal of field work. He was the Chairman of the Biology Department, St. Xavier's College, Bombay. He published a number of papers along with his colleagues and friends. A number of species are dedicated to him e.g., *Dimeria blatteri* Bor. Those who collected with him were Charles Mc Cann of the Bombay Natural History Society, T. S. Sabnis, Economic Botanist of Bombay, F. F. Hallberg, Professor of Botany and J. Fernandes. R. K. Bhide of the Poona Agricultural College plants also collected. The genus *Bhidea* Stapf ex Bor was named after him. The collections of all of them are at Blatter Herbarium, Bombay. Some are at Calcutta as well as Kew. J. F. R. D.'Almeida (1891-1949) who succeeded Blatter and kept alive the high traditions of the latter collected in various parts of the Bombay Presidency. A. P. Sagreiya (1938) gave a list of common trees of the Central Provinces and Berar.

The next botanist to dominate in Maharashtra was Rev. Hermenegild Santapau, a Spanish Jesuit priest who later became an Indian citizen. First he was attached to St. Xaviers College, Bombay. Later he became the Director of the Botanical Survey of India after its reorganization. Those who collected with him include P. V. Bole, G. L. Shah, N. A. Irani, A. J. Randeria, Y. Merchant, R. R. Fernandez, C. J. Saldanha, Z. Kapadia, S. K. Wagh etc. Santapau's (1953a) *flora of Khandala* went into three editions between 1953 and 1967. The specimens of Santapau and his fellow workers are at Blatter Herbarium.

Mahajan and Divan of Shiwaji University collected in Kolhapur district and published a paper (1968). Pataskar and Ahuja (1970), Pataskar and Kulkarni (1976), Pataskar and Moorthy (1970) reported new records. Pardeshi and Pokle (1974), and Tilak (1963) published some papers on the flora of Aurangabad.

Salsette Island was intensively studied by G. L. Shah. Chavan *et al.* (1973) studied the flora of Satara district. From 1952 onwards M. V. Mirashi collected in Nagpur and surrounding areas. U. R. Nafdey, V. P. Donde and S. A. Paradkar collected along with Mirashi and published a number of papers. Navalkar (1956) collected halophytes in Bombay and the Salsette Island. Balapure (1966, 1971a) explored Berar and Ramtek. Kapoor collected in 1959 and reported *Rhynchospora longisetis*. Patel (1968) worked out *the flora of Melghat*. B. D. Deshpande and M. B. Deshpande (1963) studied the flora of Chandmari hillocks of Wardha. Tilak (1963) published the *Flora of Aurangabad*. Ugemuge collcted in Nagpur from 1969 to 1979 and published the *Flora of Nagpur* in 1986. V. D. Vartak collected in Pune, Kolaba and Gomantak. He published a list of 1620 species under the title *Enumeration of plants from Gomantak, India* (1966). Vartak also concentrated on the sacred groves of Maharashtra. V. N. Naik collected in Osmanabad, Aurangabad and neighbouring areas from 1962 onwards and published the *Flora of Osmanabad* in 1979. Earlier, the area around Aurangabad and Osmanabad was explored by Bradley, a surgeon in the 8th regiment of the Hyderabad Nizam's infantry. Hippalgaonkar (1972) added some new records to Aurangabad. The forest flora of Patridge (1911) also covers Osmanabad and Aurangabad. Paturkar (1980) published the *Grasses of Marathwada*. Jagtap also collected in Marathwada and enumerated 203 species (1966, 1967). S. M. Almeida studied the flora of Savantwadi from 1976 to 1983 and published its flora in 1990. Her specimens are at Blatter Herbarium and Pune.

After the establishment of the Western Circle of the Botanical Survey of India at Pune significant collections were made from various parts of Maharashtra by

G. S. Puri, S. K. Jain, R. P. Patil, R. S. Rao, A. S. Rao, S. M. Karmaarkar, R. S. Raghavan, K. V. Billore, K. Hemadri, K. N. Subramanian, K. P. Janardhanan, P. J. Cherian, B. D. Sharma, B. G. Kulkarni, S. Karthikeyan, R. D. Pataskar, S. K. Malhotra, S. Moorthy, K.M. Rao etc. Billore and Hemadri collected in Harishchandragarh (1972) and enumerated 330 species. Hemadri also added 7 additions to Maharashtra. Venkatareddi explored Sakarpathar and Ambavane in Pune district (1971, 1972). Deshpande and Singh (1986) brought out the grasses of the state. Kamble and Pradhan collected from 1964 to 1971 in Akola district and published its flora in 1988, whereas Kulkarni (1988) brought out *the flora of Sindhudurg*. Lakshminarasimhan and Sharma worked out *the flora of Nasik district* (1991).

Gujarat

The Portuguese traveller S. Barbosa recorded that Surat was a large and important port in 1510. By the close of the 16th century this became a Portuguese colony and remained so till 1612. Olof Toren (1718-1753) visited Śurat and took seeds to Linnaeus. Sonnerat, the French zoologist, collected plants also in Surat around 1782 and his specimens are at Paris. In 1787 Banks sent a Polish surgeon, Anton Pantaleon Hove, to Bombay and from where to Ahmedabad to collect plants for the Kew Gardens. Burkill (1965) stated "And a diary which he kept and made over to Banks, discovered among Bank's effects long after his death was printed in 1855 as *Tours made in Guzerat, Kathiawar and the Concans in 1787 88*. Nimmo was a good collector and was in Surat in 1819. He sent specimens to W. J. Hooker. Gibson collected in Gujarat and had a good knowledge of the plants of the region as is evident from his general sketch of the Province of Gujarat (*Trans. Med. Soc. Bombay* 1: 1-40. 1838). C. T. Palin (1880) published a list of plants from Kutch. Cooke's flora (1901, 1908) covered Gujarat also. He examined all earlier collections available at Kew. Sedgwick's account (1908) of the Cyperaceae of the Bombay Presidency includes species from Gujarat as well. He also published (1914) *a list of grasses from Ahmedabad and Surat*. Blatter (1908 b) wrote on the *flora of Kutch*. He also collected in other areas. W.T. Saxton and Sedgwick explored north Gujarat and gave an account in 1918. Saxton (1922) also published an additional note. J. Indraji Thaker collected in the Barda mountains in 1910 and published an account of the plants of Kutch and their utility in Gujarati in 1926. Santapau and D'Cruz (1952) gave an account of his collections present in the herbarium of the Agricultural College, Poona. Santapau (1950) studied the *flora of Kathiawar* in 1945. He also (1953b) published the *flora of Saurashtra*. His work was continued by Bole and Pathak (1988). Santapau and Raizada (1954) contributed to the *flora of the Gir forest*. Santapau and Janardhanan published a *check list of Saurashtra plants* in 1967. Kapadia (1945, 1954 a, b) published on the flora of Kutch and Junagarh. Gandhi collected in Ahmedabad and its vicinity and published a list in 1958. Bharati (1959) explored some parts of north Gujarat. A. R. Chavan, his students and colleagues from the M. S. University, Baroda, collected and reported many new records from Gujarat. Chavan and Oza (1966 a) explored the Dangs forest. They also published (1966 b) the flora of Pavagarh listing 506 species. Ahluwalia (1964, 1965) collected the medicinal plants of Jamnagar. Bhandari of the Jodhpur University collected in Kutch (1965). Inamdar (1968 a, b) of Sardar Patel University explored Dharampur and reported some new records and also surveyed the hydrophytes of the area (1968 c). Inamdar and Patel made a survey of Bulsar - Tithal - Dungri which resulted in a paper (1971) listing 538 species. Pathak and his students collected in Baroda (1959). Raizada and Vaid (1957) surveyed Okhamandal and listed 256 species. C. K. Shah of the Gujarat University explored Taranga hills and published a paper in 1964. Vaidya (1967) published the *flora of Ahmedabad*. Thaker *et al.* (1971 a, b) collected from the ranges of Chhotaudepur and Kawant. Vyas (1974) collected in south Gujarat. A. C. Dhruwa collected in Dwarka and some of his specimens are at the Forest Research Institute, Dehra Dun. Sahni and Naithani (1976) described *Cyperus dwarkensis*. Ahuja and Pataskar (1970) made some additions to the flora of Gujarat. Pavagadh hills were surveyed by S. Bedi and his colleagues (1968, 1972). S. N. Padate collected in Salvi taluka (1971). Bedi (1973) also collected in the Ratan Mahal hills. Kanodia and Nanda (1967) studied the grasses of Kutch. The Gora Range of Rajpipla was surveyed by Bhatt, Bedi and Sabnis (1971). They also collected in the Khedbrahma region (1969, 1972). G. M. Oza collected in different parts of Gujarat (1974). R. I. Patel (1971) published the *forest flora of Gujarat state*. Another important collector was G. L. Shah of Sardar Patel University, Vallabh Vidyanagar. He and his students explored several parts of Gujarat and published many new records. He also published the *Flora of Gujarat* in two parts (1978), which also has an elaborate bibliography.

Scientists from the Western Circle of the Botanical Survey of India have also been actively collecting in Gujarat. S. K. Jain (1963 a) explored Dangs district. Jain and Deshpande (1960) collected in Kutch and reported 23 new records for the district. Jain and Kanodia (1960) also published new records from Kutch. R. S. Rao (1970) also published a paper on Kutch. S. K. Malhotra and Wadhwa (1973) explored Jamnagar district and gave a list of 785 taxa. Raghavan *et al.* (1981) prepared a check list of Gujarat plants covering all recent collections. T. A. Rao, K. R. Aggarwal and A. K. Mukherjee from the Ecology Unit of the Botanical Survey of India, Calcutta, explored the Saurashtra coast and published three papers (1964, 1966, 1971).

Rajasthan

Rajasthan is a continuation of the desert belt which, south of the Mediterranean sea, streches from north Africa, Arabia and southern Iran to the foot of the Himalayas through the Punjab (both the West and the Indian side) and its foothills and Sind. The flora is clearly desertic in character.

Earliest recorded information on botanical exploration of Rajasthan is about Jacquemont's journey from Delhi to Bombay through Ajmer and Neemuch in 1832. Some of his collections are at Calcutta. Allen's work (1852) has some coloured plates of plants but the book is not of any botanical significance. In 1869 G. King, Superintendent of the Saharanpur Botanical Garden, published a note on the famine food plants of Marwar. This was followed by another paper in 1870 on the same subject. These accounts were based on his collections and observations from Marwar and Mt. Abu in 1868. He also published an elaborate account on the *flora of Rajasthan* in 1878 which formed the first botanical information, detailed to some extent, on the Thar Desert. King's specimens are at Calcutta.

D. Brandis toured the Rajasthan forests during 1869-1870 and included his observations in his forest flora (1874). J. F. Duthie (1886 a) followed, and published a report on his collections from Ajmer. Duthie also explored Rajputana in 1903 and his specimens are at Dehra Dun. His *flora of the Upper Gangetic plain* covered southeastern Rajasthan. Macadam is believed to have published without her name or date *"An introducing note to Jodhpur trees and plants"* She also published a list of trees and other plants ot Mt. Abu in 1890. Adens (1899) listed about 50 species of plants in his book *the western Rajputana states.* Blatter and Hallberg accompanied by two of their students, T. S. Sabnis and D. V. Bulsara, collected in Barmer, Jodhpur and Jaisalmer. They published a series of papers between 1918 and 1921 and described some new taxa. Their collections are at Bombay. Parker (1918) recorded a number of plants from Jaipur and H. S. George (1937) published a report on the forests of Jaipur. Ramachandra Rao (1941) and Sankhala (1951) published lists of some plants. Sutaria (1941) collected in Mt. Abu and published an account. T. S. Mahabale and A. Kharadi (1946) also collected in Mt. Abu. B. V. Ratnam (1951) gave an account of the plants of Lohargal. His specimens have been lost. Sarup (1951) listed the plants of Jodhpur. He followed it up with some papers (1954, 1957, 1961). Other important collectors are M. B. Raizada (1954b), T. S. Bakshi (1954), V. S. Sharma (1958), N. C. Nair (1956, 1961b), and his students, G. S. Nathwat (1956, 1951), K. C. Kanodia (1959) and S. K. Malhotra (1961). Kanodia and Nanda (1966) studied the genus *Aristida.* L. N. Vyas (1964 a, b, 1965, 1967) explored Alwar district. Other publications include those of R. S. Gupta (1965, 1966), B. P. Singh and N. S. Brar (1980), S. Sharma (1967, 1974, 1989) etc. Tandon (1958) gave an account of the vegetation of Ladnum.

The Aravallis are one of the oldest mountain systems of the world. It intersects Rajasthan diagonally from near Delhi to the plains of Gujarat. The arid three fifth of Rajasthan lies west of the Aravallis. This part was intensively explored by Bhandari of the Jodhpur University. He published the *Flora of Indian Desert* (1978, ed. 2, 1990) after examining all possible earlier collections. Guha Bakshi (1969) of the Central National Herbarium, Calcutta, collected in the Thar Desert. J. K. Maheshwari from Lucknow collected in some parts. At first Rajasthan was under the jurisdiction of the Western circle of the Botanical Survey of India. G.S. Puri, S. K. Jain, R. S. Rao, Kanodia and others from this Circle explored Rajasthan. G. S. Puri *et al.* (1964) published an account of the flora of western Rajasthan.

When the Central circle of the Botanical Survey of India was established at Allahabad in 1962, Rajasthan came under its control. R. B. Majumdar and his colleagues from this Circle collected and reported several new records. Majumdar also published (1969, 1971 a) notes on Rajasthan flora. He explored the Kota Division and published two papers (1971 b, 1976 a). His account on the origin, nature and economic aspects of Rajasthan flora is very informative (1976 b).

In 1972 the Arid Zone Circle of the Botanical Survey of India was established at Jodhpur and since then B. V. Shetty, V. Singh, R. P. Pandey, B. L. Vyas, P. J. Parmar and others collected from various parts of Rajasthan. Shetty and Pandey (1983) published *Flora of Tonk district.* Shetty and Pandey (1977), and Majumdar (1977) reviewed the floristic studies in Rajasthan. Singh (1977) gave additional information on the flora of Rajasthan. He also published on the aquatic and marsh plants of Thalwar (1979) and *Flora of Banswara* (1983). Singh and Pandey (1979) gave a supplement to the synoptic flora of Kota Division by Majumdar. Shetty and Singh (1987, 1991) published the *Flora of Rajasthan* in two volumes.

S. Sharma of the Rajasthan University, Jaipur, collected intensively in northeast Rajasthan, and Sharma and Tiagi (1979) published the *Flora of northeast Rajasthan.*

Punjab and Haryana

Alexander Gerard (1792-1839), an army officer, commenced surveying and collecting in the Punjab plains in 1812. He was followed by Victor Jacquemont (1801-1832). He was sent to India by the French National Museum, Paris, to collect plants for the institution. He first arrived at Pondicherry which was in French possession in May 1929 and went northwest stopping at various places for collection. At that time Maharaja Ranjit Singh, the lion of the Punjab, was ruling the Punjab and Jammu & Kashmir. He warmly welcomed Jacquemont who collected there in 1830 and 1831.

James Edward Tierney Aitchison (1838-1898), a civil surgeon, reached India in 1858. He gathered plants from Hoshiarpur district and wrote its flora in 1871. Some of his specimens are at the Forest Research Institute, Dehra Dun. Earlier in 1869 he published another catalouge for the Punjab. In this he mostly deals with the plants of the area now in Pakistan.

Michael Pakenham Edgeworth (1812-1851) when came to India was posted in the administrative service of northwest India and was stationed at Ambala where he observed the relationship of the flora to the soil. Thus came out the first paper on Indian plant ecology. His collections are at Kew. J. L. Stewart (1832-1874) was the first Conservator of Forests of the undivided Punjab. He collected widely and also published an account of the forests of the Punjab in 1868 and Punjab plants in 1869. Along with Brandis and Walter Fitch he also published the *Illustrations of forest flora of northwest and central India* in 1874.

William Griffith (1810-1845), Superintendent of the East India Company's Botanical Garden at Calcutta for sometime was an able botanist. He died young. During his 13 years of work Griffith collected 7,000 species of plants from Burma to Afghanistan writing notes on what he saw on his journey in his diary which was published posthumously by his friend and colleague J. Mc Clelland (vide Griffith, 1847). In the Punjab he collected from Ludhiana to Simla.

Cleghorn toured the Punjab and published an account of the forests in 1864. Coldstream illustrated the grasses of south Punjab. B. H. Powell was interested in the economic products of the Punjab and he published two volumes on the subject in 1868 and 1872 respectively. In 1873 B. Ribbentrop wrote on arboriculture in the Punjab. Later he published an account of the *Forests of British India.* Coventry published a catalouge of trees in 1901. In 1880 and 1886 there were two anonymous publications pertaining to Punjab plants. A few sheets of J. R. Drummond (1851-1921) from the Punjab are at the Forest Research Institute, Dehra Dun.

John Firminger Duthie (1845-1922) with strong taxonomic interests was already an established botanist when he reached India. He worked for the Botanical Survey of India, first at Saharanpur in 1874 and then moved his herbarium to Dehra Dun when the Forest College was established here. He also worked as a teacher at the Forest School. He was an enthusiastic collector and procured material from throughout northwestern India of that time. His specimens are at Dehra Dun. A set also reached Kew. His flora of the upper Gangetic plain (1903-1922) does not cover the Punjab except for a small area in the neighbourhood of Delhi. Duthie realized the importance of fodder in the dry northwestern India and therefore paid great attention to the grasses and agriculture of the region and published six papers.

C. J. Bamber of the Indian Medical Service published his *Plants of the Punjab* in 1916 which had earlier appeared in parts in the Journal of the Bombay Natural History Society (1908-1912). He did not classify plants into families and genera but into trees, shrubs, herbs, climbers, water plants and parasites. He also provided keys to identify them to their botanical names. The work does not include sedges and grasses. Bamber's book covers the Northwestern Frotier Provinces of former undivided India and Kashmir.

R. N. Parker was a forester and a good field botanist. His forest flora (1918) deals with only woody plants and the descriptions of plants are excellent. He not only included the wild and naturalized elements but also notes a large number of exotics introduced into the region. His specimens are at Dehra Dun.

T. S. Sabnis (1940-1941) gave a list of plants of the Punjab plains and adjoining hilly areas. His collections are at Blatter Herbarium, Bombay. Luthra (1937) dealt with weeds. R. R. Stewart (1945) collected and published on grasses.

After 1947 the map of the Punjab has changed considerably due to partition. Indian side of the Punjab was further divided into three states - Himachal Pradesh, Haryana and the Punjab. Among the collectors after partition mention may be made of M. B. Raizada of the Forest Research Institute, Dehra Dun, who collected in Hissar district. The Northern Circle of the Botanical Survey of India began functioning at Calcutta in March 1956 and on 1 August 1956 its headquaters was shifted to Dehra Dun with its jurisdiction over Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Punjab, Haryana and Delhi. Immediately thereafter M. A. Rau, T. A. Rao and J. N. Vohra began collecting in Haryana and Punjab. M. A. Rau concentrated on Hissar, T. A. Rao on Gurgaon, Patiala, Chandigarh and Hoshiarpur and J. N. Vohra on Ambala, Karnal, Amritsar and Kapurthala. During 1961 to 1966 N. C. Nair collected in all districts of Haryana and Punjab except Hoshiarpur and Gurdaspur. In all these explorations he was accompanied by V. J. Nair who also intensively collected in Hissar and Rohtak districts. N. C. Nair and V. J. Nair (1963, 1964 a, b, 1966) published a number of new records and N. C. Nair consolidated the flora of the Punjab plains (1978). O. P. Misra collected in Hoshiarpur district. Daniel also explored Hoshiarpur district and published two papers (1982, 1984). U. C. Bhattacharya and C. L. Malhotra procured specimens from Gurdaspur district and they published an account of the grasses in 1985.

Botanists of other institutions were also active particularly those from the two chief centres of Patiala and Chandigarh. P. A. Adlakha *et al.* (1971) published an account of the weed flora of Ludhiana. M. Sharma and O. P. Sharma also collected in Ludhiana between 1967 and 1978 and published (1974, 1975, 1976). O. P. Sharma and M. Sharma (1966, 1967, 1968) also studied the flora of Chandigarh. M. Sharma published several papers on the plants of the Punjab plains. Meenakshi and M. Sharma (1985) gave an account of the *Flora of Ropar district.* The flora of Patiala (Sharma & Bir, 1978) is an important contribution. The specimens of O. P. Sharma are mostly at Chandigarh and those of M. Sharma at Patiala. Occasional collections of Harsukh from Hissar, Ganga Singh from Patiala, Gupta from Ambala Sivaliks, T. S. Bakshi from Jullunder and P. N. Mehra from Chandigarh are housed in the herbarium of the Forest Research Institute, Dehra Dun.

Himachal Pradesh

The earliest attempt to collect in Himachal Pradesh was made by William Spencer Webb who visited Sabathu in 1817. Almost around that time George

Govan who was in charge of the Saharanpur Botanic Garden also visited Sabathu. After a visit to Sirmur Govan returned to Scotland in 1823 with all his collections. Wallich named *Corydalis govaniana* after him. J. D. Herbert surveyed the region west of the Ganges and visited Spiti in 1819. William Moorcroft (1768-1825), the Veterinary Officer of the Government of Bengal, collected in Kangra, Kulu, Lahul and Spiti in 1821. His plants reached Wallich and in part Robert Brown. Several plants procured by him were new to science. *Aquilegia moorcroftiana* Wallich ex Royle, *Corydalis moorcroftiana* Wallich ex Hook. f., *Saxifraga moorcroftiana* Sternb. were dedicated to him.

Alexander Gerard (1792-1839) and his two brothers, Patrick Gerard (1795-1835) and James Gilbert Gerard (1794-1828) collected plants in the Sutlej Valley. Alexander and Patrick were military officers while James was an army surgeon. *Pinus gerardiana, Caragana gerardiana* etc. are in honour of the Gerards. James went to Shipki La in Tibet border as well as to Spiti. He also collected in Kotgarh near Simla. Alexander wrote an article on the journey to Shipki in 1824 and an article on Kotgarh near Shipki.

Simla was built in 1822 and since then the place has attracted many collectors. The wife of Earl Dalhousie (later Lord Dalhousie) spent the summer of 1829 at Simla and collected 600 species between Sabathu and Simla. She was competent to make determinations and was enthusiastic. R. Graham dedicated the genus *Dalhousiea* to her. Countess Dalhousie's specimens are at Edinburgh. G.W. Trail was also in Simla in 1829 and Jacquemont's visit was in 1830. He also went to Kinnaur and Spiti. *Prunus jacquemontii* Hook. f., *Parrotiopsis jacquemontiana* Rehder etc. were named after him. R. Inglis of Canton, a traveller and a member of the Asiatic Society of Bengal, collected in Simla and the Sutlej Valley and when he visited Royle in 1829 he showed him the specimens he had procured. Inglis sent his collections to Robert Brown who passed them on to Royle when he returned to London. J. F. Royle (1800-1858) who succeeded Govan at Saharanpur trained collectors to procure plants from Bashahr and Kinnaur around 1830. Many species were named after Royle e.g. *Dicentra roylei* Hook. f. & Thoms., *Anaphalis royleana* DC. etc. Wallich dedicated a genus, *Roylea*, to him. When Royle had finished his last volume of his *Illustrations* in 1840, he divided all his collections he took with him to England into sets. He kept the first set with him and it is now at Liverpool. He presented the second and third sets to the Linnaean Society and Berlin, respectively. The fourth set he sent to the National Academy of Science, Philadelphia. Some of Royle's material are at the Forest Research Institute, Dehra Dun. Von Huegel's visit to Simla was in 1835. In the same year Vicary visited Sabathu and his specimens are at Calcutta. Meanwhile William Hay also collected in Simla and its neighbourhood. His specimens ultimately reached Edgeworth and Bentham. Edgeworth collected in Simla while stationed at Ambala. He also gathered in Kulu, Mandi and Kangra. *Impatiens edgeworthii* Hook. f. was named after Edgeworth. Two of Edgeworth's friends, William Hay, Superintendent of the Hill States, stationed at Simla, and Lance collected for him. Hay went deep into Himachal Pradesh and Lance collected in Spiti and Lahul. Edgeworth gave his specimens to Bentham from whom they reached Kew. General Walker and his wife were in Simla and they sent specimens to W. J. Hooker in 1844. Among others who contributed to W. J. Hooker's herbarium are two army men, Col. Munro (1818-1880) (later General) to whom was *Ranunculus munroanus* dedicated and Lt. Col. Edwards Madden (1805-1856) who was honoured in the name *Bupleurum maddenii*.

Accompanying Prince Waldemar of Prussia the physician Werner Hoffmeister visited Simla in 1845 and went up to Shipki La in the Sutlej Valley. After his death in the Sikh war Hoffmeister's specimens reached Berlin where Johann Friedrich Klotzsch studied them and gave new names to over 100 specimens (1862). In 1847 Thomas Thomson collected in Kinnaur and Spiti. Thomson's specimens went to Kew. In the same year W. H. Parish visited Kulu and Mandi. These places were also visited by William Jameson (1815-1892) of the Bengal Medical Service. In 1847 R. S. Simpson also collected in Simla. In 1850 James William Grant collected in Kinnaur and the specimens were sent to J. D. Hooker.

Towards the close of the 19th century there were several collectors in Himachal Pradesh. J. E. T. Aitchison published an account of the Lahul plants in 1868. George Watt (1851-1930) arrived at Calcutta in 1873 as a medical man. He collected in Kulu, Lahul and Chamba and published an account in 1881. E. C. Buck (1885) gave an account of 20 trees of Simla. James Ramsay Drummond (1851-1921) obtained plants by empolying trained men among whom may be mentioned Sobharam. Considerable portion of the specimens of Drummond is at Kew and a portion is at Dehra Dun. Drummond was a contemporary of J. F. Duthie who also collected in the Simla hills. Lady E. Bruce collected in Simla and Mashobra and published in 1879. D. Brandis and J. L. Stewart also collected in the Simla hills, Bashahr and Kinnaur. Another important collector of plants from Himachal Pradesh was J. H. Lace (1847-1918). Lace came to India in 1881. There were two charges for him in northwestern India. First was the forests of Chamba and the second was in Baluchistan. In 1900 he became Assistant Inspector General of Forests and collected in the Simla hills and Bashahr. His collections from these places as well as Chamba are very valuabe. The specimens of Lace are at Dehra Dun, Calcutta, Kew and Edinburgh. Lace later became the Principal of the Forest School at Dehra Dun. G. A. Gammie collected along the route from Mussorie to Simla in 1896. He also collected in Simla, Theog, Mattiana and Mahasu. During the same period he also toured Chamba and Kangra (1898). Henry Collett, a medical man stationed at Simla collected and published an account of Simla grasses in 1888 and *Flora Simlensis* in 1902. Richard Strachey collected in the Sutlej Valley. Burkill (1908) studied the spring flora of Simla. In 1917 R. R. Stewart and Mrs. Stewart visited Kangra and Chamba, crossed the Sach Pass and collected in the Pangi Valley. Parker made extensive collections in Kulu and Bashahr. Collections of Karthar Singh from upper Bashahr and Kinnaur, S. P. Sethi, M. V. Laurie, C. R. Brown, G. S. Puri, M. B. Raizada etc. from lower

Bashahr are preserved at the Forest Research Institute, Dehra Dun. Bamber's and Parker's floras covered Himachal Pradesh too. Walter Koelz from Michigan visited Kulu and Lahul and went up to Tibet border in 1930. During his second visit in 1934 he collected in Kangra, Kulu, Lahul and Spiti. His specimens are mostly at the New York Botanic Garden and University of Michigan. Some specimens are also at Dehra Dun. In the same year Parkinson made collections from the Parbati Valley. N. L. Bor spent more than three months in Lahul in 1941 and brought back a very large collection, now at Dehra Dun. Justice Douglas collected in Lahul in 1950. In the same year S. K. Jain explored the Parbati Valley.

After the establishment of the Northern Circle of the Botanical Survey of India at Dehra Dun explorations in remote areas were conducted. M. A. Rau explored Lahul and published an article in 1960. He also collected in Kangra, Sirmur and Chamba. N. C. Nair collected in upper and lower Bashahr, Kinnaur including the Baspa Valley, Sanghakanda and Mahasa and published the *Flora of Bashahr Himalayas* in 1977. He also collected in Kulu, Manali, the Rohtang Pass, Lahul and Spiti (Nair 1964 a, b). C. L. Malhotra and V. J. Nair collected in Chamba. Bhattacharyya and Uniyal visited Lahul and Spiti during 1971-1973. K. P. Janardhanan explored the Baspa Valley during 1970-1974. P.K. Hajra collected plants in Kangra, Chamba, Parbatti valley, Rohtang Pass and Lahul valley (1984-85). S.K. Murty, J.N. Vohra & B.P. Uniyal collected plants from spiti, sirmore and Una District respectively.

Recently, personnel of the Central Drug Research Institute, Lucknow, National Botanical Research Institute, Lucknow, Regional Research Laboratory, Jammu and teachers from universities in the area have also made some collections.

Jammu and Kashmir

Poonch

Burkill (1965) stated that Jacquemont on his way to Punjab in 1830 to meet Ranjit Singh stopped at Saharanpur and called on Royle, in charge of the botanical garden there. Though Royle himself had not collected in Kashmir he had procured several plants from Kashmir through collectors and had a hundred species growing in the garden. Royle showed these to Jacquemont. In 1831 Jacquemont went to Kashmir Valley through Poonch. His collections and papers went back to France where his literary executors Cambessedes and Decaisne used them. The botanical part of the volumes was written by Cambessedes and Decaisne and published in Paris. The places he visited and stayed are given with dates but the spellings Jacquemont used for the places are very different from the usual English ones. For instance he spelt Kashmir as Cachemire and we find a number of *cachemiriana* in Kashmir flora. His Prountche must be Poonch. He seems to have collected only at random but the details are very carefully entered. He collected along the Ladak road, went east, crossed Pir Panjal from Jammu and entered

Kashmir Valley. Royle's *Illustrations of the botany and other branches of the natural history of the Himalayan Mountains and of the flora of Cashmere* (1833-1840), was published much before of Cambessedes and Decaisne account.

For the next six decades or so all plant collectors of Kashmir chose only the Poonch route. Vigne, Huegel, Winterbottom, Strachey, the Schlagintweit brothers, Clarke, Henderson, Hume, Levinge, Meebold, Falconer, Gammie, Ludlow and others used the same route and collected plants. *Gentiana huegelii* is based on a collection by Huegel from Poonch and *Primula clarkei* on a collection by Clarke from Poonch.

R.R. Stewart was very much interested in the flora of Poonch; so also was Nasir. They started collecting about 1947. Stewart collected in Pir Panjal as well as the Bedori Range. Rashid Khan and Mohamad Jan collected in Hilan Khurd in Mirpur. One of the discoveries of Rashid Khan is *Litsea deccanensis*, a characteristic member of the south Indian hills. J. N. Vehra and B.D. Naithan also ulleded from Pernch in 1985.

Gilgit

Gilgit is separated from Afghanistan by the Chitral Ranges. G.T. Vigne (1801-1863) was the first to visit Astor in 1834. He was followed by H. Falconer in 1838. He also visited Astor on his way to Baltistan and Ladak. James Winterbottom (1803-1854) went to Gilgit proper via Astor. He made very good collections which are at Dehra Dun and Kew. The next to reach Gilgit proper was C. B. Clarke (1832-1906). Towards the close of a long trip across Kashmir, east to west, he collected in Gilgit and his material went into the preparation of Hooker's flora of British India although Clarke did not write anything about his tour. John Biddulph of the Indian Army was in Gilgit from 1879 to 1881 and collected. Col. H. C. B. Tanner collected in Astor and Gilgit in 1880. Surgeon Major G. M. Giles was the collector of the Gilgit Agency from 1885 to 1887 during which period procured herbarium specimens. J. E. T. Aitchison (1836-1898) also collected in Astor. None of these collectors, however, published anything on Gilgit plants.

It was J. F. Duthie who first wrote about his visit to Gilgit. He undertook two long tours to Kashmir in 1892 and 1893. Towards the close of 1892 he visited Gilgit and published a detailed account in the *Records of the Botanical Survey of India in* 1893. Duthie also collected in Filel and Astor. It is also known that Capt. Roberts, Medical Officer to Gilgit, handed over a bundle of plants from Gilgit to Duthie. In 1894 W. M. Conway published *Climbing in the Himalayas - Maps and sciecnific reports*. He travelled over the Great Glacier from near Nagar to Baltistan. His specimens were named by W. B. Hemsley of Kew. Surgeon Capt. Alcock and Capt. H. H. Deasy collected a few plants in 1895 and 1897, respectively.

P. J. Bruhl was a professor at the Engineering College at Howrah. He is mostly known for his interest in mosses and the Ranunculaceae. He collected in Gilgit in 1902. His specimens are at Calcutta. In 1925 Visser-Hooft of the Swiss Consulate at Calcutta and his wife collected some plants on a surveying expedition to Karakorum. It was the latter who got the plants named. B. O. Çoventry of the Kashmir Forest Service also collected in Gilgit. In 1937 Carl Troll, a German ecologist, went with one expedition to one of the grandest mountains of the world, the Nanga Parbat complex. When his colleagues were trying to scale the highest peak in the region, he observed the plant associations and collected. Not only that, he located the associations in a map. His account with 22 plant associations with a map was published in 1939 entitled *Das pflanzenkleid von Nanga Parbat.* This work is very interesting in that no such map has ever been made for a Himalayan peak. But the work of Troll suffers from the fact that a number of his plants are named only up to the genus. It may be mentioned that before the German-Austrian climbers succeeded in 1953 after repeated attempts by the Germans, the tricky Nanga Parbat had taken away 33 lives.

In 1946 R. R. Stewart, his wife and Eugene Nasir visited the Gilgit area and collected in Rattu, Rupal Nallah, Rupal Glacier, Doian etc. Stewart visited Gilgit again in 1954 when Ferdinand Schmid and J. J. Bueitinger of Geneva on a Swiss Entomological Expedition collected in Kashmir and Gilgit. The expedition not only collected insects but also flowering plants.

Expeditions from the Kyoto University visited northwest Gilgit, Hunza, Nagar and Karakorum of Baltistan between 1955 and 1957. These expeditions collected among other things wild and cultivated plants. They are supposed to have discovered new species of *Glycyrrhiza, Stipa, Carex, Youngia, Scorzonera, Tricholepis, Kobrezia, Lepidium, Ferula* and *Swertia* in Gilgit. The results of the Japanese expedition were published in 1964 under the title *Plants of west Pakistan and Afghanistan : Results of Kyoto University scientific expedition* (1955-1957).

In 1954 a German-Austrian expedition visited Karakorum; K. J. Paffen, W. Pillewizer and H. J. Schneider were members. Paffen collected plants. The results of the expedition were published in *Erdkunde, Archiv fuer Wissendchaftliche Geographie* Band X, Lfg. 1. Bonn.

Oleg Polunin, an English school master, visited Gilgit, Kashmir and Nagar in 1956 and 1960. He along with Adam Stainton published a book in 1984 entitled *Flowers of the Himalayas.*

Neelam Valley

Near Muzaffarabad the Neelam River joins the Jhelum. The watershed of the Neelam stretches to the main Himalayan Range. Inayat, Duthie's collector from 1894 to 1912, collected in the Neelam Valley in 1897.

Until 1947 Muzaffarabad, Poonch, Kotli and Mirpur were part of the former kingdom of Jammu & Kashmir.

Vigne, Falconer and other early collectors reached Baltistan from Kashmir by entering the Gilgit road and ascending the Burzil Pass and crossing the Deosai plains. R. R. Stewart and his wife also collected along this route. They also collected in Muzaffarabad.

In 1954 Ferdinand Schmid and J. J. Bucitinger of the Swiss Entomological Expedition collected in the Neelam Valley.

The first foreigner to the Neelam Valley seems to be G.T. Vigne, an English traveller and explorer. He was in Jullunder when that was the frontier town of the East India Company. In 1834 Col. Wade, the Political Officer of the place, received a communication from the Rajah of Skardu in Baltistan requesting for a visit from a "sahib" He was afraid of the Sikhs and wanted help. Vigne was very anxious to visit a place which no foreigner had visited earlier and offered himself to go. Burkill (1965) stated that he carried a plant press but that he only used it on the border of Deosai and at Dras. He explored Kashmir for three or four years (1835-1839) and collected in all 95 plants which Royle named and he listed them in his book *Travels in Ladak, Kashmir and Iskardo*, 1842.
The next explorer to visit the Neelam valley was Hugh Falconer (1808-1865), a good botanical collector and palaeontologist. He employed local people for collecting and writing labels in Devnagri and Persian characters. Falconer visitied the area in 1837. His specimens went to London and was left there for several years until Hooker salvaged them and used for his flora of British India. J. E. Winterbottom (1803-1854), a friend of Richard Strachey, was the next collector. He was a medical man who did not pratice but spent life travelling. He collected in the the Neelam Valley, Astor and Gilgit and left Kashmir by the Banihal Pass.

The next collector was C. B. Clarke (1832-1906) who in 1876 made good collections from Jammu in the east of Gilgit and in the west. His specimens went to Kew. After Clarke left India he helped Hooker in writing up some of the difficult families for the flora of British India.

In 1892 J. F. Duthie entered the Neelam Valley from the Astor side by the Kamsi Pass. He made large collections for Calcutta, Dehra Dun and Kew. Duthie's collector Inayat also collected around 1897. Between 1896 and 1899 R. B. Keshavanand of Dehra Dun collected in Neelam Valley.

Alfred Meebold, a German, in 1905, Filippo de Filippi in 1909, R.R. Stewart from 1921 to 1947, Carl Troll, again a German, in 1935, G. L. Webster and Eugene Nasir in 1955, Hans Hartmann in 1962, M. A. Siddiqui and Yasin Nasir in 1966 collected in the area.

Ladak and Baltistan

Ladakh and Baltistan formed two of the Trans-Himalayan Provinces of the former principality of Jammu & Kashmir. Ladak is partly south as well as east of Baltistan.

William Moorcroft (1765-1825), a veterinary surgeon, was the first to do some collecting in Ladak from 1820 to 1822. He was the first Britisher to get into Tibet during his mission to obtain a flock of sheep which produced the "pashmina" wool which was used to make fine Kashmir shawls. This was in 1814 and the plants he collected reached London. In 1820 this pioneer of pioneers, at the age of 55, along with a companion named G. Trebeck, started out again, this time to buy stallions in central Asia to improve the breeds in India. Although this was his avowed objective R. R. Stewart stated that his real purpose was to find out what it was like behind the Himalayas which were still a large white area on the maps of 160 years old. If he had started on this exploration as an envoy of the East India Company there might have been political difficulties. So instead of entering Kashmir by the front gate through Lahore and Kashmir he decided to bypass the Sikhs as much as possible, and so avoided Punjab and Kashmir Valley by going to Kulu in the Punjab Himalayas. A petty rajah held him up for months probably fearing that if he let Moorcroft go through, he might get into trouble. Finally the party was able to proceed and crossed Rohtang into Lahul, then crossed the Baralacha La (*c.* 4875 m) into Rupshu and finally reached Leh, the little capital of Ladak. Moorcroft stayed in Ladakh for two years hoping to go to Yarkand. He made a visit to Kashmir and sent a packet of 23 specimens to Wallich in Calcutta. Most of them were new to science and Wallich described them as new, e.g., *Salvia moorcroftiana, Gentiana moorcroftiana* etc.

The next explorer was G. T. Vigne (1801-1863). He collected in Astor and Dras. Based on his good notes he wrote two volumes on his travels and listed 95 plants named by Royle. He tried to go to Gilgit but could not. The next to collect in Baltistan was Hugh Falconer. He visited the area in 1838. He also sent collectors (as Royle did) before he himself went to the region.

Thomas Thomson (1817-1878) was a surgeon in the East India Company and member of the Tibetan Boundary Commission. The commission reached Leh by a route from Kinnaur to Spiti and then westward through Rupshu to Leh. Thomson crossed the Ladak Range into Nubra and finally reached Skardo where he spent the winter. He climbed over to Dras, crossed Zoji La and reached Kashmir Valley from where he moved east to Jammu and Bhadrawah. After visiting Kishtwar he went back to Ladak. Thomson (1852) published his diary.

Henry Strachey (1816-1912) was also a member of the Tibetan Boundary Commission. He was a surveyor and collected in upper Indus and Ladak.

J. E. Winterbottom made collections in Gurez, Skardo, Astor and Gilgit near about 1848.

The Schlagintweit borthers, Herman, Adolf and Robert came to India as geographers in 1854, sponsored by the King of Prussia. The East India Company was pleased with their work and therefore employed them. These remarkable brothers collected in Baltistan, Ladak and adjoining Tibet. They were the first to procure plants from the Hushe Valley of Baltistan in 1856. They had also employed two plant collectors. Their materials were distributed from Kew.

In 1849 John Henry Lance (1793-1878) of the Bengal Civil Service collected in Kashmir, Dras, Ladak etc. His specimens went into the preparation of Hooker's flora of British India. Hooker and Thomson named the genus *Lancea* in his honour.

The next collector was J. L. Stewart, a surgeon by profession who spent his spare time in botanizing. He visited Ladak in 1859. In 1869 he published a list which includes also plants (175 species) gathered by Cayley, the trade agent at Leh. In the 1860s there was a Moravian Mission functioning at Leh and trying to penetrate into Tibet. In this mission there were two German botanists, Augustus William Heydei and Henrich Augustus Jaeschke. Hooker named *Scutellaria heydei* and *Cynanchum heydei* after the first and Kurz named *Jaeschkea* after the second. Although these men functioned largely in Keylang (Lahul) and Poo (Kinnaur), they also collected in Ladak.

The first Forsythe Trade Embassy to Yarkand was sent from Leh in 1870. George Henderson (1836-1929) who was serving in Punjab was appointed surgeon and naturalist (he later bacame the Director of the Calcutta Botanic Garden). A. O. Hume (1829-1912), an ornithologist, accompanied Henderson. In 1873 they published a book *Lahore to Yarkand* in which 412 plants are mentioned, out of which 276 are from Ladak.

The second Sir Douglas Forsythe Embassy to Yarkand was sent in 1874 with H.W. Bellow (1834-1892) as surgeon and naturalist and Ferdinand Stoliczka (1838-1874), a geologist. Both of them collected in Ladak.

George Watt (1851-1930), Economic Botanist to the Government of India, collected in Baltistan and sent the plants to Kew. J. F. Duthie collected in Deosai in 1892. In the same year J. Jacot-Guillarmond, a Swiss, procured plants from the Biafo region of Baltistan which are at Geneva.

In 1909 the Duke of Abruzzi (1873-1935), son of the Duke of Aosta, visited Kashmir and by Zoji La followed the Ladak road to Suru River and reached Baltistan. He was accompanied by Filippo de Filippi, G. Danielli and O. Marinelli. The party went as far as the vicinity of K 2. Filippi visited the Deosai plains. Renato Pampanini's (1875-1949) book *La flora del Caracorum* (1930) lists all those plants de Filippi had collected. He also gives the earlier collections from

Baltistan. Also given is a map showing the route taken by each collector. Commander Lacoste collected in Baltistan in 1906. Danguy named *Delphinium lacostei* after him.

In the expeditions of 1908-1909 to Suru and of 1913-1914 to Karakorum W. Hunter and Fanny Bullock-Workman were accompanied by botanists M. Koneza and C. Calciati who collected in Baltistan. Their specimens were sent to Freiburg.

In 1905 Alfred Karl Meebold, a German botanist, explored Ladak, the Deosai and Skardu and in 1909 he published *Eine Botanische Reise Durch Kashmir (Bot. Jahrb. Syst.* 99: 63-172).

The next explorer in Ladak was R. R. Stewart and from 1912 onwards he continued collecting till 1962. His wife, Isabella Darrow Stewart (1888-1953), also accompanied him in some of his trips and collected in Dras and Baltistan. Stewart published, *The flora of Ladak, western Tibet (Bull. Torrey Bot.* Club 43: 1916-1917), *The flora of the Deosai plains* (1964) and *An annontated catalogue of Kashmir and Pakistan plants* (1972). His specimens are at Rawalpindi, New York and Kew.

In 1927 W. Bosshard and Emil Trinker undertook the German Central Asia Expedition and collected many plants in Ladak which were named by E. Schmid. Bosshard published a paper Bot. Ergeb-nisse d. Deutsch. Zentr. As. Exped. (*Fedde. Repert.* 31. 1932).

In 1922, 1925 and 1927 P. C. Visser-Hooft and his wife made exploration trips to some of the difficult parts of Baltistan. The couple belonged to the Dutch Consulate at Calcutta. It was Mrs. Visser-Hooft who collected plants. H. E. Dolk from Holland published an account in 1929 entitled *Plants collected by Mrs. Visser-Hooft during the second expedition to the Karakorum Mts. in the year 1925.*

R. Meinertzhagen, the ornithologist, collected plants also in Ladak and possibly in Baltistan in 1925.

R. C. Clifford and Kenneth Mason were surveyors in the Survey of India. They surveyed as well as collected plants in Baltistan in 1926.

Frank Ludlow (1885-1972) of the Indian Education and Political Service procured plants from Ladak, Baltistan and along the Indian-Tibetan border. He was a specialist in *Primula* and *Corydalis.* His specimens are at British Museum.

Arthur Neve of the C. M. S. Medical Mission, Srinagar, visited Baltistan and Ladak. His specimens are at Kew.

Another important collector in Ladak and Baltistan was Walter N. Koelz of Michigan. He had varied interests in art, fishes, birds etc. He started with the Punjab Himalayas in 1930 for the Roerich Museum. Again he visited Kulu in 1931 moved on to Lahul crossing the Rohtang Pass and went to Ladak and Zanskar. In 1934 also he visited these areas and collected extensively. His collections are at New York with duplicates in various other herbaria including Dehra Dun. Rupchand Thakur was a collector for Koelz. Koelz did not publish anything about his collections. R.R. Stewart included them in his list.

Stewart's collecting in Baltistan was just after that of Koelz. He and his party followed the same path used by Vigne and Koelz. They also visited Shigar, the most populous and fertile valley in Baltistan. Stewart (1982) gave a very good account of this trip.

The specimens of R. Scott-Russel procured from Baltistan and Gilgit in 1939 are at British Museum and Kew.

A team of Harvard mountaineers visited Baltistan in 1955 with Harry Francis as the leader. Grady L. Webster and John Sack were members of the team. Eugene Nasir from Pakistan joined them. They published their observations and listed 250 flowering plants (*Pakistan J. Forestry* 15: 201-234. 1965).

An Austrian expedition visited Baltistan in 1956. G. Weiler of the expedition collected.

Hans Hartmann, a Swiss ecologist, visited Ladak and Baltistan in 1962 and procured plants. He published the floristic part in 1966. In 1972 he published the second part under the title *Uber die vegetation des Karakorum*.

The Northern Circle of the Botanical Survey of India was engaged in collecting in Ladakh. U.C. Bhattacharyya, B.M. Wadhwa and M.V. Viswanathan, P. K. Hajra, H. J. Choudhary, B. P. Uniyal and B. Balodi collected plants between 1970 and 1983.

The staff of the Department of Botany, Kashmir University, also studied the flora of Ladak. Kachroo, Sapru and Dhar (1977) published a book, *Flora of Ladakh an ecological and taxonomic appraisal*.

Stewart gave a who is who of Ladak and Baltistan collectors (1982). The following list is taken from his account and contains only names which have not been mentioned already.

Aitchison, J. E. T. (1836-1898), civil surgeon, collected in Astor, Ladak, 1873.

Ali, Zaffar, collector for Gordon College, Rawalpindi, collected in Swat, Gilgit, Deosai etc.

Axt, Wolfgang, Austrian Expedition to Karakorum, collected 48 species in 1961.

Bower, Capt. H. & Thorold, W. G. collected in Ladak in 1893.

Brandis, Dietrich (1824-1907), Inspector General of Forests, collected in Ladakh.

Clarke, C. B. (1832-1906), Indian Education Service, Kashmir, Baltistan and Gilgit.

Conway, W. Martin (1856-1937), surveyor, collected along Gilgit and Baltistan glaciers, 207 species.

Deasy, W. H. P. and Arnold Pike, collected from Frontier of Ladakh and Tibet in 1896 (BM).

Desio, Ardito, Italian conqueror of K2, 1953-1954 (BM).

De Terr, Helmut & Hutchinson, G. E. palaeontologists, collected in E. Karakorum mountains and Ladakh (NY).

Drummond, J. R. (1851-1921), Indian Civil Service, collected in Kashmir, Zanskar etc. (DD).

Dutreuil du Rhins, Jules Leon (1846-1894), collected in Ladak.

Dyhrenfurth, G. O., collected in Karakorum, 1931.

Fuller, Joseph Bamfylde (1827-1910), Superintendent, Botanic Garden, Saharanpur, collected in Kashmir, Baltistan, Gilgit etc. (DD).

Gammie George, A. (1864-1935), Botanical Survey of India, collected in Dras, Kashmir etc.

Hay, W. E. Superintendent, Simla Hill States, collected in Zanskar, Baltistan, Ladak etc. (CAL).

Hedin Sven, A. collected in Ladak and Tibet.

Honda, K. K. Ogino and C. Iwatsubo, Japanese collectors, Kyoto University and Punjab University Expedition to Karakorum in 1957.

Huegel Baron Carl von (1794-1870), German, collected in Kashmir and Ladak.

Inayat Khan, Duthie's collector, collected in Dras, Kashmir etc. (DD, K).

Kashyap, Shiv Ram (1882-1934), Professor of Botany, Government College, Lahore, collected in Ladak, Tibet etc. (LAH).

Lloyd, P.S. & S. Megan, collected in Nagar and Baltistan (M).

Malcolm, Neill & M. S. Welby, Army men, collected in Leh across Tibet.

Maxwell Janet, Southampton University, collected in Ladak in 1976 (E).

Nasir Yasin, Gordon College, Rawalpindi & National Herbarium (Pakistan), collected in Baltistan, Deosai etc. Nowitsky, W. T. collected in Ladak Frontier in 1898.

Osmaston, B.B. (1867-1961), collected in Baltistan and Ladakh (K).

Polunin Oleg, English school master, collected in Kashmir, Baltistan etc. (BM).

Roero Osvaldo di (1817-1896), Central Asian explorer, collected in Kashmir and from Leh to Yarkand in 1854.

Sahni Birbal (1891-1949), palaeobotanist, collected in Kashmir and Ladakh.

Siddiqui, M. A. collected in Baltistan (RAW).

Takamura Yaso, member, Kyoto University Expedition, collected in Baltistan and Karakorum.

Troll Karl, member German-Austrian Nanga Parbat Expedition of 1937, collected in the area.

Ward, A. E., in-charge, game preservation, Kashmir, collected in Sassir La in 1895.

Valley of Kashmir

One of the great Mughal emperors exclaimed of Kashmir "If there is a paradise on earth, it is here" No place in the Himalayas is similar to Kashmir. This elliptical bowl-shaped valley lies between the Pir Panjal Range and crest of the Himalayas.

The first to collect in Kashmir was Moorcroft. In 1814 he went to Tibet in search of a flock of sheep which give the wool used for making shawls of Kashmir. He collected a bundle of plants and sent them to Robert Brown in London and thus became the first to collect plants in Tibet. In 1820 he started out for Yarkand, this time to purchase stallions for improving the Indian breed. With great difficulty he obtained permit to enter the Kashmir Valley in 1822 and went to the Lolab Valley in western Kashmir. He sent a small collection of 23 plant specimens to Wallich in Calcutta. Wallich found that most of them were new to science and named them in honour of Moorcroft. Thus we have several *moorcroftiana* from Kashmir belonging to *Corydalis, Gentiana, Nepeta* etc. Moorcroft died in Afghanistan in 1825.

The second plant collector in the Kashmir Valley was Jacquemont. Ranjit Singh gave him permission to visit Kashmir in 1831. He chose the Hijipir variation of the Pirpanjal Pass, ascended the Jhelum to Srinagar. Several plants collected by him were new species. His collections went to France. Jacquemont on his way to the Punjab met Royle who was the Superintendent of the Saharanpur Botanic Garden as well as District Civil Surgeon. He did not visit Kashmir but employed collectors and procured material. When Jacquemont visited him Royle had about 100 species of Kashmir plants growing in the garden. Royle's *Illustrations* containing hand coloured illustrations is a marvel. Royle had a large herbarium which was variously distributed (*vide* Parker, 1931; Stansfield, 1953, 1954; Santapau 1954; Burkill, 1965). A set of his collections is at Dehra Dun.

G.T. Vigne visited Kashmir and explored the regions between 1834 and 1838. As an appendix to his work he listed 95 plants which were identified by Royle.

The next botanical visitor to Kashmir was Carl von Huegel (1794-1870), a German nobleman. *Gentiana huegelii* Griseb. from Pir Panjal was named after him. Huegel's specimens went to Austria.

Hugh Falconer reached Srinagar in 1837. He procured several bundles of herbarium specimens which were used by J. D. Hooker while writing the flora of British India. Falconer's specimens are at Kew, Calcutta and Dehra Dun.

Thomas Thomson was a member of the Tibetan Boundary Commission. He crossed the Valley eastward into Jammu. His specimens went to Kew and Hooker distributed the duplicates to variuos herbaria. After his retirement he went to Kew and helped Hooker in the preparation of the flora of British India.

William Munro collected grasses around 1848. The next collector in Kashmir was C.B. Clarke, the best collaborator of Hooker on the flora of British India. He travelled from Jammu to Gilgit in 1876 and collected plants. After his retirement from the Indian Educational Service he went to Kew and spent the rest of his days in taxonomic research. He is one among the few who did excellent taxonomic research in Indian botany.

D. Brandis of the Indian Forest Service collected plant in Kashmir in 1874.

J. F. Duthie made long plant collection trips in 1892 and 1893. He collected in the Lidder Valley watershed, also from Kashmir in 1893. He described these tours in the first volume of the *Records of the Botanical Survey of India*. His collector Inayat Khan also collected in Kashmir. Their specimens are at Dehra

Dun, Kew and Calcutta. W. Gollan of the Botanical Survey of India also collected for Duthie in 1893 and his specimens are at Dehra Dun, Kew and New York.

J.B. Fuller (1827-1916), Superintendent of the Saharanpur Botanic Garden, colllected in Kashmir and his specimens are at Dehra Dun.

Emilia Frances Noel colllected in the Valley in 1902 and her specimens are at Liverpool. B. B. Osmaston of the Indian Forest Service collected and his specimens are at Kew and Dehra Dun. Arthur Neve (1858-1919), surgeon of the Church Missionary Society and mountaineer and explorer, procured herbarium specimens which are at Kew. In 1905 A. K. Meebold covered many parts of Kashmir and discovered some new species. Rai Bahadur Keshavanand of the Indian Forest Service explored Jhelum and Kishenganga Valleys between 1906 and 1909. His specimens are at Dehra Dun, Kew and Oxford. Col. H. H. Rich of the Indian Army made good collections in 1918 and these specimens are at Kew and Dehra Dun. Birbal Sahni (1891-1949), founder of the Birbal Sahni Institute of Palaeobotany, spent summers in Gulmarg and collected. C. Fuller of the Jammu & Kashmir Forest Service collected in 1913 and the specimens are at Calcutta and Kew. G. A. Gammie of the Botanical Survey of India and a serious student of orchids collected and his specimens are at Dehra Dun, Calcutta and Kew.

Frank Ludlow collected for several years plants of horticultural interest from Tibetan border and Kashmir as well as Jammu. He published *The Primulas of Kashmir* (*J. Roy. Hort. Soc.* 96: 191-206, 1951).

Walter N. Koelz collected in 1931, 1934 and 1936 for the University of Michigan as well as for the U.S. Department of Agriculture. Duplicates of his specimens are at Dehra Dun, Kew and Edinburgh. Pennell (1943) named *Scrophularia koelzii* in his honour. Koelz had a head collector named Thakur Rupchand.

R.R. Stewart collected in Kashmir for several years starting from 1912. Mrs. Isbella Darrow Stewart also accompanied him to many places in Kashmir. In 1972 Stewart published *An annotated catalogue of the vascular plants of west Pakistan and Kashmir* which also provides an exhautive list of collectors of Kashmir. In 1974 he visited Kashmir again.

Ram Nath Chopra (1883-1974) collected poisonous and medicinal plants. In this he was assisted by his colleagues R.L. Badhwar, L.D. Kapur, M.L. Dhar and S. Ghosh. Their specimens are at Jammu. A number of papers and books have been published by Chopra and his associates.

Miss Elsie M. Saunders of the C.M.S. Hospital, Delhi, collected between 1910 and 1940. Her specimens are at Kew. Misses C.C. Burt and Pinfold collected during 1930-1937 and in 1950 respectively. R.C. Culbert visited Haramosh areas in 1937. His specimens are at British Museum. R. H. Philimore of the Survey of India collected in Gulmarg between 1950 and 1960. K.M. van Soest, a Dutch *Taraxacum* expert, collected along with Harbhajan Singh in 1959. M. M. Heybrock, a Dutch specialist on elm disease, collected *Ulmus* in Kashmir and other parts of the northwest Himalayas in 1969.

M.K. Wali and S.N. Tiku collected in the Lolab Valley and published an account in 1964. A. Muneer (1968, 1970) published accounts of plants on mud house tops and wall flora of Srinagar. G. N. Javeid published an account of the flora of Srinagar in 1968 and V. Kaul and D. P. Zutshi (1967) studied the aquatic and marshland vegetation of Srinagar. A.K. Dutt, Y. K. Sarin and L. D. Kapoor described the vegetation of Srinagar in 1965.

The Botanical Survey of India, Northern Circle at Dehra Dun was also active in collecting in Kashmir. T. A. Rao explored Kashmir in 1956 and published two accounts (1961 a, b). N.C. Nair collected in Pahalgam and Amarnath in 1966. Later M. A. Rau also collected here. P. K. Hajra collected in Baltal and Amarnath in 1982. B.M. Wadhwa, R.R. Rao, S. Kumar S.K. Murti, J.N Vohra and B.D. Naithani surveyed the valley during 1985-1988.

There are also some illustrated works on the flora of Kashmir in addition to Royle's Illustrations. Kashmir Forest Service published (1923, 1927, 1930) 3 small books on the *Wild Flowers of Kashmir*, each with 50 coloured plates accompanied by description of each flower illustrated and related species in each volume. E. Blatter of St. Xavier's College, Bombay, published (1927-1929) *Beautiful Flowers of Kashmir* in three volumes. The colour drawings are from the paintings by Halder J. Wali an art student of Bombay, and Mrs. G.A. Wathen, wife of Prof. Wathen of the Khalsa college, Amritsar. Mrs. Wathen's paintings were made on live plants in 1919 at Gulmarg. *Erysium melicentae* Dunn was named in her honour. Blatter's volumes were to have been published by Prof. P. F. Hallberg of St. Xavier's Collage, Bombay, but he died in 1924 and therefore Blatter took over Hallberg's material and prepared the books containing 62 coloured plates and each plate contains illustrations of 3 to 8 species. Hallberg's specimens are at Blatter Herbarium, Bombay. Oleg Polunin did a good deal of trekking, collecting and photographing in Kashmir for some years. Adam Stainton, who probably has no rival in trekking the Himalayas, joined Polunin and published their excellent book *Flowers of the Himalayas* in 1984. The book contains 690 photographs as well as 315 line drawings made in the field by Ann Farrer.

Recent publications on the flora of Kashmir include Botany along Sonamarg to Trunkhal by G. Singh (*Kashmir Sci.* 7: 82-88. 1970). Flowering plants of Shankaracharya hill, Srinagar, Kashmir by M.K. Kaul (*Bull. Bot. Surv. India* 1: 236-243. 1971). Phanerogamic elements of Kishtwar-Dunksum route by G. Singh and B.A. Wafai (*Indian Forester* 99: 310-319. 1973). *Forest flora of Srinagar* by G. Singh and P. Kachroo (1976), *Flora of upper Liddar Valley of Kashmir Himalaya* by B.M. Sharma and P.S. Jamwal (1988), Forest flora of Pirpanjal by V.C. Gupta and P. Kachroo (*J. Econ. Tax. Bot.* 6: 365-396. 1985) and *Alpine flora of Kashmir Himalaya* by U. Dhar and P. Kachroo (1983).

Jammu

Jammu, an irregular piece of territory, is the eastern half of the former state of Jammu & Kashmir. Jacquemont was the first to collect in Jammu in 1831. J. T. Vigne who was in Kashmir from 1838 to 1834 did good exploration also in Jammu. The next collector was T. Thomson who visited Jammu in 1848 followed by C. B. Clarke in 1879 and then Meebold in 1905. R. R. Stewart collected for several years. In 1912 he entered the Wardan Valley from Suru by Yarungshan La and then left Jammu by the Sinthan Pass. Again he visited along with his wife in 1917 ; this was after the collection trip in Kanga, Pangi via Sach Pass, Padar and Kishtwar.

There are only a few floristic accounts of Jammu. W. J. Lambert's (1933) *List of trees and shrubs*, is fairly complete. L. D. Kapoor *et al.* published a botanical tour in Trikuta hills (*J. Bombay Nat. Hist. Soc.* 50: 530-545. 1963) which deals with 111 higher plants. T.A. Rao from the Northern Circle of the Botnaical Survey of India collected in Jammu and published an account in 1961 entitled, A further contribution to the flora of Jammu & Kashmir State *(Bull. Bot. Surv. India* 2: 387-423). S. L. Kapoor published, Material for a flora of the Doda district of Jammu & Kashmir State (*Bull. Bot. Surv. India* 10: 110-134. 1968). B.P. Uniyal of Botanical Survey of India collected plants in Doda district in 1986. P. K. Hajra collected plants from Kathua district of Jammu & Kashmir (1986). B. M. Sharma and Kachroo (1981) published *Flora of Jammu* and added an illustrated volume in 1983. D. K. singh, S. Kumar, B.P. Uniyal and B. Balodi also made collections from the Jammu and surroundings.

Uttar Pradesh

The Himalayan Area, Dehra Dun and Chakrata

Dehra Dun, an open valley in the outer Himalayas, is enclosed by the Siwalik hills and the outer fold of the Himalayas.

General Thomas Hardwicke (1787-1835), a zoologist and an active botanist, was the first European to collect plants in the northwestern Himalayas when he went to the Alaknanda Valley in 1796. J.F. Royle procured plants from Dehra Dun and described them in his *Illustrations*.

N. Wallich (1825-1826), N. Vicary (1833-1834), G.T. Vigne (1833-1834), H. Falconer (1837-1838), V. Jacquemont (1839), T. Thomson (1839) and W. Griffith (1839-1840) are the other prominent early collectors who collected on their way to the interior of the Himalayas. D. Brandis collected in Dehra Dun between 1878 and 1881 which was included in his forest flora. Duthie collected intensively in the Valley and included them in his flora of the upper Gengetic plain. U .N. Kanjilal (1901) collected and published the *forest flora of the School Circle*. This was enlarged and revised by B. L. Gupta under a different title *Forest flora of Chakrata, Dehra Dun and Saharanpur Forest Divisions* in 1928. R. N. Parker, C. E. Parkinson, P.C. Kanjilal, Sri Ram, Sohan Lal, H.G. Champion etc. also collected here. These as Pell as his own collections were used by M. B. Raizada in the preparation of supplementary lists from 1931 to 1958 on the plants of Dehra Dun.

After the establishment of the Northern Circle of the Botanical Survey of India M. A. Rau, T.A. Rao, U. C. Bhattacharya, K. M. M. Dakshini, S.K. Malhortra, P. K. Hajra etc. explored the Dun Valley. C. R. Babu extensively explored the Valley and published *Herbaceous flora of Dehra Dun* (1977). P.S. Negi, B. K. Gupta and P. K. Hajra published the Ligneous flora of Doon Valley (1992). Other recent collectors are K. C. Sahni, Ram Dayal, R. C. Gaur, H. B. Naithani, K. M. Vaid, K. N. Bahadur, K. M. Balapure and S.S.R. Bennett, all of the Forest Research Institute, and Som Deva of the D. A. V. College, Dehra Dun.

Chakrata is another well-explored area of the Himalayas. This is because of its close proximity to the Forest Research Institute, Dehra Dun. Forest officials and other scientists from the institute collected among whom special mention is to be made of U. Kanjilal, P. C. Kanjilal, B. L. Gupta, H. G. Champion and C. E. Parkinson.

Garhwal

General Hardwicke went on a diplomatic mission to the king of Garhwal in Srinagar of the Alaknanda Valley. He was the first botanically minded visitor to the region. His collections are dated 1796. William Spencer Webb (1784-1865), an engineer surveyor, reached Jamnotri from where the Jamuna originates. His associate Felix Vincent Raper wrote an account of this travel (*Asiat. Res.* 11. 1810) and gave the names of plants as observed to occur. When the English-Nepalese war ended in 1816, W.S. Webb again went surveying the Himalayas west of the Kali River. Wallich from Calcutta sent a collecting party along with him and the specimens procured by the team were sent by Wallich to J. E. Smith in London. The Himalayan conifer *Abies webbiana* was dedicated to W. S. Webb. Moorcroft also visited Garhwal and passed beyond the source of the Ganges up to the Mansarover lake and brought back dried plants which were sent to Robert Brown in London. Falconer sent collectors and obtained plants. While T. Thomson was in north Indian plains from 1839 to 1847, he made trips to the Himalayas including Garhwal. Duthie (1882) mentioned the collections of Richard Strachey and J. E. Winterbottom from Garhwal. Towards the middle of the last century there was a very good strength of army men in the upper Ganges Valley and consequently there was an almost complete study of its flora. Lady Elizabeth Gomme, wife of the commander-in-chief, collected in these parts in 1856. The collections of Gamble, Keshvanand and Mackinon are at Calcutta as well as the Forest Research Institute, Dehra Dun. Kanjilal in his forest flora (1901) included part of Garhwal.

After 1950 many collected in Garwhal. R. K. Gupta (1956, 1957, 1962 d), A. C. Dey, M. R. Uniyal and V. Shankar (1968) explored the area between Bhillangna and Bhagirathi rivers. Walter Koelz also collected in some parts of Garwhal. Juyal and Uniyal (1966) studied the medicinal plants of traditional and commercial importance particularly from the Bhillangna Valley. The spectacular alpine Himalayan flora is typified by that of the Bhyundar Valley accidently seen by F.S. Smythe in 1931 as a member of the British *Kamet Expedition* on the return journey and aptly named the area as the Valley of Flowers in 1938. The list of plants collected was included in the book *Kamet conquered* (1932). Smythe again visited the valley in 1937 and collected more than 250 species. This high valley was a centre of attraction for collectors of alpine flora. Ghildyal made two exploration trips to the valley and other parts of Garhwal and listed 289 species (1957).

Staff of the Botanical Survey of India, Northern Circle, have explored Garhwal for the past three and a half decades. The work of M. A. Rau, who organized this Circle and served uninterruptedly for 18 years is very significant. He collected not only in the Alaknanda Valley but also in the Mandakini and Bhagirathi Valleys as well as the Valley of Flowers and Jumnotri (Rau, 1961a). His two books (1973, 1975) cover Garhwal plants also. *Anemone raui vernonia raui* and *Bulbophyllum raui* were named in his honour. Others from the Circle who explored Garhwal are N. C. Nair, A. S. Rao, U. C. Bhattacharyya, B. D. Naithani, M. V. Vishwanathan, B. V. Shetty, P. K. Hajra, B.P. Uniyal, B. Balodi D. Basu etc. Bhattacharyya and Goel published a list of plants from the Tehri Dam area (1982), and Bhattacharyya *et al.* (1982) reported on some rare or unknown plants from the Garhwal Himalayas. *The Plant Wealth of Nanda Devi Biosphere Reserve* was published by P. K. Hajra and B. Balodi (1995). The flora of Chamoli district was published by Naithani (1984).

Others, not from the Botanical Survey of India, have also been collecting. Som Deva (1978 a, b, 1980) reported on new and little known plants. Recently, workers from the Garhwal University have also been collecting. Incidentally, it may be mentioned that the highest point at which a flowering plant was collected at 6,300 m was on Mt. Kamet by Gurdial Singh. The plant was *Christolea himlayensis* (Brassicaceae). The specimen is at the Forest Research Institute, Dehra Dun.

Kumaon

George William Trail, author of the account of the rural economy of Kumaon and A. D. Lindley, author of the account of the economy of the uplands of Pithoragarh were friends of Royle who also had interest in botany. Trail and Lindley sent material to Royle. Falconer who succeeded Royle at Saharanpur sent collectors to Kumaon and procured plants. Edward Madden (1805-1856) of the army collected in the Pindari Glacier in 1846. Earlier he visted the Shattul and Buram Passes. His collections are at Kew.

Collections of Strachey and Winerbottom from Kumaon were made between 1846 and 1849. These specimens were sent to the Hookerian herbarium, British Museum and the Linnaean Society. Based on their collections a catalogue was published by Duthie in 1882 in J. E. T. Aitchison's *Gazetteer of Northwest Provinces*. This list was supplemented after checking the nomenclature and revising the manuscript by Duthie and published again in 1906. O. E. Osmaston made an excellent account of the *Forest Flora of Kumaon* in 1927. H. G. Champion collected in Nainital and adjoining areas. His specimens are at Dehra Dun. K. C. Sahni collected in the 1950s. Sinha collected in the Pindari Glacier and published a paper in 1951. (1958) and Gupta published *Flora Nainitalensis* in 1968. Workers from the Northern Circle Nainital, Botanical Survey of India collected in various parts of Kumaon. T. A. Rao collected in the Pindari Glacier in 1957 and the various parts of Kumaon. N. C. Nair collected in the Gouriganga Valley and described *Aristolochia gourigangaica*. U. C. Bhattacharyya explored Pithoragarh, Almorah and Rupkund area. C.M. Arora collected orchids, and Seidenfaden and Arora published an enumeration in 1982. P. K. Hajra explored Pithoragarh during March-April, 1983. P.C. Pant surveyed the Corbett National Park and published its flora in 1986.

The Plains

Duthie's (1903-1929) flora of the upper Gangetic plain also included the whole of the U. P. plains. Nair and Nair (1977) reviewed the status and future strategies of floristic studies in the upper Gangetic plain and provided a comprehensive list of references.

General William Munro (1844) who catalogued the plants of Agra appears to be the first to study the flora of this part of the country. Edgeworth (1852, 1867) catalogued the plants of Banda district and later studied the flora of Banda. In his study of the flora of Lucknow Anderson (1859) also included the cultivated plants. There was a lull as it were for quite sometime in the study of the flora of this region. Parker (1918) in the forest flora also dealt with plants of Delhi. The forest flora of Gupta (1928) covered the Saharanpur Division as well. Kanjilal (1933) included the forests of Gorakhpur as well as that of the erstwhile Oudh in his flora. However, it was Duthie (1903-1929) who in his flora of the upper Ganetic plain covered the whole of the U.P. plains. Grasses were not dealt with in Duthie's flora. Soon after the publication of Duthie's flora Raizada (1931, 1935, 1936, 1939, 1950, 1954 c, 1958; Raizada *et al.*, 1957; Raizada & Jain, 1964, 1966) began publishing additions to the flora of Duthie with emphasis on grasses in later years with his colleagues. This eventually led to the publication of his Supplement (Raizada, 1976). Srivastava (1938, 1949) made an extensive study of the flora of Allahabad. Mukerjee (1953) gave an account of the vegetation of the Delhi Ridge. The flora of Agra district was studied by Watts (1953) whereas the grasses of this district were dealt with by Bharadwaja *et al.* (1956). Srivastava (1955) presented a note on the flora of

Mirzapur, later he also added many grasses to the flora of Lucknow (Srivastava, 1963). Patil (1958) studied the flora of Lucknow and its environs.

The reorganization of the Botanical Survey of India and the establishment of its Northern Circle at Dehra Dun led to increased floristic studies in this region by the perssonel of the Survey as well as those from other institutions. Rau (1961b, 1969), studied the flora of Banda district and updated Duthie's flora by including all additions and brought out in the form of a check list. Gupta (1960 c, 1961) of the Soil Conservation Research Institute, Dehra Dun, concentrated on the vegetation and flora of Muzaffarnagar district. A decade later some additional notes were presented on this flora by Tayal and Bhasin (1970). With a slant on ecology, Sen (1960), and Singh (1961) made a study of the weeds of Gorakhpur. Patil (1960, 1963) who was earlier stationed at the Botanical Survey of India, Lucknow, gave an account of the flora of Lucknow and its environs with particular reference to the grasses. P.K. Hajra and U. Shukla Studied the flora of Dudhwa national Park and published an account of plants (1982). Murthy and Singh (1961a, b) of the Meerut College added a number of plants to the flora of the upper Gangetic plain from Meerut and its vicinity and also studied the flora of Hastinapur. Kapoor (1962) of the National Botanic Gardens, Lucknow, and his associates (*vide* Nair & Nair, 1977) also studied the botany of Lucknow district. A little later Sharma (1964) also contributed to the flora of Lucknow district. In the same year an account of the vegetation of this district was provided by Balapure and Srivastava (1964). Vedi and Sharma (1965) of the Lucknow University studied the hydrophytes of Lucknow and its vicinity. Again Balapure (1971b) enumerated the grasses of Lucknow district whereas Hussain and Kapoor (1970) presented a list of interesting plants from Lucknow and its neighbourhood.

Bhattacharyya (1963, 1964) of the Botanical Survey of India, Dehra Dun, studied the flora of Mirzapur district whereas Bhattacharya and Malhotra (1964) gave an account of the flora of Hamirpur district with special reference to the Mahoba aquatics. After years of intensive exploration Maheshwari (1963 a, 1966) who was earlier at the Delhi University brought out the flora of this Union Territory. Singh (1964; also *vide* Nair, 1977) of the Botanical Survey, Dehra Dun, added some plants to the flora of the U. P. plains ; he also gave an elaaborate account of the flora of Bulandshahr disrict (Singh, 1969). Panigrahi of the Botanical Survey, Allahabad, and his associates extensively explored the Allahabad district and greatly contributed to its flora (Panigrahi & Arora, 1962 ; Panigrahi & Rajagopal, 1967, 1968; Panigrahi & Saran, 1968; Rajagopal, 1965 ; Rajagopal & Panigrahi, 1965, 1966). Verma (1973), and Verma and Misra (1979) made futher contributions to the flora of Allahabad. Dixit *et al.* (1966) reported some additional weeds in the flora of Gorakhpur whereas Panigrahi & Saran (1967) contributed to the flora of the Gorakhpur Division. The botany of the forests of the Bahraich district was dealt with by Panigrahi *et al.* (1969). A supplement to the aquatic and swampy vegetation of Gorakhpur was made by Sahai & Sinha (1969) whereas Gupta (1969) enumerated the common grasses of Gorakhpur. Siddiqui and Dixit (1969, 1972), added a note on some interesting polygonums from Gorakhpur. Singh & Dixit (1969, 1972), on the other hand, enumerated the Cyperaceae of Jaunpur district and Gorakhpur. Singh (1971) of the Meerut College studied the common grasses of Meerut. Srivastava (1976) brought out a comprehensive flora of Gorakhpur. Sharma and Pandey (1984) published the exotic flora of Allahabad. A number of workers published additions to the flora of the upper Gangetic plain of Duthie from the U. P. plains (*vide* Nair & Nair, 1977)

Madhya Pradesh

The state of Madhya Pradesh took shape only in 1948 when it was formed from the then Central Provinces and Berar. The latter became a part of Maharashtra in 1956. Later, the then Central India Agency (or Central India) onetime part of Rajputana, and Vindhya Pradesh, onetime part of the region called Bundelkhand became part of Madhya Pradesh. Bastar, Jaspur and Sarguja, once part of the Eastern States Agency, also bacame part of the present Madhya Pradesh later.

Sen Gupta (1977) reviewed the botancial explorations and floristic studies in Madhya Pradesh and gave a very comprehensive and chronological list of collectors as well as an exhaustive bibliography. Verma (1977) presented the floristic studies conducted till then in the southeastern corner of the state with emphasis on future needs. the French naturalist Victor Jacquemont seems to be the first to explore this part of the country. He collected in Bundlekhand in 1830, and around Malwa in 1832. These specimens, now at Paris, were later studied and described by J. Decaisne and J. Cambessedes (Jacquemont, 1841 1844). Major N. Vicary collected in central India, Bundelhand, Jabalpur and Sagar in 1838. In 1838 M.P. Edgeworth explored Bundelkhand; he also collected in Dhar, Indore and Malwa in 1848. William Griffith, a surgeon in the East India Company, had the collections of D. F. Macleod, Principal Assistant to the Commissioner at Jabalpur, made in 1839, in his possession. Griffith also explored Jabalpur, Malwa and the Narbada Valley in 1839, and published his observations (Griffith, 1842). Around 1839-40, General William Munro explored the Chambal area. R. H. Beddome before going to the Madras Presidency to join the Forest Service collected in Jabalpur in 1848 soon after his arrival in India. The Satpura Range and Bundelkhand were botanized by D. Brandis, Inspector General of Forests, in 1863 and during 1888-89; his observations were incorporated in his forest flora (Brandis & Stewart, 1874). Based on his studies in 1867 in Bundelkhand, Guna, Malwa and Sagar, G. King (1878) brought out the flora of Rajputana. J. C. Hobson in the early 1870s and T. C. Jerdon, a zoologist, and R. H. E. Thomson of the Forest Service in 1968 and in 1870, explored the Central Provinces and Khandwa respectively. Otto Kuntze, the German traveller-botanist and polemic nomenclatural reformer during his around-the-world trip during 1874-76 collected in Jabalpur during 1875-1876. In 1876, A. Barclay, later Professor of Physiology at the Calcutta Medical College, collected in Guna whereas C.B. Clarke collected in Bundelkhand, Jaspur and Sarguja. J. J. Wood's

(1902) (he had earlier retired from the Madras Medical Service) flora of Chotanagpur which he explored in 1878 also included Jaspur and Sarguja. Duthie who was in charge of the Saharanpur Garden explored a number of areas including Betul, Bundelkhand, Damoh, Hoshangabad, Indore, Jabalpur, Khandwa and Sagar during 1888-91; these results were incorporated in his flora (Duthie, 1903 22). The Gwalior region was explored by C. Maries and Col. Wintage around 1890. During 1896 1915 Hole (1904, 1906) of the Forest Service extensively explore the Central Provinces, Bhopavar, Hoshangabad, Jabalpore and Seoni. In the 1890s two missionaries, Rev. A. Campbell and Rev. L. Carden collected in Jaspur and Sarguja. Around that time A. Meebold botanized Bhopal, Chatarpur, Jabalpur and Raisen. The flora of the Central Provinces (and Berar) was studied by Burkill (1910). C. G. Rogers of the Forest Service collected in the Khandwa region in 1910. Biscoe (1910) listed the trees and shrubs of Indore. During the second decade Masters explored Gwalior and Guna, whereas Allington collected in Indore. Haines of the Forest Service explored extensively the Vindhya Range, Balaghat, Bilaspur and Pachmarhi and contributed to the flora of this region (Haines, 1912, 1914, 1916). A. B. Pande collected in Indore in 1911 and P. Mukharji in Gwalior and Indore during 1917-1918. A study of the weeds of Gwalior was mady by Kenoyer (1924). Mooney botanized for a number of years from 1936 onwards Bastar, Jaspur and Sarguja (Mooney, 1942, 1944). Around this time, H. Crookshank also collected in Bastar. Hewetson (1940-1951) studied the forest and flora of the Central Provinces.

After independence and establishment of the state of Madhya Pradesh there was a renewed interest in the flora. The flora and vegetation of Sagar particularly attracted many in the Sagar University who studied with special emphasis on ecology (Srivastava, 1951; Misra & Joshi, 1952; Pandeya, 1952, 1953; Misra, 1953; Singhal, 1954; Bhattacharya, 1955; Bhargava & Bhattacharyya, 1957; Mall, 1960; Rao, 1966; also *vide* Sen Gupta, 1977). S. D. N. Tiwari of the Forest Service explored many areas in the state and described the grasses (Tiwari, 1954, 1955; also *vide* Sen Gupta, 1977). Maheshwari (1958) studied the woody plants of Khandwa.

The revival of the Botanical Survey of India gave an impetus to the study of the flora of the state. G. S. Puri of the Botanical Survey of India, Poona collected extensively in Bhopal, Dhar, Indore, Jhabna, Kargow, and Shivpuri during 1957-1959 and made a preliminary report (Puri & Wadhwa, 1959). J.V. Vasavada, also of the same institution, collected in Ratlam in 1957. Rao and Narayanaswami (1960) of the Botanical Survey of India, Calcutta, described the *vegetation and flora of Pachmarhi*. Kapoor and Yadav (1962) of the Natioal Botanic Gardens, Lucknow, also contributed to the flora of Pachmarhi. Maheshwari (1960 a, b, c, 1961) of the National Botanic Gardens, Lucknow, studied the flora of the Khandwa region and Asigarh, and also the flora of the Kanha National Park (Maheshwari, 1963b). Tiwari and Maheshwari (1963, 1964) described the Orchidaceae and Cyperaceae of the state. The hydrophytes and marshy vegetation of Raipur attracted the attention of Tiwari (1960a, b) of the Science College there. S. K. Jain (1963 b, c, d, 1964, 1965; also *vide* Sen Gupta, 1977 & Verma, 1977) of the Botanical Survey of India, Calcutta, particularly explored the Bastar region with emphasis on ethnobotany. The hydrophytes of Jabalpur weed studied by Seerwani (1962) of the Science College there. Sebastine and Balakrishnan (1963) of the Botanical Survey of India, Coimbatore, published a series of papers on the flora of northeast M. P. The flora of the reserve forests in Bori and Khari was concentrated by Joseph (1963) and Joseph and Vajravelu (1967) of the Botanical Survey of India, Coimbatore. Subramanyam and Henry (1966) described the *flora of Bastar*. Rao and Sastry (1966) of the Botanical Survey of India, Poona, gave an account of the flora of Indore.

The establishment of the Botanical Survey of India, Central Circle at Allahabad in 1962 gave further fillip to the study of the flora of the state by the personnel of the Survey as well as those in universities and colleges and other institutions. G. Panigrahi of the Botanical Survey of India, Allahabad, botanized the various regions of the state for about a decade from 1962 and published many papers with his associates (Panigrahi & Arora, 1965 ; Panigrahi & Verma, 1965; Panigrahi *et al.*, 1966 ; Panigrahi & Prasad, 1966 ; Panigrahi & Singh, 1967; Ramlal & Panigrahi 1966 ; Shukla & Panigrahi, 1967). Balapure (1962, 1966) described the flora of the Central Provinces and Jabalpur. Sankaran Unni (1967a, b) of the Raipur Science College gave an account of the wetland vegetation and Compositae of Raipur. Tiwari (1968, 1972 ; also *vide* Sen Gupta, 1977 & Verma, 1977) studied the flora of Bandhwagarh and Bansapur. Based on his explorations in Amarkantak, Chindwara and Pachmarhi Saxena (1970, 1971 ; also *vide* Sen Gutpa, 1977) enumerated the flora of this area. Arora (1968), and Saxena and Khotele (1976) also contributed to the flora of Bastar. Oomachan (1977) of the Motilal Science College, Bhopal, studied the flora of Bhopal. Oomachan and his associates also studied the various aspects of the flora Bhopal (*vide* Sen Gupta, 1977). Kaushik (1969 a, b) of the Government Science College, Gwalior, gave an account of the flora of Shivpuri whereas Agrkar (1969) of the same institution enumerated the flora of the lower Chambal Valley. Sen Gupta of the Botanical Survey of India, Allahabad, explored Raigarh, Rewa, Sidhi and Sarguja during 1968-76 and brought out the flora of the Sidhi district (Sen Gupta & Ramlal, 1973). In the 1970s the personnel of the Botanical Survey of India, Allahabad, intensively studied the flora of the state. C. R. Das and D.M. Verma explored Bastar and Raipur respectively. S. K. Murti, V. J. Nair and R. M. Mamgain collected in Bilaspur, Balaghat and Satna. Durg and Raigarh were explored by P. C. Pant and N. C. Rathakrishnan. L. K. Banerjee collected in Seoni whereas O. P. Misra collected in Dhar, Khargon, Shaholol and Ujjain. Based on these explorations and studies some of the floras and accounts on particular groups have been consolidated recently. Verma and Chandra (1981) gave an account of Cyperaceae of the state. Roy (1984), on the other hand, brought out the grasses. A. K. Mukherjee (1984) published the flora of Pachmarhi and Bori Reservs and Verma *et al.* (1985) published the flora of Raipur, Durg and Rajnandgaon. Recently *the flora of Madhya Pradesh (vol I)* has been Published by the B.S.I. (1993)

Orissa and Bihar

J.D.Hooker seems to be the first botanist to study the flora of Bihar. He collected in the Parasnath hills in 1848. Later M.P. Edgeworth also explored these hills followed by T. Thomson in 1858. The same year Thomson also visted along with Thomas Anderson. Anderson's (1863) paper on the flora of Bihar which was a consolidation of observations based on the collections of Hooker, Edgeworth, Thomson and Anderson himself seems to be first account on the flora of this region. Later Ball (1866, 1867,1869) made a study of the flora of Manbhum and Hazaribagh with particular reference to the food plants of the natives. In the last century F. Buchaman-Hamilton, C. B. Clarke and J. Taylor also collected in Bihar. At the end of the last century Gamble explored Gumsoor (Bhanjanagar) in the Ganjam area. Wood (1903) who studied the flora of Chotanagpur also included Jaspur and Sarguja, now in Madhya Pradesh, in its fold. Haines (1910) studied the forest flora of Chotanagpur. In the early part of this century C.A. Barber, later attached to the Sugarcane Breeding Station, Coimbatore, as an expert, explored Kollalamalai, Mahagudi, Raikia and Tickopadi in Ganjam. Around this time N. Annandale also collected in the Ganjam area. He described the vegetation of Barkuda (Annandale, 1922). His collections are at CAL. Gamble's flora of Madras also included Ganjam and Koraput, then part of this presidency. Gamble apart from his own collections also made use of the collections of Barber now at CAL, K and MH. Haines extensively collected in Bihar and Orissa and consolidated the flora during 1921-25. He also made use of the earier collections of Grieve and Cooper from Orissa (Saxena, 1977). Around this time Howard and Khan (1922) studied the wheats of Bihar and Orissa. The medicinal plants and plants of folk-lore of the Santals were studied by Bodding (1927). Some orchids were recorded by Henderson (1929) form Ganjam. Mukherjee (1935) enumerated some plants from Mahendragiri. Biswas (1934, 1935) gave an account of the vegetation of the vicinity of th Ranigunge and Jharia coal fields and Tundi in Hazaribagh district whereas Biswas and Sampathkumaran (1945) studied the flora of the Parasnath hills. Mooney (1937, 1941, 1944, 1947, 1950) of the Forest Service collected very extensively and added a number of species to the flora of Bihar and Orissa of Haines which culminated in his Supplement. Mooney also referred to the plants earlier collected by P. K. Parija, D. B. Mukherjee, P. Misra, H. Patanaik, C. M. Basha and others in Orissa, now housed at the Ravenshaw College, Cuttack. Ghosh's (1938) study of the flora also included Bihar and Orissa. Mukherjee (1947, 1956) studied the flora of Chotanagpur and the Parasnath hills. Raizada (1948) presented a list of interesting plants from Orissa. Bressers (1951) published the botany of the Ranchi district. Ara (1954, 1960, 1966) made a study of the orchids of Chotanagpur and also the flora of the Hazaribagh National Park in Bihar. Srivastava (1954, 1955 a, b, 1956 a, b, 1958 a, b, 1959, 1961, 1964) made a very comprehensive study of the vegetation of some of the districts in Bihar and also recently introduced aliens.

The reorganization of the Botanical Survey of India with these states under the jurisdiction of the headquarters at Calcutta led to intensification of floristic studies in this region by the personnel of the Survey as well as those in academic institutions. Pattnaik (1956) of the Ravenshaw College, Cuttack, studied the useful weeds of Cuttack whereas Pattanaik and Patnaik (1956) gave an account of the hydrophytes of Cuttack. Sanyal (1957) presented additional notes to the flora of the two states by Haines and the Supplement by Mooney. The grasses of the Parasnath were studied by Bharadwaja (1958). But, Verma (1961, 1963) studied the grasslands of Champaran in Bihar from an ecological viewpoint. Srinivasan and Subba Rao (1961) of the Botnaical Survey of India, Calcutta, gave an account of the flora of Parlakamedi in Orissa. Kapoor (1964) of the National Botanic Gardens, Lucknow, studied the flora of the Mahendragiri hills of Orissa. The botanical observations in Balimla Project in Orissa were presented by Raju (1964) whereas Panigrahi *et al.* (1964) gave an elaborate account of the flora of Cuttack, Keonjhar, Mayurbhanja and Bolangir-Sambalpur districts. An account of the forest botany of the Angul Division was provided by Singh and Verma (1964). Panigrahi (1966) also studied the flora of Rajmahal hills in Bihar. Many plants were added as new to the flora of Bihar by Kanodia and Malick (1966), and Rao and Mukherjee (1969) and that of Orissa by Rao and Banerjee (1967). Srivastava *et al.* (1966), on the other hand, gave an account of the weeds of wheat fields in Bihar. Misra (1969, 1970, 1971) and Misra and his associates concentrated on the flora of Darbhanga in Mithila, Bihar (*vide* Krishrna, 1977). Banerjee and Banerjee (1968) gave an account of the flora of Champaran district in north Bihar (also *vide* Krishna, 1977). The medicinal plant lore of the Santals was provided by Jain and Tarafdar (1970). Majumdar and Biswas (1971) described the vegetation of Chaibasa, Singhbhum district in north Bihar. Some plants were added to the flora of the Orissa coast by Banerjee and Das (1972). The study of grasses by Jain *et al.* (1975) also included those from Bihar and Orissa. Saxena (1973, 1974, 1976) added some plants to the flora of Orissa and provided some notes on the flora of Bihar and Orissa. Maheshwari and Paul (1975) studied the exotic flora of Ranchi. Paul (1975) also recorded two plants as new to Orissa.

Krishna (1977), and Saxena (1977) reviewed the floristic studies in Bihar and Orissa respectively and suggested measures to be considered in future. Krishna explored the districts of Palamau, Ranchi, and Singhbhum in the late 1970s. Personnel of the Regional Research Laboratory, Bhubaneswar, have been studying the flora in Dhenkanal, Ganjam, Puri, Sambalpur and Simlipal districts, and the tidal forests of Mahanadi and Brahmani rivers since 1971(Saxena, 1977). Saxena and Brahmam (1978) made a further contribution to the flora of Mahendragiri. And Brahmam and Saxena (1980) gave an account of the flora of Ganjam. The Cyperacease of Orissa were listed by Rath *et al.* (1981). Varma (1981) of the Bhagalpur University brought out the flora of Bhagalpur. The vegetation of the Eastern Ghats of Orissa was dealt with by Dani (1982). Uniyal and Datta (1984) added some grasses to the flora of Bihar and Orissa. The flora of Patna was brought out by Singh (1986). P. K. Mukherjee and P. Mondal of the Calcutta University, M. K. Misra and P. K. Das of the Berhampur University, S. N. Patnaik and P. Panda of the Utkal University and A. P. Das and S. Panda of Presidency College, Calcutta, have been studying the flora of Keonjhar, Koraput, Puri and Sambalpur districts respectively.

West Bengal

Floristic studies in West Bengal appear to have begun with the establishment of the Asiatic Society of Bengal by W. Jones in 1784 and the botanic garden near Calcutta by Robert Kyd in 1787. The herbarium at Calcutta (CAL) started around the year 1793 by Roxburgh is also closely linked with the progress of this. It houses many valuable collections made from different parts of West Bengal also, including a number of type specimens. Buchanan-Hamiliton, N.Wallich, J.D. Hooker, T. Thomson, W. Griffith, J. Mc Clelland, C.B. Clarke, R. L. Heining, D. Prain and others' collections from this area are available here.

Hortus Bengalensis compiled by Roxburgh (1814) contains a list of plants that were grown in the Calcutta Garden. Roxburgh did not travel much from Calcutta. But he sent out his collectors all around and procured specimens. He prepared about 2533 coloured illustrations of plants of which some are from West Bengal.

William Carey and Buchanan - Hamilton helped Roxburgh in the collection of plants from central Bengal and the Sundarbans. He maintained a garden at Serampre which was as important as the Calcutta Garden in those days. Voigt (1845) in his *Hortus suburbanus Calcuttensis* included plants present in this garden, the Calcutta Botanic Garden and the list drawn up by Master for his abandoned Calcutta flora. During the same period, the French botanist V. Jacquemont made collections from Chandernagore, Hooghly, Burdwan and Raniganj.

J.D. Hooker after reaching India in 1848 travelled through the Bengal plains and collected in the Sundarbans. He also made intensive collections around Darjeeling. Tthe botanical observations made by him during these expeditions are available in his various publications (for a detailed bibliography on the West Bengal flora *see also* Basak, 1973; Basak & Guha Bakshi, 1977; Matthew, 1970; Thothathri & Das, 1984). Long (1857-1859) wrote on the indigenous plants of Calcutta and Ball (1869) on the flora of Manbhum.

C.B. Clarke explored Madhupur jungles of Mymensingh, the Sundarbans and other parts of Bengal. His main interest was herbaceous weeds, especially those of the families Cyperaceae, Commelinaceae and Scrophulariaceae. Gamble's collections (1872-1888) are mainly from Darjeeling, Jalpaiguri, Sundarbans and the adjoining areas. Kurz and Ball collected in Midnapur jungles. Kurz wanted to write the flora of Bengal which he could not do as he was asked to shift his activities from Bengal to the Andamans and Burma. King and Haines explored various part of north Bengal and Duars.

Prain's (1903a) *Bengal* plants is the only comprehensive work available so for on the flora of the Bengal plains. He also published *Flora of the Sundarbans (1903)* and *Flora of Howrah, Hooghly and 24 Parganas* (1905).

The hilly Darjeeling district of West Bengal also attracted the attention of many plant explorers. In fact, many early plant collectors of the Sikkim Himalayas made ample collections in Darjeeling (also *vide* Matthew, 1970; Thothathri & Das, 1984). Hooker is known to have collected extensively in and around Darjeeling. The weeds and other flowering plants have been listed by various workers like Watts (1954), Ghose (1949, 1951, 1953 1959), Matthew (1969b), Sharma and Ghosh (1970) and others.

Botanists of the Botanical Survey of India, Forest and Agricultural departments and others published papers on varous aspects of the flora of West Bengal. Benthal (1946) described and illustrated 350 tree species found near Calcutta. Majumdar (1956, 1962) studied the grasses and weeds of 24-Parganas. Mitra (1952, 1958) dealt with the family Commelinaceae and other monocotyledonous plants. Trees and shrubs of Shantiniketan attracted the attention of Basu and Dutta (1957). Datta and Majumdar (1966) studied the flora of Calcutta and its neghbourhood. Guha Bakshi *et al.* (1976), and Sur and Das (1976) enumrated the grasses of West Bengal. Jain *et al.* (1975) included the grasses of West Bengal also in their accout. Uniyal and Datta (1984) added some more grasses to this list. Maiti and Guha Bakshi (1981) wrote on the invasion of exotic weeds in West Bengal. Banerjee and Pal (1984) gave an account of the neglected plants. Krishna and Das (1984) gave a list of additions to the flora of Bengal. Ghosh and Mitra (1986) studied the Asteraceae of West Bengal.

Many new species and new records have been established since the publication of *Bengal plants* by Prain (1903a). Some of the notable new species described recently are : *Hydrocotyle himalaica* (Mukherjee, 1969) from Darjeeling district, *Hypericum assamicum* (Biswas, 1971) from Assam and Darjeeling, and *Dalbergia duavensis* (Thothathr, 1975) from Alipur Duars, north Bengal. Maheshwari (1964), Bennet (1965), Biswas (1971), Guha Bakshi *et al.* (1980), Krishna and Dutta (1981) and many other published new distributional records.

In recent years intensive explorations have been undertaken by different workers in various parts of West Bengal. This includes Howrah district (Bennet, 1979), Nadia district by Sanyal, Calcutta Botanic Garden by V.S. Sharma, Hooghly by P.K. Hajra and Sen, Tollygaunge and adjoining arease by Mitra, Murshidabad district (Guha Bakshi, 1984), Purulia district (Malick, 1966), Birbhum district by Basak, Hooghly estuary and vicinity by Mukherjee and 24-Parganas by Malick.

Sikkim

The richness of the flora of Sikkim attracted a number of plant hunters from different parts of the world eversince Griffith's visit to this are in 1843. According to W.W. Smith, "probably no corresponding area in India has been ransacked for its flora and none so well, as the Sikkim Himalyas" (Burkill, 1965).

J. D. Hooker visited Sikkim during 1848-1849. He established his base camp in Darjeeling, now in the state of West Bengal and commenced intensive collections by sending out 18 collectors in different directions. Later on he traversed interior regions of the Sikkim Himalayas reached Nepal. The observations made during this trip were published in his *Himalayan journals* (Hooker, 1854). C. B. Clarke collected in Sikkim 1873. During 1877 the well known traveller and scientist Henry John Elwes made the first of his expeditions to Sikkim. Subsequently at about 1888 he made one more trip to this place. His collections are available at K. Watt botanized Jongri in 1881. Henry Alfred Cummins, an army medical officer, collected in Sikkim and along the borders of Bhutan in 1888. In 1892 G. A. Gammie botanized Sikkim. Around 1900 collections were made on the northern frontier of Sikkim by Fracis Younghusband, D. Prain and two army medical officers Walton and Lawrence Austin Waddell. W. W. Smith, G. King, R. Pantling, J. M. Cowan and C. Montford are some other important collectors of that period. Many publications based on these collections have appeared from time to time (for a detailed bibliography *vide* Matthew, 1970; Thothathri & Das, 1984). Biswas (1952, 1956, 1966), Ghose (1953), Rao (1963), Sharma and Ghosh (1970) are some of the more recent important contributors to the knowledge on the flora of this area. Ghose (1951-57) published a catalogue of plants of the Sikkim Himalayas. Tokyo University, Japan, conducted botanical expeditions to various parts of the eastern Himalayas including Sikkim during 1960-1963. Hara (1963-1971) brought out important publications on the flora of the eastern Himalayas based on the results of these expeditions. Recently, Mitra and Chakraborty (1991) described a new species of *Macaranga* from Sikkim. Exploration work gained momentum after the establishment of a unit of the Botanical Survey of India at Gangtok in December 1979. P. K. Hajra, P. Chakraborty, B. Krishna, D. C. S. Raju, M. Sanjappa R. C. Srivastava, S. Singh, D. Banerjee and N. R. Mandal collected plants in different parts of the state including the Sakyang Valley (Lepcha's Land). Raju, Sanjappa & S. Singh explored along Lachen and Lachung valleys, Kerang, Cho-in-mo, Dorji-la, Tista glavier. Raju & S. Singh also explored Chola and singlila ranges. Sanjappa and Raju recorded Prezwalskia tangutica-a momotypic solanaceous genus from Alpine Sikkim as new to India. Krishna (1987), Krishna and Singh (1987) have brought out some publications recently.

North-East India

North-East India at present comprises seven states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. Botanically this region is probably the richest in India and as such has attracted the attention of many plant collectors and botanists. Based on the data available in Burkill (1965) and other publications Deb (1963), Rao (1974), Balakrishnan (1981), and Rao and Verma (1982) traced the histroy of plant explorations and floristic studies conducted in this area.

Buchanan-Hamilton was the first serious plant collector in northeast India. He gathered plants in the vicinity of Guahati. M.R. Smith who held a magisterial post made some live collections of plants in the Khasi and Jaintia hills which were sent to the Calcutta Botanic Garden where Roxburgh cultivated and studied them. A missionary couple, Mr. & Mrs. Mack collected in the Khasi hills in 1826. During 1826-1830 David Scott who was one of the Governor General's Agents in northeast India made some collections in the Khasi and Mikir hills, and the Brahmaputra Valley, mostly during 1834-1835. Wallich and Griffith who were deputed as members of the "Assam Tea Delegation" to establish the occurrence of tea made vigorous botanical collections from a cross section of the region with Sylhet at one end and the Mishmi hills at the other, with a view to knowing the flora of that area. Griffith during 1836-37 collected in Sadya, the Mishmi and Naga hills. Again in 1838 Griffith left Calcutta for Bhutan traversing and collecting in the Khasi hills and the present Kamrup district. Griffith collected about 1700 species in Assam, Meghalaya and about 800 species in Arunachal Pradesh, besides about 1000 species that he received form his personal collectors. In 1837 J. Gibson collecting for the Duke of Devonshire gathered several orchids for cultivation including a new *Dendrobium* later named as *Dendrobium gibsonii*. In 1848 Thomas Lobb visited the Khasi and Jaintia hills for collecting live orchids for the famous orchid nursery, Veitch & Sons of Chelesa. The celebrated botanists J. D. Hooker and T. Thomson made extensive collections in Meghalaya during 1850-1851. Some of the other important persons who collected in this area are: Master during 1843-1873 in Golaghat, Nowgong, Sadia and in the hills of Angami Nagas, Oldham in 1850 in the Khasi hills, Falconer's collectors during 1852-1854 in the Khasi hills, Kenan during 1872-1873 in Cachar, Watt during 1882-1883 along Golahat Kohima Manipur Cachar but mostly along the Burma border, Collett in 1891 in Kohima, King's collector Gammie in 1894 between Guahati and Sadia, Gallatly in 1894 in the Khasi hills, C. B. Clarke during 1866-1887 in the Khasi hills and along Golahat Kohima Manipur area, Gage in 1899, Mrs. Parry during 1924 1928 and Wenger during 1924-1932 in the Lushai hills, Meebold during 1906-1907 along Golahat - Kohima Manipur area, Prain in Nagaland, Burkill during 1911-1912 in the Abor hills and Kingdon Ward during 1927-1950 in Manipur and Lohit.

Most of the earlier collections were either for introduction of exotics into English gardens or for a general knowledge of the flora. The credit for organized efforts for making collections for a detailed knowledge of the flora of northeast India goes to Gustav Mann who began collecting for Brandis during 1863-1881. He collected extensively throughout northeast India and most of his specimens are deposited in the herbarium ASSAM. Following in the footsteps of Mann, many people like U. N. Kanjilal, P. C. Kanjilal, De, Dutta, Sharma, Purkayastha, Syam and Deka enriched this herbarium by their collections. Some of the other collections are by N. L. Bor in the Khasi and Jaintia hills, S .K. Kukherjee in 1948 and D. B. Deb during 1951-1955 in Manipur.

The state of Tripura remained independent from time immemorial and was never under the British rule. It was finally integrated to the Indian Union on 17.9.1949. Probably because of this independent status the area remained botanically unexplored for a long time. The first botanical exploration to Tripura was undertaken by Deb Burman, Curator of the Herbarium, Royle Botanic Garden, Calcutta, who explored the area during 1914-1921. His collections are from places around Agartala, Unokot, Udapur and Sonamura. K. Biswas, Superintendent of the Indian Botanic Garden, Calcutta, made collections in Agartala, Fatikroy, Dopada, Lathrai Umnupui during 1941-1942. R.S. Rao explored Charilam, Garjee, Chandrapur and Radhakishorpur in 1957. During 1956-1962 D. B. Deb made extensive collections from various parts of the state including the Jampai and Sakhan Ranges.

The Botanical Survey of India, Eastern Circle, Shillong, came into being in 1956. This resulted in added vigour to collecting activities and a large number of gatherings including lichens and bryophytes of the area were made.

Robinson (1841) in his descriptive account on Assam gave some details about the flora of northeast India. This seems to be first characterization of the flora of this region. There are some early accounts on various aspects of the flora of this area written by different authors. However, the first detailed floristic work is *The flora of Assam* in 5 volumes by U.N. Kanjilal *et al.*(1934-1940). Kanjilal died on 25 October, 1928 even before the first volume of his flora was completed. His son, P.C. Kanjilal, along with his colleagues Das, Purkayastha and De edited and continued its publication. The first four volumes cover the dicotyledons but chiefly the woody species. Of the monocots only the family Gramineae (by N. L. Bor) is available in the fifth volume. In an attempt to complete the flora A.S. Rao and Verma (1972-1979) published a series of papers on the monocots of this region. Rao and Verma (1982) also brought out a detailed account on the Cyperaceae of north-east India. Rao & Hajra (1975) published a series of papers. Biswas (1941), Deb (1957, 1958,1962 a, b), Srinivasan (1966), Panigrahi and Joseph (1966), Deb and Dutta (1972, 1975), Islam (1991a, 1991 b) and Malick and Safui (1988) have contributed some important papers on the flora of some areas of this region mainly based on the intensive explorations conducted by them. Explorations conducted by the Botanical Survey of India, Eastern Circle, Shillong, have resulted in many important findings including the discovery of more than 80 species new to science. Chauhan (1985, 1987), Joseph and Mani (1985), Joseph and Abbareddy (1985), Verma

(1986), and Thothathri and Pal (1986) are some of the authors who have published accounts on new species. Besides, some important books on the flora of this area, like *Orchidaceae: Genus Coelogyne* (Das & Jain, 1980), *Flora of Jowai* (Balakrishnan, 1981, 1983), *Flora of Nongpoh* (Joseph, 1982), Cyperaceae of Northeast India (Rao & Verma, 1982), Sacred groves of Shillong plateau and Law - Lyngdoh Sacred groves (Raju,1964; Hajra, 1975), *Threatened and endemic orchids of Sikkim and northeast India* (Kataki & Jain, 1984), *Forest flora of Meghalaya* (Haridasan & Rao, 1985, 1987), *Orchids of Meghalaya, India* (Joseph & Joseph, 1986), *Lady's slipper orchids in India* (Kataki, 1984), and *Flora of Tripura state* (Deb, 1981, 1983) have been published by the Survey and other workers.

The Andaman & Nicobar Islands

Lt. Blair by orders of the East India Company founded a settlement in South Andaman in 1789 under the name of Port Cornwallis, later rechristened as Port Blair. For the first time the Andamans were explored for plants in 1791 by Col. Robert Kyd, Secretary in Calcutta to the Military Department of Inspection of the East India Company. As in charge of the Company's Botanic Garden at Sibpur, Calcutta, which was established in 1787 at his suggestion, Kyd vistied these islands and intorduced many plants into the garden. Plants thus introduced by him were later studied and a few new species described by his succesor William Roxburgh, the patriarch of Indian botany, in his *Flora Indica* (1820, 1824; 1832). The settlement in South Andaman was shifted to North Andaman in 1792 for strategic resaons but carried the old name Port Cornwallis. In 1796 the vhole setlement was removed form North Andaman to Penang. Consequently, botanical explorations in these islands received a serious setback till 1858. There were, however, a few periodical explorations in between Kyd's visit in 1791 and 1858.

J. W. Helfer, an Austrian geologist who already settled in 1837 in Tenasserim, Burma, collected plants there. At the instanse of the East India Company he visited the Andamans in 1839 to assess the mineral potential. In the course of his geological studies he also collected plants. His career, however, was destined to come to an abrupt end when he was mudered by the natives of north Andaman. This resulted in his collections from the Andamans getting mixed up with his earlier collections from Burma and labelled "Tenasscrim and Andamans", and many of his Burmese plants being attributed to the Andamans. Many herbaria in Europe particularly B, BM, K, L, LE, and CAL in India and a few herbaria in north America have his collections.

The Danish corvette "Galathea" on its voyage around the world (1845-1847) surveyed many islands of the Nicobar group in early 1846. The aim of the expedition was to decide whether it was worthwhile to maintain the Danish claim on these islands. D. F. Didrischen, the surgeon-botanist on board, besides studying the vegetation also collected plants, now present at C, KIEL, B and US. The observations of Didrischen with a list of plants comprising 266 genera belonging to 99 families were published in Danish in 1849 by Capt. St. Bille, the chief of the expedition. This is the earliest account on the botany of these islands. N. Wallich (1850) translated it into English enabling the English-knowing botanical public to have a preliminary knowledge on the till unknown flora and vegetation of these islands. Kurz (1876) generously made use of this work.

The Austrian frigae "Novara" on its expedition (1857-1859) touched the Nicobars in 1858. A. Jelinek, a horticulturist of the team, also collected plants besides making observations on the geology. Jelinek's collections with a list of Burmese names were deposited in the Vienna Museum and few in CAL. Kurz who studied these specimens later described many new species, some honouring Jelinek himself.

Soon after the first war of independence the government decided to establish a penal settlement in the Andamans. Acordingly F. J. Mouat was deputed to survey these islands and he was accompanied by G. Playfair, a surgeon in the Royal Army. The latter besides his role of a physician also surveyed and collected plant. A short while before Playfair, another sugeon, G. von Liebig also collected plants particularly in the Barren Islands. Another name that cannot be overlooked is Parish. Rev. C. Parish, the orchild-lover, was a chaplain in Moulmein, Burma, during 1852-1887. In 1861 he botanized the Andamans. His collections are present at CAL and K.

Kurz, the German botanist-forester, has a special niche for himself. He joined the Dutch East India army in Java in 1856 under the fictitious name of Johann Amann. He assisted Dr. Teysmann of the Buitenzorg Botanic Garden in identifying plants from 1859-63. It was during his stay here Kurz recognized the distinctive characters of the culm-sheaths in bamboos to be employed as a taxonomic atribute to diferentiate the species. After he was discharged from the army, he sailed for India to take up the post of curator in 1864 under T. Anderson, Superintendent of the Calcutta Botanic Garden. It did not take long for D. Brandis, Inspector General of Forests, to recognize the talent in Kurz and recommend to the government for forestry work. He was asked by the government to assess the forest wealth of the Andamans, collect seeds and seedlings for introduction into the garden and plants for preparing a report. He systematically explored the Andamans and Nicobars including the Katchall, Kamorta and the Nancowrie Islands between 1866 and 1876. It was a formidable task with problems galore. The Burmese convicts who were instructed to serve him in the field turned hostile and chose to desert him. But an indomitable Kurz overcame all such apparently insurmountable hurdles and submitted his report to the government in 1867. This was revised after another visit and published in 1870 containing 660 phanerogams, 50 cryptogams and observations on timber yielding plants. He also treated many of these plants in his forest flora (1877). Kurz (1875) described 37 new taxa from the Nicobar Islands. Again Kurz (1876) published a detailed account of the vegetation of the Nicobar Islands including the evergreen forests of the Kamorta and Katchall Islands, and enumerated 625 species of flowering plants. Included was also the notable feature of the hilly plateau of the Nicobars, the presence of "grass heaths". Kurz's collections are present at CAL. Plants collected by A. O. Hume in 1870, now at SLBI, were also studied by Kurz. Major General E.S. Berkeley also collected in the Andaman and Nicobar Islands in 1881. His collections are at K, but his orchids are at W.

A number of plants from these islands were included in the flora of British India (Hooker, 1872-1897). H. E. Mann during his tenure as Deputy Superintendent in the islands in 1859 after the penal settlement was established and later as Superintendent collected plants.

D. Prain of the Indian Medical Service joined the Calcutta Botanic Garden as a curator of the herbarium while G. King was its superintendent. He undertook a series of explorations to these islands from 1889 onwards and collected plants which are at CAL. He published a detailed account of the vegetation of Little Andaman and Car Nicobar Islands (1891a), the Cocos Islands (1891c) and the volcanic Narcondam and Barren Islands (1893). The more significant contribution, however, is his account on the non-indigenous species of the Andaman flora (Prain, 1891b) in which he traced the origin, history and present status of such species and concluded that they got introduced primarily by human agency as the vast sea formed a veritable barrier. G. King, the first Director of the Botanical Survey of India, visited these islands in 1890. Besides collecting by himself, he also employed collectors. Most of his collections are at CAL. When King and Gamble (1889-1936) prepared the flora of the Malay Peninsula, a number of plants from the Andamans were also described including some novelties. They also made use of H. E. Mann's collections. R. L. Heining and C. G. Rogers of the Indian Forest Service during their incumbency in the islands during 1901-1902 respectively. Based on these collections now at CAL and DD in India and many herbaria in Europe and North America, Gamble (1903) published a preliminary list of plants. Heining also compiled a *Forest manual of the Andamans* which was published in 1900 (Burkill, 1965). M. C. Bonnington is said to have collected in the beach forests of the Great Nicobar Islands in 1914. His collections, however, still remain untraceable.

C.E. Parkinson, Extra-Assistant, Conservator of Forests in these islands, undertook the challenging task of preparing a forest flora and collected extensively during 1914-1918. His collections are present at CAL, DD and K. The forest flora of Parkinson (1923) describes 650 species of trees, shrubs and climbers with keys and notes on distribution, economic uses, and quality and utility of timber.

There was a lull in the botanical activity in these islands for nearly 2 decades after that of Parkinson till Chengappa (1944) of the Forest Service described the forests of the Andamans. K. C. Sahni of the Forest Research Institute, Dehra Dun, explored the Great Nicobar Islands in 1952 to assess the timber resources and collected plants. Based on this he enumerated 200 species (Sahni, 1953). Later he dealt with the mangroves of the Andaman and Nicobar Islands (Sahni, 1958). Bhargava (1958) of the Forest Service gave a detailed account of the tropical evergreen forests of the Andamans whereas Srinivasan (1960 b) of the Botanical Survey of India, Calcutta, studied the foreshore vegetation of the Car Nicobar Island. K. Thothathri of the Botanical Survey of India, Calcutta, made five trips, in 1958-59, 1964, 1966, 1971 and 1974 which covered almost all these islands. The 1966 trip was a joint expendition in collaboration with the Anthropological, Geological and Zoological Surveys of India, Forest Department of the Andamans, Indian Meteorological Department and the All India Institute of Hygiene and Public Health, extending for 100 days. Thothathri collected about 7000 specimens. S. P. Banerjee, P. K. Mukherjee, P. K. Hajra and G. D. Pal were the member of this expedition. Apart from his observations on the vegetation and flora he also gave due considerations to phytogeography and ethnobotany. Based on his studies Thothathri (1960 a, b, 1961, 1962, 1975; also *vide* Thothathri, 1977) published a series of papers. Thothathri *et al.* (1973a, b) recorded many Malaysian species and presented the result of the joint expedition. Thothathri (1977) also reviewed the floristic studies in the Andaman and Nicobar Island and discussed the phytogeography at length giving a long list of references. Ellis and Ramanmurthy of the Botanical Survey of India, Coimbatore, explored the Andamans in 1964 and colleced about 240 field numbers. These specimens are now present at MH and PBL.

With the establishment of a Circle of the Botanical Survey at Port Blair in 1972 under the stewardship of N. P. Balakrishnan, a lot more collecting has been done in these islands resulting in a number of publications on the flora. Balakrishnan N. G. Nair, and M. K. Vasudeva Rao explored north Andaman. Balakrishan, N. Bhargava, Vasudeva Rao; Partha Basu, and Premanth collected in middle Andaman. Much collecting has been done in south Andaman by Balakrishnan, Bhargava, Vasudeva Rao, Nair and R. Ansari. Balakrishnan and Bhargava also studied the flora of Little Andaman. Bhargava (1981, 1983) studied the flora with special reference to ethnobotany. Balakrishnan, Vasudeva Rao and Nair explored Car Nicobar. Extensive collections have been made in the Katchall, Kamorta and Nancowrie Islands by Balakrishnan, Vasudeva Rao, Nair and Paritosh Chakravarty. Great Nicobar has been visited for plant collection by a host of botanists including Balakrishnan, Vasudeva Rao, D. K. Hore, R. P. Dwivedi, M. Sanjappa, U. Chatterjee and T. Chakravarty. Balakrishnan (1977) dealt with at length the more recent botanical studies in the Andaman and Nicobar Islands. Besides chalking out the future programme for the Circle, he also discussed the phytogeography and gave a list of 136 rare and endangered endemic plants. Balakrishnan and Nair (1979) wrote on the wild population of *Areca* and *Cocos* in these islands. Vasudeva Rao (1983) provided an interesting accounting on the early botanical history. Balakrishnan and Vasdeva Rao (1984) presented a list of rare species from these islands. T. Chakrabarty and N. P. Balakrishnan published the family Euphorbiaceae of the Islands (*J. Econ. Tax. Bot. Add. Ser.* 9.1-124. 1992).

More recently J. L. Ellis, M. Sanjappa and Vasudeva Rao explored the Rutland Island in south Andaman and the Saddle Peak in north Andaman. Vasudeva Rao also collected in Great Nicobar. Ellis (1987a) described a new rice plant, *Oryza indandamanica*, which he collected in the Rutland Island. Debnath collected in middle and Little Andaman, whereas L. N. Roy collected in south and middle Andaman. P. Basu, on the other hand, collected in south and middle Nicobar. Balakrishnan *et al.* (1984) described the flora of the Great Nicobar Island covering the vegetation and economic botany as well. Realizing the richness of the flora they proposed the creation of a boiopshere reserve in this island. Based on this a biosphere reserve was established in the Great Nicobar Island in 1991. Ellis (1986) presented the flora of the Andamans, floral composition of the near-shore vegetation (Ellis, 1987 b), plant diversity with emphasis on endangered and endemic species (Ellis, 1989 a) and North Andaman Biosphere Reserve (1989 b). Vasudeva Rao (1986) published a preliminary report on the angiosperms with a very comprehensive, up-to-date and annotated bibliography including all new taxa. Saldanha (1988) also brought out a select bibliography for an environmental impact assessment. Singh and Kothari (1989) gave an account of the national parks and sanctuaries in the Andaman and Nicobar Islands.

HERBARIA IN INDIA

The number of herbaria in India notwithstanding her rich and varied flora in the vast area is indeed undesirably small as pointed out by Henry and Daniel (1990). The information provided hereunder is far from complete. Herbaria with small holdings are likely to exist in certain other centres of some known floristic activity.

Allahabad

Herbarium acronym	:	BSA
Name of the officer-in-charge	:	Deputy Director
Address	:	Botanical Survey of India, Central Circle, 10 Chatham Lines, Allahabad-211 002.
Year of establishment	:	1962
Number of specimens	:	48,000
Important collections	:	L.K. Banerjee, C.R. Das, V.J. Nair, G. Panigrahi, P.C. Pant, N.C. Rathakrishnan, G.P. Roy, G. Sen Gupta & D.M. Verma.
Areas of collections	:	Eastern Uttar Pradesh and Madhya Pradesh.

Anantapur

Herbarium acronym	:	SKU
Name of the officer-in-charge	:	T. Pullaiah
Address	:	Department of Botany, Sri Krishnadevaraya University, Anantapur 515 003.
Year of establishment	:	1980
Number of specimens	:	12,000
Important collections	:	T. Pullaiah and his associates.
Areas of collections	:	Mostly the districts of Adilabad, Anantapur, Cuddapah, Guntur, Kurnool, Medak, Nizamabad and Ranga Reddy in Andhra Pradesh.

Aurangabad

Herbarium acronym	:	
Name of the officer-in-charge	:	V. N. Naik
Address	:	Department of Botany, Marathwada University, Aurangabad 431 004.
Year of establishment	:	1968
Important collections	:	V. N. Naik and his associates.
Area of collections	:	The Himalayas, Khasi hills, Marathwada, North Kanara, Ooty, Pachmarhi and Western Ghats.

Banaras

Herbarium acronym	:	BAN
Name of the curator/ officer-in-charge	:	C. D. Mishra
Address	:	Department of Botany, Banaras Hindu University, Varanasi 221 005.
Year of establishment	:	1931
Number of specimens	:	4735

Areas of collections	:	Mostly Uttar Pradesh, and some other states.

Bangalore

Herbarium acronym	:	JCB
Name of the officer-in-charge	:	C.J. Saldanha
Address	:	Centre for Taxonomic Studies, St. Joseph's College, Bangalore 560 001.
Year of establishment	:	1964
Number of specimens	:	50,000*
	*	These colletions are now housed in Centre for Ecological Studies, Indian Institute of Science, Bangalore.
Important collectios	:	C. J. Saldanha and his associates.
Area of collections	:	Karnataka

Bangalore

Herbarium acronym	:	RRCBI
Name of the curator	:	S. N. Yoganarasimhan
Address	:	Regional Research Centre (Ay.), Government Central Pharmacy Annexe, Jayanagar, Bangalore 560 011.
Year of establishment	:	1971
Number of specimens	:	6000
Areas of collections	:	Karnataka, plants used in Ayurvedic system of medicine.

Baroda

Herbarium acronym	:	BARO
Name of the Curator	:	K. N. Sharma
Address	:	Department of Botany, M.S. University of Baroda, Vadodara-390 002.

Year of establishment	:	1920
Number of specimens	:	20,000
Important collections	:	R. J. Ansari P. P. Bhagwanani, R. P. Bhatt, S. J. Bedi, J. N. Joshi, G. M. Oza, S. N. Padate, S. N. Patil, K. S. S. Rao, S. D. Sabnis M. Sanjappa & D. N. Thaker.
Areas of collection	:	Gujarat.

Berhampur

Herbarium acronym	:	BOTB
Name of the officer-in-charge	:	M. K. Misra
Address	:	Department of Botany, Berhampur University, Berhampur.
Year of establishment	:	1982
Number of specimens	:	2000
Important collections	:	P. K. Das and M. K. Mitra
Areas of collections	:	The districts of Ganjam, Koraput and Phulbani in Southern Orissa.

Bhagalpur

Herbarium acronym	:	
Name of the officer-in-charge	:	S. K. Varma
Address	:	Department of Botany, Bhagalpur University, Bhagalpur 812 007.
Year of establishment	:	1970
Number of specimens	:	12,000
Important collections	:	A. Kumar, A. K. Sinha, D.K. Sriwastava and S. K. Varma.
Areas of collections	:	Eastern Bihar including Bhagalpur, Santhal Pargana, Munger, Kosi and Chotanagpur Division and eastern Nepal.

Bhubaneswar

Herbarium acronym	:	RRLB
Name of the Curator	:	H.O. Sexena

Address	:	Regional Reseach Laboratory, Bhubaneswar 751 013
Number of specimens	:	5000
Important collections	:	H.O. Saxena and his colleagues.
Areas of collection	:	Mostly Orissa.

Bhubaneswar

Herbarium acronym	:	—
Name of the officer	:	Head, Department of Botany.
Address	:	Department of Botany, Utkal University, Vani Vihar, Bhubaneswar 751 004.
Year of establishment	:	1969
Number of specimens	:	5000
Important collections	:	C. G. Bairiganjan, B. Behera, B. P. Choudhury, S. N. Patnaik, B. C. Patra & S. P. Rath.
Areas of collections	:	Mostly from Orissa.

Bombay

Herbarium acronym	:	BLAT
Name of the officer-in-charge	:	S.M. Almeida
Address	:	Blatter Herbarium, Department of Botany, St. Xavier's College, Bombay 400 001.
Year of establishment	:	1918
Number of specimens	:	100,000
Important collections	:	E. Blatter and his associates, P. V. Bole, C. McCann, H. Santapau and his associates, L. J. Sedgwick & Bell.

Calcutta

Hebarium acronym	:	BSIS
Name of the officer-in-charge	:	Scientist SE

Address	:	Economic Herbarium, Industrial Section, Indian Museum, Botanical Survey of India, Sudder Street, Calcutta 700 016.
Year of establishment	:	1896-1897
Number of specimens	:	50,000
Important collections	:	C. A. Barber, I.H. Burkill, G. Watt & K. S. Srinivasan.

Calcutta

Herbarium acronym	:	CAL
Name of the officer-in-charge	:	Joint Director
Address	:	Central National Herbarium, Botanical Survey of India, P.O. Botanic Garden, Howrah 711 103.
Year of establishment	:	1834
Number of specimens	:	15,00,000
Important collections	:	C. A. Barber, R. H. Beddonme, K. Biswas, C. B. Clarke, M. P. Edgeworth, G. Forrest, J.S. Gamble, W. Griffith, A. Henry, J. D. Hooker & T. Thomson, G. King, W. S. Kurz, E.D. Merrill, S. K. Mukherjee, V. Narayanaswami, R. Pantling, D. Prain, W. Roxburgh, B. Scortechini, G. H. K. Thwaites, N. Wallich & R. Wight.
Areas of collections	:	Worldwide

Calcutta

Herbarium aconym	:	CUH
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, Calcutta University, 35 Ballygunge Circular Road, Calcutta 700 019.

Year of establishment	:	1921
Number of specimens	:	25,000
Areas of collections	.	Assam, eastern Himalayas and West Bangal.

Calicut

Herbarium acronym	:	CALI
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, Calicut University, Calicut 673 635.
Number of specimens	:	18,500
Important collections	:	K.S. Manilal, B. K. Nair, M. Sivadasan, V. V. Siryarajan and their students.
Areas of collections	:	Mostly Kerala.

Chandigarh

Herbarium acronym	:	PAN
Name of the curator	:	M. P. Sharma
Address	:	Department of Botany, Punjab University, Sector 14, Chandigarh 160 014.
Year of establishment	:	1947
Number of specimens	:	35,000
Important collections	:	P. N. Mehra and his associates.
Areas of collections	:	Mostly the Himalayas.

Coimbatore

Herbarium acronym	:	FRC
Name of the officer-in-charge	:	K. N. Subramanian
Address	:	Institute of Forest Genetics and Tree Breeding, R.S. Puram, Coimbatore 641 002.
Year of establishment	:	1962
Number of specimens	:	15,000

Important collections	:	T.F. Bourdillon, C.E.C. Fischer, Rama Rao & K. N. Subramanian.
Areas of collections	:	The southern states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.

Coimbatore

Herbarium acronym	:	MH
Name of the officer-in-charge	:	Joint Director
Address	:	Botanical Survey of India, TNAU Campus, Coimbatore 641 003.
Year of establishment	:	1853
Number of specimens	:	2,23,000
Important collections	:	N.P. Balakrishnan, C. A. Barber, R. H. Beddome, T. F. Bourdillon, J. L. Ellis, C. E. C. Fischer, J. S. Gamble, A. N. Henry, J. D. Hooker & T. Thomson, K. C. Jacob, Jivanna Rao, J. Joseph, M. A. Lawson, N. C., Nair, V. J. Nair, K. Ramamurthy, K. Rangachari, N. C. Rathakrishnan, J. P. Rottler, K. M. Sebastine, B. D. Sharma, B. V. Shetty, G. V. Subba Rao, K. Subramanyam, D. Sunderaraj, Tadulinga Mudaliar, G.H.K. Thwaites, E. Vajravelu, K. Vivekananthan & R. Wight.
Areas of collections	:	Mostly the southern states of Andhra pradesh, Kerala and Tamil Nadu.

Darbhanaga

Herbarium acronym	:	DMU
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, Mithila University, Darbhanga 846 004.
Year of establishment	:	1970
Number of specimens	:	5000
Areas of collections	:	Mainly from Mithila, North Bihar.

Dehra Dun

Herbarium acronym	:	BSD
Name of the officer-in-charge	:	Deputy Director
Address	:	Botanical Survey of India, Northern Circle, Kaulagrah Road, Dehra Dun 248 006.
Year of establishment	:	1956
Number of specimens	:	1,00,000
Important collections	:	C. M. Arora, C.R. Babu, U. C. Bhattacharyya, H. J. Chowdhery, P. Daniel, P. K. Hajra, K. P. Janardhanan, C. L. Malhotra, S. K. Malhotra, O. P. Misra, N. C. Nair, V. J. Nair, B. D. Naithani, P. C. Pant, A. S. Rao, R. R. Rao, T. A. Rao, M. A. Rau, N. P. Singh, B. P. Uniyal, M. V. Viswanathan, J. N. Vohra S. K. Murty, B. M. Wadhwa, B. V. Shetty, B. Balodi & S. Singh
Areas of collections	:	Haryana, Himachal Pradesh, Jammu & Kashmir, northwestern Himalayas and westen Uttar Pradesh.

Dehra Dun

Herbarium acronym	:	DD
Name of the officer-in-charge	:	Scientist 'SE'
Address	:	Forest Research Institute and Colleges, P.O. New Forest, Dehra Dun 248 006.
Year of establishment	:	1890
Number of specimens	:	3,25,000
Important collections	:	J.E.T. Aitchison, K. N. Bahadur, S.S. R. Bennet, N. L. Bor, D. Brandis, J. F. Duthie, J. S. Gamble, G. Govan. G. Mann, H. H. Haines, W. Jameson, U. N. Kanjilal, A. E. Lowrie, H. F. Mooney, A. E. Osmaston, R. N.

		Parker, C. E. Parkinson, M. B. Raizada, J. F. Royle, K. C. Sahni, R. R. Stewart & K. M. Vaid.
Areas of collections	:	Countrywide

Gangtok

Herbarium acronym	:	SHC
Name of the officer-in-charge	:	Scientist SD
Address	:	Botanical Survey of India, Sikkim Himalayan Circle, Gangtok 737 101.
Year of establishment	:	1979
Number of specimens	:	10,000
Areas of collections	:	Sikkim
Important Collections	:	P. K. Hajra, B. Krishna, D. C. S. Raju, M. Sanjappa, S. Singh, R. C. Srivastava, A.S. Chauhan.

Gwalior

Herbarium acronym	:	JUG
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, Jiwaji University, Gwalior.
Year of establishment	:	1980
Number of specimens	:	6100
Areas of collections	:	Mostly Madhya Pradesh.

Hyderabad

Herbarium aconym	:	HY
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, Osmania University, Hyderabad-7.
Year of establishment	:	1953
Number of specimens	:	5000

Area of collections	:	Hyderabad

Itanagar

Herbarium acronym	:	ARUN
Name of the officer-in-charge	:	Scientist SD
Address	:	Botanical Survey of India, Arunachal Pradesh Circle, New Itanagar 791 111.
Year of establishment	:	1979
Number of specimens	:	7000
Areas of collections	:	Arunachal Pradesh

Jabalpur

Herbarium acronym	:	—
Name of the officer-in-charge	:	R. K. Pandey.
Address	:	State Forest Research institute, Polipather, Jabalpur 482 008.
Year of establishment	:	1963
Number of specimens	:	5000
Important collections	:	P. C. Kotwal, R. K. Pandey, H. O. Saxena & J. L. Srivastava.
Areas of collections	:	Forests of Madhya Pradesh.

Jaipur

Herbarium acronym	:	RUBL
Name of the curator	:	S. Sharma
Address	:	Department of Botany, University of Rajasthan, Jaipur 302 004.
Year of establishment	:	1963
Number of specimens	:	14,000
Areas of collection	:	Mostly Rajasthan, the Aravallis, Jaipur and Jhalawar districts, Himalayan hill stations, the Nilgiris and the Krusadi Islands in Tamil Nadu.

Jammu-Tawi

Herbarium acronym	:	RRL-JH
Name of the officer-in-charge	:	Deputy Director
Address	:	Regional Research Laboratory, Canal Raod, Jammu Tawi 180 001.
Year of establishment	:	1943
Number of specimens	:	17,460
Important of collections	:	B. K. Abrol, K. S. Ahluwalia, R. L. Badhwar, R. N. Chopra, A. K. Dutt, B. K. Kapahi, L. D. Kapoor, S. K. Kapoor, Y. K. Sarin, D. R. Sharma, S. N. Sobti, T. N. Srivastava & S. K. Tandon
Areas of collections	:	Mostly the northwestern Himalayas.

Jodhpur

Herbarium acronym	:	BSJO
Name of the officer-in-charge	:	Deputy Director
Address	:	Botanical Survey of India, Arid Zone Circle, D-7 Shastri Nagar, Jodhpur 342 003.
Year establishment	:	1972
Number of specimens	:	16,500
Important collection	:	R. P. Pandey, B. V. Shetty, V. singh & E. Vajravelu.
Area of collections	:	Rajasthan

Jodhpur

Herbarium acronym	:	JAC
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, Jodhpur University, Jodhpur.
Year of establishment	:	1953
Number of specimens	:	5000
Important collections	:	Santisarup, M. M. Bhandari and his associates.
Areas of collections	:	Rajasthan

Lucknow

Herbarium acronym	:	CDRI
Name of the curator	:	B. N. Mehrotra
Address	:	Central Drug Research Institute, Chattar Mazil Palace, Lucknow 226 001.
Number of specimens	:	35,000
Important collections	:	B. N. Mehrotra and his colleagues.
Areas of collections	:	Countrywide

Lucknow

Herbarium acronym	:	CIMAP
Name of the Curator	:	N. C. Shah
Address	:	Central Institute of Medicinal and Aromatic Plants, Faridinagar, Lucknow 226 010.
Year of establishment	:	1978
Number of specimens	:	1500
Important collections	:	N. C. Shah and his colleagues.
Areas of collections	:	Countrywide

Lucknow

Herbarium acoronym	:	LWG
Name of the officer-in-charge	:	Director
Address	:	National Botanical Research
	:	Institute, Lucknow 226 001.
Year of establishment	:	1948
Number of specimens	:	1,10,000
Important collections	:	S. L. Kapoor, J. K. Maheshwari and their associates, S. R. Paul & V. S. Sharma.
Areas of collections	:	Countrywide

Madras

Herbarium acronym	:	MCCH
Name of the curator	:	C. Livingstone
Address	:	Department of Botany, Madras Christian College, Tambaram, Madras 600 059.
Year of establishment	:	1983
Number of specimens	:	4000
Important collections	:	P. Dayanandan, D. Giles Lal, D. Livingstone, D. Narasimhan and their students.
Areas of collections	:	Hill stations in Tamil Nadu, Madras city and Chengalpattu district in Tamil Nadu.

Madras

Herbarium acronym	:	PCM
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Departmental of Botany, Presidency College, Tripilicane, Madras 600 005.
Year establishment	:	1901
Number of specimens	:	1,00,000
Important collections	:	P. F. Fyson, E. Govindarajulu & B. G. L. Swamy.
Areas of collections	:	Madras Presidency

Nagpur

Herbarium acronym	:	—
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, Nagpur University, Amravati Road, Nagpur 440 010.

Year of establishment	:	1963
Number of specimens	:	8000
Important collections	:	P. S. Athavalae, S. K. Chitaley, K. H. Makde, P. P. Moghe, M. P. Padhye & B. M. Patil.
Areas of collections	:	Chandrapur, Gadchiroli, Nagpur and Wardha districts of Maharashtra.

New Delhi

Herbarium acronym	:	IARI
Name of the officer-in-charge	:	Director
Address	:	Division of Plant Introduction, Indian Agricultural Research Institute, New Delhi 110 012.
Year of establishment	:	1940
Number of specimens	:	5500
Areas of collections	:	Countrywide, introduced plant of economic and wild relatives of crop plants.

New Delhi

Herbarium acronym	:	DUH
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, University of Delhi, Delhi 110 007.
Year of establishment	:	1947
Number of specimens	:	15,000
Areas of collections	:	Delhi and adjacent areas, and the Himalayas.

New Delhi

Herbarium acronym	:	RHMD
Name of the curator	:	M.V. Viswanathan

Address	:	Raw Material Herbarium & Museum, Publications & Information Directorate, Hillside Road, New Delhi 110 012.
Number of specimens	:	4500
Areas of collections	:	Countrywide

Patiala

Herbarium acronym	:	PUN
Name of the curator	:	M. Sharma
Address	:	Department of Botany, Punjabi University, Patiala 147 003.
Year of establishment	:	1967
Number of specimens	:	28,500
Important collections	:	S. S. Bir, M. Sharma and their associates.
Areas of collections	:	The Punjab plains and the western Himalyas.

Peechi

Herbarium acronym	:	KFRI
Name of the curator	:	N. Sasidharan
Address	:	Kerala Forest Research Institute, Peechi 680 653.
Year of establishment	:	1979
Number of specimens	:	7000
Important collections	:	K. K. N. Nair, N. G. Nair, V. P. K. Nambiar, C. Renuka & N. Sasidharan.
Areas of collections	:	Forests of Kerala (general); countrywide (canes).

Pondicherry

Herbarium acronym	:	HIFP
Name of the officer-in-charge	:	Director

Address	:	Institut Francais, 10 St. Louis Street, Pondicherry 605 001.
Year of establishment	:	1956
Number of specimens	:	7000
Areas of collections	:	South India

Port Blair

Herbarium acronym	:	PBL
Name of the officer-in-charge	:	Deputy Director
Address	:	Botanical Survey of India, Andaman & Nicobar Circle, Horticultural Road, Port Blair 744 102.
Year of establishment	:	1972
Number of specimens	:	40,000
Important collections	:	N. P. Balakrishnan, N. Bhargava, T. Chakrabarty, D. K. Hore, N. G. R. Nair, J. L. Ellis, K. Thothathri & M. K. Vasudeva Rao, M. Sanjappa.
Areas of collections	:	Mainly the Andaman and Nicobar Islands.

Pune

Herbarium acronym	:	AHMA
Name of the officer-in-charge	:	M. S. Kumbhojkar
Address	:	M. A. C. S. Research Institute, Law College Road, Pune 411 004.
Year of establishment	:	1946
Number of specimens	:	21,000
Important collections	:	R. S. Badve, S. D. Bonde, V. S. Ghate, N. P. Gunjatkar, D. K. Kulkarni, M. S. Kumbhojkar, R. D. Madavgane, T. S. Mahabale, B. A. Razi, H. D. Sane, A. K. Shyam, A. S. Upadhy & V. D. Vartak.

Areas of collections	:	Goa and western Maharashtra.

Pune

Herbarium acronym	:	BSI
Name of the officer-in-charge	:	Deputy Director
Address	:	Botanical Survey of India, Western Circle, 7 Koregaon Road, Pune 411 001.
Year of establishment	:	1898
Number of specimens	:	1,50,700
Important collections	:	M. Y. Ansari, R. K. Bhide, T. Cooke, S. K. Jain, S. Y. Kamble, S. Karthikeyan, M. J. Kothari, G. S. Puri, R. S. Raghavan, A. S. Rao, R. S. Rao, B. D. Sharma, N. P. Singh, W. A. Talbot, J. I. Thakar, B. M. Wadhwa & G. M. Woodrow.
Areas of collections	:	The states of Gujarat, Karnataka, Maharashtra and Rajasthan, and the Union Territories of Goa, Daman, Diu and Nagarhaveli.

Sagar

Herbarium acronym	:	—
Name of the officer-in-charge	:	T. R. Sahu
Address	:	Department of Botany, Dr. Hari Singh Gour Vishwavidyalaya, Sagar 470 003.
Year of establishment	:	1948
Number of specimens	:	15,000
Important collections	:	Rama Rao, P. Sahu, T. R. Sahu and Y. D. Tiagi.
Areas of collections	:	Throughout India

Shenbaganur

Herbarium acronym	:	SHC

Name of the curator	:	K. M. Matthew
Address	:	Anglade Institute of Natural History, Sacred Heart College, Shenbaganur, Kodaikanal 624 104.
Number of specimens	:	7000
Areas of collections	:	Southern India

Shillong

Herbarium acronym	:	ASSAM
Name of the officer-in-chare	:	Deputy Director
Address	:	Botanical Survey of India, Eastern Circle, Shillong - 793003.
Year of establishment	:	1920
Number of specimens	:	2,50,000
Important collections	:	N. P. Balakrishnan, N. L. Bor, P. K. Hajra, J. Joseph, P. C. Kanjilal, U. N. Kanjilal, S. K. Kataki, C. L. Malhotra, G. Mann, G. Panigrahi, A. S. Rao, R. S. Roa, A. R. K. Sastry, D. K. Singh D. M. Verma & K. P. Singh
Areas of collections	:	Assam, Manipur, Tripura and NEFA, and the eastern Himalayas.

Shillong

Herbarium acronym	:	NEHU
Name of the officer-in-charge	:	Y. Kumar
Address	:	Department of Botany, Northeastern Hill University, Shillong 753 014.
Year of establishment	:	1976
Number of specimens	:	17,500
Important collections	:	A. K. Baishya, K. Haridasan, N. S. Jamir, Y. Kumar, S. Myrthong, B. Neogi & R. R. Rao.

Areas of collections	:	The states of Meghalya and Nagaland.

Srinagar

Herbarium acronym	:	KASH
Name of the curator	:	A. R. Naqshi
Address	:	Department of Botany, University of Kashmir, Srinagar 190 006.
Year of establishment	:	1972
Number of specimens	:	13,000
Important collections	:	G. N. Dhar, P. Kachroo, A. R. Naqshi & N. A. Shah.
Areas of collections	:	Northwestern Himalyas and central Asia.

Srinagar (Garhwal)

Herbarium acronym	:	GUH
Name of the officer-in-charge	:	R. D. Gaur
Address	:	Department of Botany, Garhwal University, Srinagar (Garhwal) 246 174.
Year of establishment	:	1978
Number of specimens	:	12,000
Important collections	:	K. C. Bhatt, B. S. Bartwal, M. K. Bisht, L. R. Dangwal, R. D. Gaur, K. S. Negi, D. S. Rawat, J. K. Semwal, C. M. Sharma, M. P. Sharma, R. A. Silas & J. K. Tiwari.
Areas of collections	:	Garhwal and Kumaon Himalayas.

Thiruvananthapuram

Herbarium acronym	:	TBGT
Name of the officer-in-charge	:	Director, Palpu Pushpangadan
Address	:	Tropical Botanic Garden & Research Institute, Karimancode, Pachapalode-695 562.

Year of establishment	:	1979
Number of specimens	:	5750
Important collections	:	C. Anilkumar, T. F. Bourdillon, K. C Koshy, D. Mathew, P. J. Mathew, N. Mohanan, S. Mukuntha Kumar, G. B. Nair, T. S. Nair, M. Rama Rao, C. Sathiskumar, A. E. Shavaraskhan & K. Venkoba Rao.
Areas of collection	:	The states of Kerala, Tamil Nadu, Sikkim and the Andaman and Nicobar Islands.

Thiruvananthapuram

Herbarium acronym	:	UCT
Name of the officer-in-charge	:	Head, Department of Botany.
Address	:	Department of Botany, University College, Thiruvanathapuram.
Number of specimens	:	5000
Important Collections	:	T.F. Bourdillon, M. Rama Rao & K. Venkoba Rao.
Areas of collections	:	Mostly from the earstwhile state of Travancore.

Tiruchirapalli

Herbarium acronym	:	RHT
Name of the officer-in-charge	:	K. M. Matthew
Addrees	:	Department of Botany, St. Joseph's College Tiruchirapalli 620 002.
Year of establishment	:	1967
Number of specimens	:	60,000
Important collections	:	K. M. Matthew and his associates.
Areas of collections	:	Mainly southern India.

Tirupati

Herbarium acronym	:	Not assigned
Name of the curator	:	N. Yesodamma
Address	:	Department of Botany, S. V. University, Tirupati.
Year of establishment	:	1959
Number of specimnes	:	2000
Important collections	:	H. R. Gopalakrishna, K. Narayana Rao, C. P. Rao, K. Raja Reddy, D. Rangachari & N. Yesodamma.
Areas of collections	:	Chittoor district (especially of Tirupati hills) in Andhra Pradesh.

Ujjain

Herbarium acronym	:	Not assigned
Name of the curator	:	L. K. Chaturvedi
Address	:	School of studies in Botany, Vikram University, Ujjain 450 010.
Year of establishment	:	1961
Number of specimens	:	5000
Important collections	:	V. S. Khare, L. P. Mall, M. Oomachan & V. P. Singh.
Areas of collections	:	Mostly Madhya Pradesh, also hill stations in the Himalayas, the Andaman and Nicobar Islands, Karnataka (Agumbe) and the Lakshadweep.

Vallabh Vidyanagar

Herbarium acronym	:	SPUH
Name of the curator	:	Smitaben Amin
Address	:	Department of Bio-Sciences, Sardar Patel University, Vallabh Vidyanagar 388 120.

Year of establishmnt	:	1958
Number of specimens	:	7500
Important collections	:	J. A. Inamdar, G. L. Shah and their students.
Areas of collections	:	Gujarat and north-western Maharashtra.

Visakhapatnam

Herbarium acronym	:	AUH
Name of the curator	:	N. Saradamani
Address	:	Department of Botany, College of Science & Technology, Andhras University, Visakhapatnam Waltair 530 003.
Year of establishment	:	1958
Number of specimens	:	9850
Important collections	:	S. Harasreeramulu, P. V. B. Murthy, P. N. Rao, T. V. V. S. Reddy, N. Saradamani, V. Seshavatharam, S. Sudhakar, M. Umamaheswara Rao, M. Venkaiah & P. Venkanna.
Areas of collections	:	East Godavari, Krishna, Srikakulam, Visakhapatnam, Vizianagaram and West Godavari districts of Andhra Pradesh.

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5. PHYTOGEOGRAPHIC DIVISIONS: GENERAL CONSIDERATIONS

(N.P. Balakrishnan)

India is a unique country in many ways, more so in its biological diversity. With its wide range of physiographic and climatic conditions, it has a rich varied flora, unparalleled in any other country in the world. The high mountains in the north and sea on all other sides, have in effect resulted in physical isolation of the country. The physiographic diversity of the country has produced all possible types and extremities of climatic conditions suitable for supporting wide varied types of ecosystems. The north-east India boasts of areas with the highest annual rainfall in the world. At the same time, parts of Rajasthan deserts may have no rains for years. While the northern plains experience summer temperatures of about 50°C. India's river systems include the mighty Ganga and Brahmaputra originating from the highest reaches of Himalayas and Tibetan plateau respectively. These two rivers when in spate flood and fertilise the plains of north India and north-east India. The shorter and swift rivers of peninsular India draining from the Western Ghats irrigate the Deccan plateau and the West Coast. The long coastline of 7500 km facilitate varied coastal vegetations. The two groups of islands in Arabian Sea and Bay of Bengal being isolated from mainland have support distinct types of floras. The net result is that in India we find all possible types of vegetations, such as tropical, subtropical, temperate and alpine, humid evergreen rain forests, semideciduous and deciduous forests, scrub jungles, hot dry arid zones, cold dry arid zones, coastal mangroves, submerged seaweeds and seagrasses, salt marshes, swamps, sand-dune formations, fresh water and saline aquatic vegetations, etc.

India, lying in the tropical belt between 6° 45' and 37° 6' N latitudes and 68° 51' and 97° 25' E longitudes, with a total area of about 329 million hectares (3,287,263 sq. km) represents 2.46% of the total world landmass. It is estimated that about 45,000 species of plants which forms the conspicuous vegetal cover comprises about 17,000 species, representing about 6.8% of all known flowering plants of the world. With 2.46% of land area having 6.8% of flowering plants, India is recognised as one of the top 12 megadiversity centres of the world.

The flora of Indian region has no endemic families, but there are a number of endemic genera (about 130) and is very rich in endemic species. Distribution of endemic species, their concentration and the level in biological hierarchy are very important aspects in judging the phytogeographic affinities and demarcations.

Chatterjee (1940) estimated about 11,000 species of flowering plants in Indian region, which included Bangladesh, Bhutan, Myanmar, Nepal, Pakistan and Sri Lanka. Among them he estimated that about 6700 species are endemic to the region, representing 61% of the flowering plants. Recent changes in the political boundaries in the region and the additional knowledge on taxonomy and phytogeography gained during subsequent years necessitate revision of these estimates. Present estimate, pertaining to the political boundaries of present day India, is that about 6100 species or about 36% of the 17,000 species of flowering plants are endemic to this country. Perhaps it would be necessary to revise these figures once the revision of the entire Flora of India in the present series is completed. These endemics are largely concentrated in three principal biogeographic zones, viz. the NW. & W. Himalayas (about 800 species), E. Himalayas and NE. India (about 2500 species) and Peninsular India (about 2600 species). The Andaman & Nicobar Islands contribute about 200 endemic species.

The reasons for such high level of endemism are the high mountains in the north preventing migration northwards, the separation of the southern region by large water-mass of the Arabian Sea, Bay of Bengal and Indian Ocean, the extremely arid conditions on the western parts blocking westward migration of species from middle and eastern regions and the humid tropical conditions of Western Ghats and north-eastern India, resulted in the evolution and speciation of several endemic elements, as in the case of oceanic islands.

The flora of the country shows affinity with the floras of northern countries in Middle East, Central Asia, Russia, China and East Asia. Some elements in Indian flora belong to distant places like Africa and Australia. Weeds have, through a variety of means, reached here from far off places, as far as the New World. Several Malesian elements, particularly among the arborescent species, are common in the flora. Sino-Japanese elements are common, particularly in the eastern Himalayas. European floristic elements, mainly herbs have migrated and naturalised in the temperate and alpine NW. & W. Himalayas and a few in the southern temperate hill tops. African elements are common in the Western parts of the country and peninsular India. Thus Chatterjee (1940, 1962) concluded that there existed an original flora in India, which not mixed up and partly masked due to invasion of plants from outside.

Several workers have attempted division of the world's flora into phytogeographic divisions based on comparative studies. The first attempt was that of the Danish Botanist J.F. Schouw in 1823. He divided world's flora into 25 kingdoms with several provinces in each. Subsequently Engler (1882, 1924), Diels (1908, 1918), Good (1947, 1974). Turrill (1953, 1959) and others have attempted and presented several classifications. The most recent one is that of Takhtajan (1986). He based his classification on climatic parameters, geographic position, evolutionary history and taxonomic affinities and divided the world's flora into the following six kingdoms.

1. **Holarctic Kingdom** (Holarctics) North America, Europe, North Asia and Arctic regions.

2. **Paleotropical Kingdom** (Paleotropics) Africa, Indo Malesia and Polynesian regions.

3. **Neotropical Kingdom** (Neotropics) Tropical Central and South America.

4. **Cape Kingdom** (Capensis) Southern most end of Africa only.

5. **Australian Kingdom** (Australia) Australia and Tasmania.

6. **Holantarctic Kingdom** (Holantarctics) New Zealand, Antarctica and the southern most end of South America.

These kingdoms have been further divided into subkingdoms, regions and provinces.

The classification of Taktajan (1986) provided a list of key elements and endemics in each of the regions and provinces and their significant affinities. The territory of India fits into his classification as shown below.

A. HOLARCTIC KINGDOM

- **Boreal Subkingdom**

- **Eastern Asiatic Region**

1. Eastern Himalayan Province : Darjeeling, Sikkim and Arunachal Pradesh, including Bhutan and parts of Tibet.

2. Khasi-Manipur Province : Meghalaya, Manipur, Nagaland, Mizoram and Tripura.

- **Tethyan Subkingdom**

- **Irano-Turanian Region**

1. Western Himalayan Province : NW. Himalayas including Kashmir, Himachal Pradesh and Garhwal Himalayas, extending to N. Pakistan and Afghanistan.

B. PALEOTROPICAL KINGDOM

Indo-Malesian Subkingdom

- **(a) Indian Region**

1. Malabar Province : West Coast and Western Ghats.

2. Deccan Province : Deccan plateau, south of Vindhya Hills, Eastern Ghats and Coromandel Coast.

3. Upper Gangetic Province : From Aravalli Hills and Yamuna river eastward to Kosi river and northwards to Siwalik hills and south to Vindhya hills.

(b) **Indo-Chinese Region**

1. Andaman Province : Andaman group of islands alone.

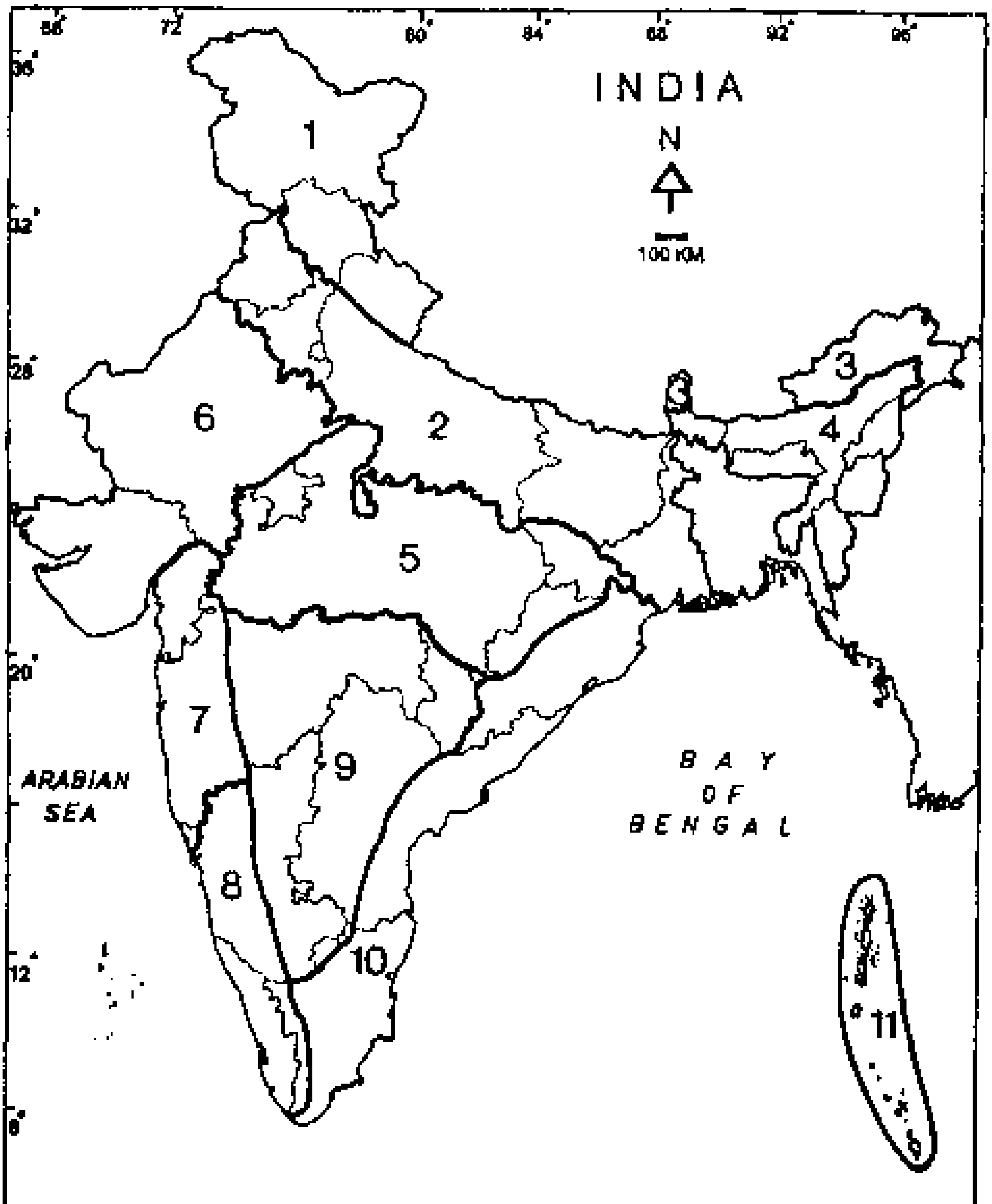
(c) **Malesian Region**

1. **Sumatran Province** : Nicobar group of islands extending to Sumatra and adjoining islands.

Any review of the phytogeopgraphy of the Indian subcontinent should be in the the context of its historical geomorphology. Three factors, the ancient Gondwanaland with which it formed a part the grand northward migration of the Indian plate after breaking away from the Gondwanaland of southern hemisphere and its collision with the Asian mainland, of northern hemisphere, the Eurasian continent, resulting in the rise of the mighty Himalayas and the Great Ice Age which caused southward migration of several northern floristic elements and the subsequent northward migration of southern floristic elements during the retreat of ice, have all influenced the formation of the present flora of this region.

Clarke (1898) published a paper on the sub subareas of the then British India where he expertly analysed the flora of Indian subcontinent, including Sri Lanka, Myanmar, and Malayan Peninsula. Hooker (1904) in his sketch of the flora of British India, modified Clarke's work and presented a new classification for the Indian subcontinent, taking into consideration the migration of plants from Siberia, China and Tibet in the north, Malesia in the south and Africa and Europe in the west. Chatterjee (1940, 1962) taking this view and relying mostly on the herbarium materials available to him, made an elaborate analysis of the flora of th Indian subcontinent including Pakistan, Nepal, Bhutan, Bangladesh, Myanmar and Sri Lanka. He based his conclusions on the percentage of endemics as an indication of the distinctiveness of the flora and also the natural barriers of the lofty Himalayas and the Indian Ocean separating the subcontinent from all other regions.

The vegetation of India has been broadly classified from the forest angle by Champion and Seth (1968) and Sagareiya (1969). Several other recent publications (Arora 1960 & 1964, Thothathri *et al.* 1976, Rao 1974, Rau 1974, Subramanyam & Nayar 1974, Balakrishnan 1977 & 1988, Jain & Sastry 1978 & 1982, Nair *et al.* 1980, Nair & Daniel 1986, Nayar 1980, Jain 1982, Hajra & Shukla 1982, Hajra 1982, Hajra & Rao 1990 and Rao & Murti 1990) have provided useful data for different regions of India.



Map 11. Map showing phytogeographic divisions.

1. North-West Himalayas, 2. Indo-Gangetic plains, 3. Eastern Himalayas, 4. Assam, 5. Central India, 6. Arid Zone, 7. Northern Western Ghats and West Coast, 8. Southern Western Ghats, West Coast and Lakshadweep, 9. Deccan, 10. Eastern Ghats and Coromandel Coast, 11. Andaman and Nicobar Islands.

Survey of the above literature and several other floristic works on Indian flora has shown very interesting phytogeographic affinities. The flora of North - Western Himalayas has many elements of the Mediterranean, West Asian and Central Asian regions. Similarly one also finds certain elements common to the floras of Western India with the eastern parts of Africa. The flora of southern Western Ghats have several elements common to Sri Lanka and even to distant Australia. The flora of North East India has considerable admixture of floristic elements of Tibet, China, Japan, Indo China, Myanmar, Thailand and Malesia. The flora of Andaman Islands show close affinity to the flora of Myanmar, Indo - China, Thailand and Malaysia. Similarly the affinity of Nicobar Islands is towards the eastern and southern territories of Malaysia, Indonesia and particularly to Sumatra and Java. It is thus certain that there has been continuous migration, in both ways, of floristic elements with all surrounding regions and also from distant lands. These migratory elements got mixed up with the indigenous elements of India to produce the present day complex phytodiversity in India.

Consolidating the present knowledge gained by the extensive floristic surveys of the country during the last 38 years by Botanical Survey of India and Universities, coupled with the available literature, the country can be broadly classified into the following phytogeographic zones. Practical utilitarian and matter - of - fact considerations have also played important roles in the following demarcation (Map 11).

1. North West Himalayas
2. Indo Gangetic Plains
3. Eastern Himalayas (Arunachal Pradesh & Sikkim)
4. Assam (North-Eastern India excluding Arunachal Pradesh and North Bengal)
5. Central India
6. Arid Zone
7. Northern Western Ghats and northern West Coast
8. Southern Western Ghats, southern West Coast and Lakshadweep
9. Deccan
10. Eastern Ghats and Coromandel Coast
11. Andaman & Nicobar Islands

Detail account on these phytogeographic zones has been dealt separately.

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5.1. NORTH WEST HIMALAYAS

(P.K. Hajra & J.N. Vohra)

The Phytogeographical region of North west Himalaya comprises the States of Jammu & Kashmir, Himachal Pradesh and Western Uttar Pradesh, following C.B. Clarke (1876) who also used the term Northwest Himalayas for this region. J.D. Hooker (1903) preferred to include this region under the Western Himalaya. D. Chatterjee (1930, 1946) followed Hooker in designating this region as Western Himalaya. On the other hand Rau (1974) used the term Northwest Himalayas only for the States of Jammu & Kashmir and Himachal Pradesh and the term Western Himalaya for the sector of the Himalayas between the Sutlej and the Kali river valley on the Indo-Nepal border. Recently Rodgers and Panwar (1988) have recognised ten broad biogeographic zones and according to them Trans Himalayas and Himalayas are the two zones of the Himalayas under which there are five biotic provinces namely Tibetan, North west Himalayas, West Himalayas, Central Himalayas and East Himalayas. Singh & Singh (1987) recognised three major botanical regions, viz. the Western, the Central and Eastern Himalaya including the mountains of North-eastern India and Assam.

Roughly, the mountain ranges that lie West of 77° E longitude. fall within the Western region (Kashmir, Punjab and Himachal Pradesh), between 77° and 84°E longitude in the Central region (mountains of Uttar Pradesh and W. Nepal) and beyond 84° E longitude in the Eastern region.

BOTANICAL HISTORY

The unique nature of flora of North-western Himalaya has attracted numerous botanists over the last two centuries. The European botanists were the first to make botanical collections in this region in different parts evident from the collections of the plants housed in various herbaria.

Thomas Hardwick seems to be the first person to have made plant collections from the Alakananda valley while on a political mission to contact the ruler of Garhwal in Srinagar as early as 1796.

During the last over two centuries people from all walks of life like missionaries, surveyors, doctors, government civil servants, army officers, tourists and professional botanists have collected plants from this area.

To mention a few important early collectors one can not but remember William Moorcroft who made collections largely from Lahul and Spiti, Kangra and Kullu in Himachal Pradesh and from Kashmir. With the establishment of

Botanical Garden at Saharanpur in the year 1821, a more systematic effort was made to collect the plant in this region. C.B. Clarke, H. Collett, J.F. Duthie, H. Falconer, G.A. Gammie, W. Gollan, G. Covan, W. Griffith, T. Hardwick, V. Jacquemont, Inayat Khan (Duthie's collector), J.F. Royle, Schlagintweit brothers, J.L. Stewart, H. Strachey, R. Strachey, T. Thomson, J.E. Winterbottom, etc. were among the pioneers who have made remarkable and intersting plant collections from this region. In the present century Keshavananda, W. Koelz, Rupchand Thakur, U.N. Kanjilal, R.N. Parker, N.L. Bor, R.R. Stewart, S.P. Sethi, M.V. Laurie, G.S. Puri, C.R. Brown and M.B. Raizada made extensive collections and studied the flora of this region.

After reorganisation of the Botanical Survey of India in 1954 botanists like M.A. Rau, T.A. Rao, N.C. Nair, U.C. Bhattacharyya, A.S. Rao, B.M. Wadhwa, J.N. Vohra, P.K. Hajra, M. Viswanathan, H.J. Choudhery, J.R. Sharma, S.K. Murti, P.C. Pant, B.D. Naithani, B.P. Uniyal and many others of the Survey have also collected plants from this region and published numerous research papers.

VEGETATION

The vegetation type met within any particular area largely depends on the climate, soil, topographical situation and geographical location. The topography of N.W. Himalayan region is irregular and intercepted by valleys and plateaus of various extent and as such the stratification is not clear. There is also a great diversity in the floristic pattern due to great altitudinal variation, coupled with rainfall factor which becomes lesser and lesser from east to west. Based on the altitude and climate the vegetation of this region can be divided into follwoing types and sub types.

1. Subtropical semi-desert type or Artemisia steppe type.
2. Tropical forests :
   (i) Scrub forests
   (ii) Deciduous forests
   (iii) Tree savannah forests
   (iv) Swamp forests
3. Subtropical forests :
   (i) Broad-leaved forests
   (ii) Pine forests
   (iii) Subtropical evergreen sclerophyllous forests

4. Temperate forests :

   (i) Broad-leaved forests

   (ii) Coniferous forests

5. Subalpine forests

6. Alpine vegetation.

1. Subtropical semi-desert type or Artemisia steppe type :

This type of vegetation is generally met with throughout Ladakh, Lahul and Spiti and the higher hills of Garhwal region (Niti and Mana Pass, Nelang valley of Uttarkashi) up to 3000m in the northern and southern exposition.

The vegetation is subjected to arid conditions and hill slopes look like desert. There is no forest vegetation. In the extreme south there is transition to Artemisia steppe.

The plants can be categorised into three groups.

(i) Plants of the desert.

(ii) Plants of oases, that is the plants which live because of irrigation in the villages.

(iii) Plants which grow near melting snow or beside the streams following down from the snow peaks.

(i) The desert type plants include :

Artemisia brevifolia, A. dracunculus, A. scoparia, A. tournefortiana, Chenopodium botrys, C. foliolosum, C. glaucum, Kochia prostrata, K. indica, Suaeda microsperma, Halogeton glomeratus, Linum perenne, Tribulus terrestris, Peganum harmala, Astragalus densiflorus, A. confertus, A. falconeri, A. frigidus, A. gracilipes, A. zanskarensis, Oxytropis cachemiriana, O. densa, O. glabra, O. pusilla, Berberis ulicina, Clematis orientalis, Rosa macrophylla, R. webbiana, Hippophae rhamnoides, Cirsium arvense, Olgaea thomsonii, Saussurea bracteata and species of *Tanacetum, Myricaria, Ephedra, Braya, Corydalis, Arnebia, Thermopsis, Potentilla, Draba,* and the like.

(ii) The follwoing are the commonly cultivated trees in irrigated areas :

Prunus armeniaca, Populus euphratica, P. ciliata, P. nigra, P. pamirica, Salix alba, S. babylonica and *S. caesia.*

(iii) Near the melting snow or besides the streams the species of the followoing common genera are usually found :

Gentiana, Carex, Aquilegia, Delphinium, Ranunculus, Corydails, Saxifraga, Sedum, Sibbaldia, Primula, Geranium, Saussurea, etc.

One of the most characteristic features of the vegetation of Ladakh is the cushion forming plants viz. *Acantholimon lycopodioides, Thylacospermum caespitosum, Caragana versicolor, Arenaria* sp., *Stellaria* sp., etc. The cushion-forming habit is an adoption to withstand cold and dry climate and blizzards.

The vegetation of Lahul and Spiti is very sparse and attributes to the dryness, very low rainfall and excessive grazing. The area remains covered with snow for more than six months in the year. The hill slopes facing south and east are practically devoid of any vegetation, whereas the north and west facing slopes are covered with sparse vegetation.

The vegetation in some pockets of Lahul valley is of typical Western Himalayan type. Exclusive strands of *Pinus wallicihiana* and *Cedrus deodara* are seen in certain places beyond Trilokinath. Besides, sparse growth of *Picea smithiana* and *Juniperus communis* can also be seen. *Salix denticulata* flourishes well in moist gullies.

Cousinia thomsonii, Meconopsis aculeata, Iris kumaonensis, Cotoneaster sp., *Astragalus* sp., are some of the common plants at about 3000m.

2. Tropical forests :

(i) Scrub vegetation in N.W. Himalayas can be noticed in Kathua and Jammu districts of Jammu and Kashmir state, in lower elevations of Uttar Pradesh and Himachal Pradesh, on foothills between the Chenab and Ravi rivers. The vegetation consists of predominantly thorny, deciduous and xerophytic species. The trees never exceed 10 m in height. The summer temperature records as high as 31°C.

The dominant tree species are *Ziziphus mauritiana, Acacia modesta, A. nilotica, A. catechu, Phoenix* sp., etc. Among the thorny shrubs mention may be made of *Flacourtia indica, Carissa spinarum, Euphorbia royleana, Capparis sepiaria, Vitex negundo, Lantana camara, Casearia elliptica, Adhatoda zeylanica, Dodonea viscosa, Woodfordia fruticosa* and species of *Cassia* and *Calotropis*, etc.

The herbaceous plants include *Cleome sp., Amaranthus* spp., *Solanum* spp., *Ageratum conyzoides, Euphorbia* spp., *Martynia annua, Sida* spp., *Tephrosia* sp., *Trianthema* sp., *Boerhaavia diffusa*, etc.

Plate 1. Subtropical coniferous forest of Western Himalayas

Plate 2. Grassland vegetation at foothills of Western Himalayas

Plate 3. Disturbed vegetation (due to biotic factors) in Western Himalayas

Plate 4. Temperate *Quercus* forest of Western Himalayas

Plate 5. Cold desert of Ladakh showing *Ephedra* sp.

Plate 6. Cold desert (Alpine vegetation) of Ladakh

Plate 7. Temperate coniferous forest of Western Himalayas

Plate 8. Cold desert of North Western Himalayas

Among the climbers mention may be made of *Bauhinia vahlii (Phanera vahlii), Porana paniculata, Cissampelos pareira, Aspidopterys wallichii, Hiptage benghalensis*, etc.

Scrub forests in general are not of much economic significance except for fuel, fodder and wild edible berries of a few species. Champion & Seth (1968) categorise these forests under Northern Tropical forests.

(ii & iii) Deciduous and Tree savannah forests : These types of forests include many of the economically important species like *Bombax ceiba, Albizia* spp., *Mangifera indica, Dalbergia sissoo, Shorea robusta*, etc., and as such these forests are much disturbed. Forests fires (man made) are also frequent.

The common tree species found here are *Butea monosperma, Syzygium cumini, Mallotus philippinensis, Ficus benghalensis, Bauhinia variegata, Lannea coromandelica, Grewia disperma, Aegle marmelos, Garuga pinnata, Toona ciliata, Semecarpus anacardium, Desmodium oojeinense, Buchanania latifolia, Erythrina suberosa, Bauhinia malabarica, B. racemosa, Terminalia alata, T. belirica, T. chebula, Premna mucronata, Cassia fistula, Schleichera oleosa*, etc.

Common shrubs in this region are *Eupatorium spp., Lantana camara, Vitex negundo, Cassia spp., Adhatoda zeylanica, Flacourtia indica, Clerodendrum viscosum, Phyllanthus emblica, Indigofera atropurpurea, Boehmeria platyphylla, Asparagus racemosus, Glycosmis arborea, Murraya koenigii, Woodfordia fruticosa, Colebrookea oppositifolia, Helicteres isora, Artemisia nilagirica, Maesa indica, Callicarpa macrophylla, Ardisia solanacea, Sabia paniculata, Ziziphus xylopyrus, Z. oenoplia*, etc., The harbacous plants include *Cleome sp., Amaranthus spp., Solanum* spp., *Agertaum conyzoides, Euphorbia* spp., *Martynia annua, Tephrosia* sp., *Trianthema* spp., *Boerhaavia diffusa, Oxalis corniculata, Polygala arvensis, P. crotalarioides, Drymaria cordata, Sida acuta, S. cordata, S. cordifolia, Abelmoschus crinitus, Urena lobata*, etc. Among the climbers mention may be made of *Bauhinia vahlii, Porana paniculata, Cissampelos pareira, Aspidopterys wallichii, Hiptage benghalensis, Celastrus paniculatus, Gouania leptostachya, Helinus lanceolatus, Ventilago denticulata, Tetrastigma campylocarpum, Cissus adnata, Mucuna capitata, M. nigricans, M. pruriens, Pueraria tuberosa, Shuteria involucrata*, etc.

This type of forests are found ascending up to 1000 m in Kathua, Jammu, Rajouri, Poonch and Udampur districts of Jammu and Kashmir, Sirmur, Bilaspur, Mandi and Kangra of Himachal Pradesh and in the lower altitudes of Garhwal and Kumaon Himalayas.

The Siwalik Sal forests of Champion & Seth (1968) also can be brought under this category. But the only conspicuous feature is the occurrence of *Shorea robusta* (Sal) as the dominant tree speices forming canopies. In some places they are found in association with *Terminalia tomentosa, Adina cordifolia, Anogeissus latifolia,* *Mallotus philippinensis, Syzygium cumini, Phoebe lanceolata, Litsea glutinosa, L. monopetala,* etc. The common shrubs and herbs found in this type of forests are *Colebrookia oppositifolia, Murraya koenigii, Woodfordia fruticosa, Clerodendrum viscosum, Pogostemon sp., Thysanolaena maxima, Boehmeria sp.* etc.

The Sal dominated deciduous forests are very common in the Siwalik region of Himachal Pradesh and Uttar Pradesh. On dry slopes, *Euphorbia royleana* is a dominant plant of the upper tropical and lower subtropical zones in Jammu & Kashmir, Himachal Pradesh and Uttar Pradesh.

iii) Tree Savannah forests :

Savannah vegetation is also quite extensive in subtropical region of North-western Himalaya. These grasslands are not climax type but are constantly maintained by prescribed burning and regular harvesting. The grassland appear wherever clear felling has been done in deciduous forests and thus one can commonly notice *Bombax ceiba, Shorea robusta, Lannea coromandelica* in these grasslands and hence termed as 'Tree Savannah' in comparison with 'Shrub savannah' which are common in the foothills of Eastern Himalaya.

The Dominant grasses in these savannahs are *Apluda mutica, Arudinella spp., Imperata cylindrica, Themeda* spp., *Saccharum* spp., etc. and are of high fodder value. Shrubby species such as *Flemingia fruticosa, Clerodendrum* sp. and several legumes and compositae members grow abundantly mixed with the grasses especially after rains. This type of vegetation is common around foothills region of Uttar Pradesh and Himachal Pradesh. Extensive work has been done on the grasslands of W. Himalaya and interested readers may refer Seth 1954, Gupta 1980, Singh and Saxena 1978, etc.

(iv) Swamp forests :

There are some patches of swamp forests in the foothills region specially in Uttar Pradesh. Kanjilal (1901), Somdeva and Aswal (1974) and others have mentioned about these forests. This type of forests have almost disappeared due to several biotic factors.

Quercus leucotrichophora, Trewia nudiflora, Syzygium cumini, Bischofia javanica, Carallia brachiata, Alstonia scholaris, Pterospermum acerifolium, Diospyros peregrina, Ficus racemosa, Shorea robusta, Glochidion assamica, Mallotus philippinensis, Xylosma longifolium, etc. are some of the dominant plants found in this type of forests. *Calamus tenuis, Diplazium esculentum, Fimbristylis aphylla, Ardisia floribunda, Baliospermum montanum, Tropidia curculigoides,* etc., are some of the common herbaceous and shrubby plants found here.

3. Subtropical forests :

(i) *Broad-leaved forests :*

This type of forests are predominant in undisturbed areas in the subtropical zone similar to subtropical Pine forest areas.

An interesting aspect of the subtropical broad-leaved forest is the occurrence of numerous temperate elements, such as *Rhododendron arboreum, Alnus nepalensis,* etc. Unlike deciduous forests the subtropical broad-leaved forests exhibit high degree of species diversity with numerous shrubby and herbaceous species although there is no clear stratification of the forests. The epiphytic flora is well represented with species of orchids and ferns. The dominant orchids are species of *Dendrobium Cymbidium, Eria, Oberonia, Pholidota, Vanda,* etc.

Dense patches of these forests can be noticed in the surroundings of Thal-Shandev, Didihat-Askot, Gori and Kali valleys, Hindorahal, etc. of Uttar Pradesh.

Quercus leucotrichophora, Rhododendron arboreum and *Lyonia ovalifolia* form dominant association. *Persea obovatissima, P. duthiei, Lindera pulcherrima, Cinnamomum tamala, Photinia integrifolia, Stranvaesia nussia, Rhus punjabensis, Fraxinus floribunda, F. xanthoxyloides, Olea ferruginea, Morus serrata, Engelhardtia* sp., *Alnus nepalensis,* etc., are some of the dominant tree speices commonly noticeable in this type.

(ii) *Pine forests :*

Subtropical Pine forests usually occur between 100-1800 m. *Pinus roxburghii* (Chir Pine) predominates over all other species. The pine forests are of secondry nature appearing in places where natural broad-leaved forests are disturbed. *Carissa sp., Rubus ellipticus., Flacourtia sp., Prinsepia utilis, Anaphalis adnata, Flemingia fruticulosa, Myriactis wallichii, Strobilanthes, sp.* etc., are the common elements found as undergrowth in this type of forests.

(iii) *Subtropical evergreen sclerophyllous forests:*

Just like savannah forests in the tropical zones there are grasslands in subtropical zones too and appear almost in the same way in forest cleared areas, and merge with pine forests. Some of the grass species are also common between these two zones. The dominant speices here are *Arundinella nepalensis, Chrysopogon fulvus, Heteropogon contortus, Bothriochloa bladhii, Imperata cylindrica, Themeda anathera, Saccharum* spp., etc.

Subtropical evergreen sclerophyllous forests of Schweinfurth (1957) can be brought under this category.

Dodonaea viscosa, Punica granatum, Olea ferruginea, etc. are some of the dominant plants found in this type of forests and can be noticed in Kathua and Poonch districts of Jammu and Kashmir and Simla district of Himachal Pradesh.

4. Temperate forests :

The chief character of this type of forest is the extensive development of coniferous species although oaks are also frequent. These forests are similar to those of other parts of North temperate zone in Europe and America (Champion & Seth 1968). The rainfall varies between 1000 2500 mm and the altitudes ca 1500-1900m.

Two main subtypes of forests can be recognised under this category mainly based on the species composition and diversity of flora. In the subtype broad-leaved forests, angiospermic species are dominant, while in the other the coniferous species are dominant almost in pure patches.

Species composition in broad-leaved temperate forest again varies *with* altitudes. At lower *areas* (1500-2100m) the forests are dense although the species diversity is extremely poor. At places extensive patches of oaks (*Quercus semecarpifolia*) forming either pure stands or in association with *Cedrus deodara, Pinus wallichiana*, etc., can be seen as in the Brahmour Valley of Chamba.

The other interesting and common temperate species are *Celtis australis, Quercus dilatata, Q. lanuginosa, Q. semecarpifolia, Ilex excelsa, Fraxinus excelsior, Carpinus viminea, Berberis asiatica, Myrsine africana, Randia tetrasperma, Boenninghausenia albiflora, Arundinaria falcata, Acer caesium, Acer pictus, Buxus wallichiana., Aesculus indica, Corylus jacquemontii, Juglans regia, Ulmus wallichiana*, etc. Usually the ground flora is very poor and only a few shrubs and herbs like *Daphne papyraces, Coriaria nepalensis, Indigofera heterantha, Inula cappa, Sarcococca saligna, Sorbus spp., Spiraea spp., Strobilanthes sp., Wikstroemia canescens*,etc., can be noticed in more exposed situations.

At higher reaches of the temperate zones (2100 2900 m) specially in Garhwal, Kumaon, Himachal Pradesh, Kashmir where rainfall is below 1000 mm and due to several biotic factors like over grazing, lopping of trees, etc., the original forests have turned into scrub forests, where species of *Berberis, Rosa, Hippophae rhamnoides, Salix* spp., *Juniperus* spp. dominate over others. Champion and Seth (1968) classify this type under the Himalayan dry temperate forests.

Cedrus deodara forms pure stands (North of Simla, Khajar in Himachal Pradesh) and *Pinus gerardiana* (only in Himachal Pradesh and Jammu and

Kashmir) appears to be gregarious in relatively dries slopes. In some places *P. gerardiana* occurs in association with *Quercus, Ilex, Betula utilis, Rhododendron campanulatum,* and such other species.

5. Subalpine forests :

Although a distinct line cannot be drawn separating the alpine region with that of subalpine type, the zone between 2900 - 3500 m can be regarded as subalpine zone. Just like the alpine zone, this zone too experiences a severe snowfall for 4-6 months in a year depending upon the area. Conifers like *Abies pindrow, A spectabilis, Picea smithiana, Pinus wallichiana* are found intermixed with broad-leaved species of *Quercus semecarpifolia, Betula utilis, Acer spp.*, etc. *Betula utilis* sometimes form pure stands in places like the approach to the Valley of Flowers, near Dhanasi pass in Nanda Devi National Park approaching Rhotang pass and on way to Gangotri, near Jamnotri.

Taxus baccata subsp. *wallichiana* is also occassionally seen in the lower subalpine zone. Besides these, *Rhododendron campanulatum,*· *Viburnum cotinifolium, V. nervosum, Ribes emodense, R. glaciale, Rosa macrophylla, R. sericea, R. webbiana, Cotoneaster acuminatus, C. brandisii, C. cashmeriensis, C. duthieanus, C. falconeri, C. garhwalensis, C. microphyllus, C. prostratus, C. rotundifolius, Piptanthus nepalensis, Salix pycnostachya, S. lindleyana, S. fruticulosa, Senecio alatus, S. candolleanus, S. graciliflorus, Smilacina purpurea, Thalictrum cultratum subsp. platycarpus, T. pauciflorum, T. elegans, Berberis jaeschkean, B. kashmiriana, B. kumaonensis, B. garhwalensis,* etc., are some of the dominant species forming the ground vegetation/sublayer of forests in this zone. *Osmunda claytoniana* is the most common fern in this zone. The shrubby layer as often composed of gregarious growth of different species of *Juniperus* and *Cotoneaster*. *Rhododendron campanulatum* is another common species found in this region. This type of forests extend from Uttar Pradesh to Jammu and Kashmir.

6. Alpine vegetation :

This type of vegetation is generally found in the altitudes of 3300 and 3600 m. The common plants in this region are *Cotoneaster microphyllus, Juniperus pseudosabina, Rhododendron anthopogon, R. lepidotum, Salix denticulata, S.divergens, S. flabellaris, S. karelinii, S. lindleyana, S. oxycarpa, S. sclerophylla* etc. The dominant herbaceous plants are *Aconitum violaceum, Allium stracheyi, A. wallichii, Anaphalis contorta, A. cuneifolia, A. nepalensis, A. royleana, Aster asteroides, A. stracheyi, A. thomsonii, Bergenia stracheyi, Carex alpine, C. atrodusea var. angustifructus, C. borii, C. cruenta, C. duthiei, C.haematostoma, C. kashmirensis, C. lehmannii, C. nivalis, Caltha palustris, Clematis orientalis, Cassiope fastigiata, Corydalis cashmeriana, C. crassifolia, C. crassissima, C.*

crithmifolia, C. govaniana, C. stricta, Cyananthus lobatus, C. microphyllus, Dactylis glomerata, Danthonia cachermyriana, Epilobium angustifolium, E. laxum, Euphrasia spp., Festuca spp., Gentiana spp., Iris spp., Juncus bracteatus, J. lampocarpus, J. sphacelatus, J. triglumis, Poa alpina, P. angustifolia, P. calliopsis, P. jaunsarensis, P. kedzii, P. nemoralis and many species of *Saussurea., Jurinea Primula, Saxifraga, Kobresia, Leontopodium, Morina, Polygonum, Potentilla, Taraxacum, Sedum,* etc.

As this zone is subjected to severe climatic variations such as heavy snowfall during November-January, the species tend to remain stunted and bushy and several of them are ephemerals adapted to ecological stress conditions. Any slightest disturbance, therefore creats an imbalance in this fragile high altitude ecosystems.

Several of the alpine species particularly in Garhwal-Kumaon sector and further eastwards appear to have migrated from Tibet, West China and adjoining northern-east Asia, whereas the north-western sector has been subjected to considerable influence from the adjoining, floristically rich area like the Karakoram, Pamir and further north in the Tienshan range of mountains.

There are also some alpine species which show restricted distribution in the Western Himalayas (up to Afghanisthan) like *Aquilegia nivalis, A. fragrans, Christolea himalayensis, C. parkeri, Pheonychium parrypides, Heracleum thomsonii, Meconopsis aculeata, M. robusta, Cardamine loxostemonoides, Gentiana cachemirica, Saussurea costus, S. subulata, Inula racemosa, Balanophora involucrata, Corydalis crassissima, Delphinium cashmerianum,* etc., but there are others like *Chenopodium foliosum, Thalictrum alpinum, Cardamine flexuosa, Hyoscyamus niger, Barbarea vulgaris, Viola biflora, Hypericum perfoliatums* and few others which have worldwide distribution.

Arabis tibetica, Physochlaina praealta, Thylacospermum caespitosum, Cardemine macrophylla, Halogeton glomeratus, Christolea crassifoila, Arnebia auchroma, A. guttata, Myricaria squamosa, Cerastium dahuricum, etc., are some elements in this zone which extend northwards into Central Asian Highlands.

Circaeaster agrestis, Cypripedium elegans, C. himalaicum, Nardostachys grandiflora, Saussurea obvallata, Picrorhiza kurrooa, Rhododendron anthopogon, R. lepidotum, Pegaeophyton scapiflorum, Ermania himalayensis, Geranium procumbens, etc., are some of the plants which are known from both Western and Eastern Himalayan regions.

In the high altitude stream beds, banks, marshes and similar wet situation one can commonly notice species of *Juncus leucomelas, J. membranaceous, Polygonum* spp., *Caltha palustris, Pinguicula alpina, Najas minor, N. marina,* *Sparganium ramosum, Potamogeton natans, P. lucens, P. crispus, P. pectinatus, Triglochin maritima,* etc.

The alpine and subalpine grasslands in the Garhwal and Kumaon region are known as 'Bughyals' and are generally noticed in the altitudes above 3500 m as at Joharpatti in Kumaon, Bishtola, Baidni, Ali and Bajmore in the Nandakini basin of Grahwal. In Himachal Pradesh 'Charande' is applied to grazing lands. They are very variable in size and shape and scattered throughout and are burnt annually. Similarly the alpine and subalpine meadows in the inner valleys of Kashmir are locally known as 'margs'. These grazing pastures are above the tree line and below the snow line and are dominated with grasses like *Danthonia cachemyriana, Stipa concinna, S. orientaila, Poa annua, P. stewartiana, Elymus himalayanus, E. longi-aristatus* subsp. *canaliculatus, Agrostis munroana, Calamagrostis decora, C. emodensis, Dactylis glomerata* and others. *Kobresia duthiei, and K. nepalensis* are the common Cyperaceae plants found along with the grasses in these pasture lands.

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5.2. INDO-GANGETIC PLAINS

(G. P. Roy)

Indo-Gangetic Plains cover South-East Punjab below Satluj and Beas rivers, plains of Haryana, plains of Uttar Pradesh and Bihar in between the Himalayas in the north and Vindhyas and Rajmahal hills on the south. The area has been demarcated lower and humid region of the Gangetic plains which also extends up to Bangladesh including Sunderbans.

In general, the climate is characterised by a warm wet season from the end of June or beginning of July to the end of September and then a dry season for the rest of the year. Middle of October to end of February may be regarded as the cold season and April to end of June as the hot season. During the monsoon period the rainfall varies for different tracts. During the dry cold season after rains the temperature and relative humidity of day and night are very variable, resulting in heavy dew falls. Towards the end of December or in January usually some rainfall occur. During April May thunder-storms or dust-storms may occur. Hot winds known as '*Loo*' are common in May and June particularly in Uttar Pradesh and Bihar. The above climatic conditions support the growth of dry deciduous and xerophytic forests in this region.

VEGETATION TYPES :

Most of the areas of Gangetic plains have been under cultivation since time immemorial. Due to extensive agricultural practice, population pressure, excessive felling of trees, overgrazing, fire and human interference, forests have been degraded to open scrub jungles with scattered small trees like *Butea monosperma, Streblus asper, Casearia tomentosa, Holarrhena antidysenterica, Mallotus philippensis* and thorny species like *Flacourtia indica*, species of *Ziziphus, Carissa, Acacia, Mimosa* and *Gardenia*, etc.

Dense forests are confined to Terai regions of the Himalayas and areas boardering Bundelkhand, Vindhya and Kaimur Hills. In Bihar some good forests are found. In West Bengal there are tropical evergreen forests and mangroves in Sunderbans.

Forest vegetation in upper Gangetic plains is generally of tropical dry deciduous type. Most of the trees shed their leaves in the beginning or middle of hot weather and come to leaf again after six to eight weeks. The monsoon period is characterised by the rapid growth of shoots and production of leaves and by the phenomenal growth of numerous annuals which complete their life cycle by early winter. The best time for the flowering of woody species is during the hot season, while a large number of grasses and suffructicose perennials flower at the close of rains or in early winter. The undergrowth during rainy season is generally very dense. Various climbers and scattered bamboos are common. *Shorea robusta, Tectona grandis, Madhuca latifolia, Mangifera indica, Dalbergia sissoo* are very important economic tree species. The ten dominating families are Fabaceae, Poaceae, Cyperaceae, Asteraceae, Euphorbiaceae, Acanthaceae, Rubiaceae, Lamiaceae, Scrophulariaceae and Convolvulaceae.

In general, soil is alluvial and consists largely of sandy or clayey loam. The composition changes even within short distances and varies from pure sand to clay. Sometimes gravelly soil occurs near the surface. On these soils vegetation is of open stunted xerophytic character. Sometimes forests on good soils are interrupted and grassland formation give the appearance of savannah. This is due to secondary succession. The dominant grass species vary with each type of grassland and often form good indicators of a particular locality. In well drained areas the dominant grass is *Saccharum narenga*. This denotes a suitable soil condition for sal. *Imperata cylindrica* indicates clayey soil not suitable for sal. It often forms a dominant species in the type of grasslands known as *majhars* found is Gorakhpur and is usually associated with *Vetiveria zizanoides*. In waterlogged and low lying areas *Arundo donax, Phragmites karka, Sclerostachya fusca* are the characteristic grasses which indicate a condition unsuitable for the growth of tree forests. Roughly five types of forests may be recognised in the area:

1. Sal forests.
2. Mixed forests.
3. Swamp forests.
4. Alluvial forests.
5. Mangroves of Sunderbans.

1. *Sal Forests* : This type of forest is common in the northern belt. The principal species is Sal (*Shorea robusta)* constitute up to 90% of the land. The quality and composition vary with locality. It grows best in well-drained loamy soils, as on slopes. The best quality of sal forests in this area occur in North Kheri. Common species associated are : *Terminalia tomentosa, T. bellirica, Lagerstroemia parviflora, Stereospermum suaveolens, Milliusa velutina, M. tomentosa, Holarrhena antidysenterica, Cassia fistula, Semercarpus anacardium, Buchanania latifolia, Kydia calycina, Grewia* spp., *Diospyros tomentosa, Emblica officianalis, Dillenia pentagyna, Bauhinia* spp., etc. Common climbers are: *Bauhinia vahlii, Millettia extensa, Acacia pennata, Porana paniculata, Smilax* spp., etc.

Following shrubs and low trees are common in the area : *Clerodendrum viscosum, Xeromphis spinosa, Mallotus philippinensis, Croton oblongifolius, Pogostemon benghalense, Flemingia chappar, F. semialata, Desmodium* spp., *Murraya koenigii, Ardisia solanacea,* etc.

2. ***Mixed Forests :*** These forests are characterized by a large number of species, the composition vary from place to place depending on local factors. They pass imperceptibly into the drier types of forests on one hand and into *Sal* forests on the other. Common species are: *Bombax malabaricum, Lagerstroemia parviflora, Stereospermum suaveolens, Emblica officinalis, Adina cordifolia, Mitragyna parvifolia, Lannea coromandelica, Garuga pinnata, Butea monosperma, Bauhinia* spp., *Hymenodictyon orixense, Pterocarpus marsupium, Cassia fistula, Casearia tomentosa, Sterculia* sp., *Kydia calycina, Mallotus philippinensis, Holarrhena antidysenterica, Syzygium cumini, Anogeissus latifolia, Alangium salviifolium,* etc.

In dry condition thorny species like *Ziziphus mauritiana, Z. xylopyrus, Acacia catechu, Flacourtia indica,* etc. form a large proportion of the forest population.

At the north-east boundary of Gorakhpur, several eastern and sub himalayan species like *Premna scandens, Mallotus repandus, Uvaria hamiltonii, Clematis cadmia, Alangium begoniifolium,* etc. are common. This tract mainly lies in tarai which is close to the foothills of Nepal.

Along the Bundelkhand, Kaimur Hills, Vindhyan region generally forest vegetation is of a dry type. It may be broadly divided into two types :

a. Mixed deciduous forests.
b. Dry thorn forests.

Mixed Deciduous Forests : Common tree species found in this type are : *Terminalia tomentosa, T. bellerica, Anogeissus latifolia, Cordia myxa, Lagerstroemia parviflora, Dalbergia latifolia, Ougenia dalbergioides, Cassia fistula, Lannea coromandelica, Acacia catechu, Butea monosperma, Schleichera oleosa, Diospyros tomentosa, Madhuca longifolia, Bridelia retusa, Ficus tomentosa, Schrebera swietenioides, Albizia lebbeck, Flacourtia indica, Grewia* sp., etc.

Dendrocalamus strictus is the common bamboo and often occurs in patches. *Tectona grandis* occurs on quartzites and gneiss along Jhansi district.

Moisture loving species like *Diospyros embryopteris, Terminalia arjuna, Syzygium cumini, Ficus glomerata, Ficus retusa,* etc., occur along perennial streams and moist ravines. In Banda, stunted sal of dry type appears in association with several different species of trees.

Dry Thorn Forests : These forests occur in dry parts of the area, usually on level ground. Characteristic species of this scrub vegatation are : *Balanites aegyptiaca, Ziziphus xylopyrus, Z. mauritiana, Z. nummularia, Grewia* spp., *Acacia leucophloea, Butea monosperma, Calotropis procera, Prosopis spicigera, Capparis aphylla, Dichrostachys cinerea,* etc.

3. ***Swamp Forests :*** These forests occur in water-logged swampy areas. Species composition varies with the degree of water-logging. However, it is difficult to demarcate because of the overlapping species composition. Characteristic species are : *Syzygium cumini, Trewia nudiflora, Drypetes roxburghii, Ficus glomerata, Bischofia javanica, Terminalia arjuna, Celtis tetrandra, Glochidion assamicum, Litsaea polyantha, Trema orientalis, Albizia procera,* etc. Sometimes *Calamus* occurs in association but does not form dense brakes.

Along the edge of the water the characteristic trees are *Barringtonia acutangula* and *Salix tetrasperma.* Some characteristic shrubs are : *Phlogacanthus thyrsiflorus, Daedalocanthus nervosus, Hyptianthera stricta, Ficus heterophylla, Ardisia solanacea.* In the eastern districts, the bush *Cephalanthus naucleoides* often occurs in compact groups in the shallow parts of the *Jheels.* In Gorakhpur the eastern swamp rose, *Rosa involucrata* is sometimes found in open grassy swamps which marks the present western range of this species.

4. ***Alluvial Forests :*** This type of forests occur along the banks of rivers and is frequently flooded and submerged. The soils are the recent alluvium and consist mostly of fine mud. On these formations the most characteristic species is *Tamarix dioica* which occurs gregariously mixed with 'Kans' *Saccharum spontaneum.* Usually the dominant *Tamarix eleminates Kans.* When the soil ceases to be new alluvium due to the river changing its course or becomes otherwise elevated above its original level by silt deposits, trees like *Acacia catechu, Dalbergia sissoo, Bombax malabaricum, Ziziphus mauritiana, Ehretia laevis, Lannea coromandelica, Garuga pinnata,* etc. gradually appear and resemble savannah land with dotted trees which may finally lead to formation of miscellaneous forests as described above.

5. ***Mangrove Forest of Sunderbans :*** It is typically an evergreen forest with trees of moderate height on tidal muddy flats which are permanently wet with salt water submergence from every tide. Common species found in Sunderbans are *Heritiera fomes, Rhizophora, spp., Kandelia candel, Avicennia alba, Bruguiera conjugata, Xylocarpus molnuccensis, Ceriops tagal, Lumitzera racemosa, Xylocarpus granatum, Ceriops roxburghiana, Sonneratia apetala,* etc.

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5.3a. EASTERN HIMALAYAS (SIKKIM)

(R.C. Srivastava)

The State of Sikkim situated on the flanks of the Eastern Himalayas between 27°10' 28°5' N and 88°30' 89 E is bounded by Nepal in the West, Bhutan in the South-East, Tibet in the North and North-East and the Darjeeling district of West Bengal in the South.

The topography of this pretty Himalayan State is varied. The altitudes range from 244 m to over 8598 m. Most of the 7300 sq km area is interlashed with jungle-clad ridges and deep ravines created by, and through which, the raging torrents of the mountain rivers speed and emerald valleys alternating with their terraced hill-sides and dense forests ; a variety of plant beauties along with water-falls, rivulets, lakes and snow-capped mountains girdling the state in a protective embrace, embellish the land.

The climatic, edaphic, altitudinal and biotic variations with their complex inter-relationship and species composition have resulted in different kinds of vegetation cover in the area. The forests cover *ca* 42.8% (3124 sq km) of the total geographic area, of which 2260 sq km are protected and reserve forests. The state is very rich in biological diversity. It is estimated that *ca* 5000 species of flowering plants, *ca* 350 Pteridophytes and *ca* 15 species of Gymnosperms occur in this region. In addition to these a large number of non-flowering plants such as ferns, liver-worts, lichens, mosses, algae, fungi also occur.

BOTANICAL EXPLORATIONS

Sikkim's botanical diversity has attracted a large number of plant collectors from different parts of the world since Griffith's visit in 1843. The famous botanist J.D. Hooker also visited Sikkim during 1848-49 and the account published by him in '*Himalayan Journals*' is still one of the most comprehensive description of the botanical splendour of this region.

Subsequently, distinguished botanists such as G. King, C.B. Clarke, G.H. Cave, W.W. Smith and J.M. Cowan visited the area during later part of the 19th century and early 20th century. In the post 1940 period, comparatively little collections were made except by K.P. Biswas, B.N. Ghosh, R.S. Rao, B.D. Sharma & B.Ghosh and Hara *et al.* But the exploration work gained momentum after the establishment of the Sikkim Himalayan Circle of the Botanical Survey of India at Gangtok in December 1979. In the post 1979 period, A.R.K. Sastry, P.K. Hajra, P. Chakraborty, B. Krishna, A.K. Verma, D.C.S. Raju, R.C. Srivastava, S. Kumar and N.R. Mandal, P. Basu, B. Mitra, S. Singh, M. Sanjappa, M. Ahmedullah, V. Sampat Kumar, K. D. Kumar, N.C. Raut, L.B. Chaudhary collected plants from different areas of the state including the areas like Sakyong Valley (Lepcha land). The Herbarium (SHC) of this Circle now houses *ca* 14000 specimens.

VEGETATION

Broadly Sikkim can be divided into three distinct botanical zones viz. Tropical, Temperate and Alpine depending on the elevation and characteristics of the vegetation. The foothills of Sikkim are covered with forests consisting of the species of *Shorea, Adina, Dalbergia, Dillenia, Artocarpus, Ficus, Bauhinia, Litsea,, Lagerstroemia, Terminalia* etc. In the lower hill ranges (600 1500 m) the forests chiefly include the species of *Schima, Eugenia Duabanga, Engelhardtia, Ficus, Castanopsis, Pandanus, Cyathia, Michelia, Quercus, Saurauia, Photinia, Juglans, Leucoceptrum* etc.

The temperate vegetation comprises *Alnus, Acer, Betula, Magnolia, Rhododendron, Larix, Berbeirs, Salix, Crotoneaster, Vaccinium, Daphne, Sorbus, Rubus* and the herbaceous species of *Aconitum, Anemone, Potentilla* etc. *Abies densa, Larix griffithiana, Tsuga dumosa, Picea spinulosa* and *Taxus walichiana* represent the coniferous belt in the altitudinal range of 2700 3900 m. The Rhodoendron-Conifer forests comprising the several species of *Rhododendron, Daphine, Betula* etc. mark the timberline in the altitude of *ca* 4000 m and above.

The alpine vegetation which occurs above 4500 m and upto a limit of 5500 m is confined to moorlands of coarse meadows with many stunted and dwarf shrubby speices of *Rhododendron*, prostrate plants of *Juniperus squamata* and cushion-like herbaceous species of *Arenaria, Androsace, Aconitum, Cassiope, Saxifraga, Primula, Pingicula, Sedum, Rheum, Saussurea, Gentiana, Kobresia, Carex* etc.

The vegetation in the area may be classified into the following categories :

i) *Low Hill Forests* (tropical to subtropical type, upto 900 m) : From the base (244 m) to 900 m, the sub-mountianous tracts are inhabited by dense broad-leaved semi evergreen forests with trees attaining 24 - 36 m height. The rainfall is heavy, even upto 500 cm annually. Canes and climbers are common. Epiphytes, orchids, aroids etc. are abundantly represented. The undergrowth is luxuriant and varied. *Shorea robusta* (sal) is very common, covering large tracts especially along the Teesta and Rangit rivers. *Schima wallichii, Bauhinia purpurea, Cedrela toona, Stereospermum tetragonum, Bombax ceiba, Dillenia pentagyna, Lagerstroemia* *parviflora, Sterculia villosa, Terminalia myriocarpa, T. tomentosa* and *Albizia* spp. are prominent components of these forests. Other trees occasionally met with *Garuga pinnata, Cedrela microcarpa, Amoora wallichii, A. rohituka, Chukrasia tabularis, Evodia meliaefolia, Ailanthus grandis, Duabanga grandiflora, Tetrameles nudiflora, Celtis tetrandra, Castanopsis indica, Eugenia formosa* and *Michelia champaca* together with laurels like *Phoebe lanceolata, P. hainesiana, P. attenuata Litsea polyantha,* and *Cinnammomum tamala.* Species of *Artocarpus* such as *A. integrifolia, A. chaplasha* together with *Bischofia javanica* also occur. Large cultivated trees of *Ficus elastica* are often seen along banks of the river Teesta, along side Pakyong road and near Dickchu. Occasionally interspersed in the forest are *Ficus semicordata* and *Pandanus nepalensis.* Tree-ferns are not uncommon in the low-land forests of Sikkim.

ii) *Middle Hill Forests* (subtropical type, 750-1500 m) : These are formed largely of dominant evergreen species Deciduous trees may also occur. The trees are usually 20 30 m in height. Epiphytes and climbers occur in large numbers. The undergrowth is not dense and consists of numerous herbaceous and shrubby species. *Castanopsis tribuloides, C. indica, Schima wallichii* and *.Phoebe hainesiana* are the commonest tree species between 750 and 1200 m. *Michelia champaca* and *Stereospermum tetragonum* may also be occasionally met with. Other prominent components of these forests are : *Drimycarpus racemosus, Juglans regia, Engelhardtia spicata, Spondias lutea, Exbucklandia populnea, Michelia cathcartii, Talauma hodgsonii, Saurauia nepalensis, Ficus oligodon, F. semicordata, Betula alnoides, Alnus nepalensis, Terminalia* spp., *Macaranga* sp., *Litsea polyantha, Phoebe lanceolata, P. attenuata,* and members of the family Meliaceae Large evergeen trees of *Quercus glauca, Q. spicata, Q. serrata* and *Q. griffithii* grow in dense formations between 1200 and 1600 m or above. Bamboos may also be found near habitations.

Cryptomeria japonica is introducted and extensively cultivated in these areas. It thrives best in this climate and covers large areas and forms dense forests between 1200 and 2400 m altitude but due to rapid growth the wood remains soft and loses much of its commercial value. The undergrowth is almost lacking except for a few ferns on the fringes of such forests.

iii) *Upper Hill forests* (warm or wet temperate type, 1500 2700 m) : These forests are evergreen with medium-sized trees, rarely over 24 m in height. There are a number of deciduous species but these form only a small proportion. Oaks and laurels form large patches. The oaks have branched crowns and are densely covered with mosses and other epiphytes. These forests are extremely dense and supports both undergrowth as well as epiphytic vegetation. The shelter of trees provide shade and prevent rapid air movements to a considerable extent. This results in a prolific growth of small herbs, shrubs and ferns on the forest floor. Woody climbers are frequent but not conspicuous.

Several altitudinal zones may be distinguished by the preponderance of certain elements, such as laurels between 1800 and 2100 m, *Quercus lamellosa* between 2100 and 2400 m, and *Q. pachyphylla* between 2400 and 2700 m, though freely overlapping. *Michelia cathcartii, Mangolia campbelli, Machilus edulis, Quercus fenestrata* and *Castanopsis hystrix* are quite common in all the forests upto 2100 m. Between 2100 and 2400 m of altitudes, *Quercus lamellosa, Castanopsis tribuloides, Acer campbellii, Michelia excelsa* and *M. cathcartii* are dominant. *Quercus lineata, Betula alnoides* and *Symplocos theaefoila* are also frequently met with, where the former being quite prominent. The oaks constitute the greater part of the trees of top canopy and the members of Lauraceae are usually relegated to the second storey, though numerically predominant. Laurels like *Machilus gammieana, M. gamblei, M. edulis, Litsea sericea, L. kingii, L. zeylanica* and *Cinnamomum obtusifolium* are not uncommon. *Alnus nepalensis* grows mainly along water courses and is the chief colonizer of new landslip areas. *Michelia excelsa* is well known timber tree of this zone.

Still higher up, between 2400 m and 2700 m or so, *Quercus lamellosa, Q. pachyphylla, Castanopsis tribuloides, Acer campbellii, Magnolia campbellii, Symplocos, theaefolia* and *Taxus walhichiana* are the prominent elements of the forests. Above 2700 m in this zone, *Quercus pachyphylla* occurs in pure formations. Under the shade of these forest, *Rhododendron griffithianum* finds a favourable place. Dwarf bamboos, *Arundinaria* spp. are not uncommon as undergrowth at higher altitudes.

iv) *Rhododendron-Conifer Zone* (cold temperate or sub alpine, 2700-3600 m) : The forests of this zone are also evergreen, mainly composed of Rhododendrons and Conifers. Quite often *Quercus pachyphylla* and *Q. lineata* formations extend above 2,700 m altitude and *Acer campbellii A. caudatum, Betula utilis* and *Magnolia campbellii,* may also be met with, though very infrequently. As one proceeds higher up, there is a gradual replacement of oak trees by *Rhododendron arboreum R. campanulatum R. grande* and other species of the genus. *Betula utilis* is occasionally found in the high attitude *Rhododendron* forest at the head of Lachen valley near or above Samdong (3300 m). *Taxus wallichiana* grows commonly in these forests as one proceeds above Lachung. Interspersed with these are patches of *Tsuga dumosa* and *Abies densa*. Between 2700 and 3000 m, in Lachen valley, *Tsuga dumosa* grows in abundance and is the dominant tree. It also grows at Chhoka in West Sikkim. *Picea spinulosa* grows abundantly on all the hills around Lachen intermixed with *Tsuga dumosa* but does not extend beyond 3000 m. The bamboo, *Arundinaria aristata* forms dense undergrowth in silver fir forests, especially where fire has destroyed the tree canopy. *Abies densa* also occurs in almost pure formations between Karponang and Chhangu (East Sikkim), and from Samdong to Thangu (North Sikkim) extending upto 3600 m or a little above. Few trees of *Salix wallichiana*, are also seen growing near Thangu along streams.

Rhododendron arboreum forms scrub on steeper slopes at about 3000 m. Above the tall tree line, the vegetation is a sort of mosaic of *Rhododendron campanulatum, R. wightii, R. thomsonii, R. cinnabarinum* and *R. decipens*. Lacaita scrub on slopes near Chhangu (3900 m) and near Thangu (3900 m). *Rhododendron anthopogon, R. setosum* and *R. barbatum* may also be occasionally met with. Grasslands are frequent at 2700 m altitude and above. *Arisaema* spp. may be found in open places. Various species of *Aconitum* grow abundantly on the forest floor underneath Rhododendrons at high altitudes especially around Thangu.

v) *Alpine Scrub and Grasslands* (3600 4300 m and above) : At the heights above 3600 m where the tree line ends, *Juniperus pseudo-sabina*, and *J. recurva* grow in bushy formations in North and East Sikkim especially on the exposed sunny hill slopes around Thangu (4200 m) and Chhangu (4300 m). *Ephedra gerardiana* covers vast areas along slopes of hills around Thangu (*ca* 4200). The species has not been seen flourishing anywhere else. The beautiful yellow-flowered *Rhododendron lepidotum* is another plant of high altidudes (3600 m or above) and grows in exposed rock crevices, hardly attaining 30 cm. In the open meadows, on gentle mountain slopes a few species *Ranunculus, Anemone, Delphinium, Rhus, Potentilla, Primula, Fragaria, Cassiope, Allium,* etc. are seen.

PHYTOGEOGRAPHICAL ASPECTS

Owing to the varied climatic and ecological conditions in its entire length and breadth, the Sikkim Himalayan region offers very suitable spots into which a variety of floristic elements have migrated from several near and far-off lands. Sino-Japanese elements (viz. species of *Quercus, Schima,* etc.) are quite common in this region. The floristic elements of Western China, which are distributed all along the Sikkim Himalayas are *Aletris pauciflora, Anemone rupicola, A. vitifolia* and others. *Primula sikkimensis* and *Magnolia campbelli* are also the species of Western China which extend from Yunnan to the Eastern Himalaya. The European and Mediterranean elements are represented by the species of *Ranunculus, Gentiana, Swertia, Anemone, Tamarix, Allium, Artemisia,* etc. The American elements in Sikkim flora are exhibited generally by weeds of agricultural lands, open forest edges and waste places e.g. *Eupatorium adenophorum, E. odoratum, Parthenium hysterophorus, Mikania cordata* and *Lantana camara*. African elements such as the species of *Flacourtia, Grewia, Holarrhena, Alstonia* are represented in this region. The Siberian elements are exhibited in many predominantly temperate genera like *Potentilla, Pedicularis* and *Lonicera*. Tibetan elements like *Hippophae, Przewalskia* etc., are also found. An example of considerable phytogeographical significance is the occurrence of *Glaux maritima* (Primulaceae) in Leh area of Kashmir and Llonhak valley of Sikkim. This plant is distributed along the coastal and inland salt marshes of northen temperate and arctic regions. In addition to such examples, there are very interesting areas that can be called Isolation belts' that have led to the isolation of certian species. *Meconopsis bella, Cathcartia lyrata Senecio chola, Saussurea laneana, Geranium* spp., *Primula elwesiana, P. wattii* and *Swertia burkilliana* serve as such examples in the Sikkim Himalayas.

Cytological studies made by Janaki Ammal on genera viz. *Magnolia, Camellia, Lonicera, Rhododendron* and *Viburnum* represented by many species in this region revealed high polyploidy which led her to consider this region (Eastern Himalayas) as a region of active speciation. The occurrence of many families and genera of primitive flowering plants such as *Magnolia, Manglietia, Euptelea, Tetracentron, Pycnarrhena, Haematocarups, Aspidocarya, Holboellia, Exucklandia, Houttu ynia, Myrica, Alnus* and *Betula* has led Takhatajan to consider this region (Eastern Himalaya) *the* cradle of flowering plants.

PLANT RESOURCES

Germplasm

In Sikkim, the tribals Germplasm have preserved primitive but important germplasm of several crops. Still there is a tendency to preserve the local land races and varieties of crop plants which are the products of many years of natural selection and perhaps contain genetic treasures having natural resistance to pests and diseases and adaptability to stress conditions. Noteworthy among these are the prevailing enormous genetic diversity in Iskush, Maize, Wheat, Ginger, Cardamom, Mango, Banana, Orange, Saccharum, etc. The region is particularly important for crop plants such as brassica, rice, cucumber, banana, mango, cardamom, *Dioscorea, Alocasia, Colocasia, Amorphophalus,* and those horticultural significance like Orchids, Rhododendrons, Primulas, Pedicularis, etc. Apart from these, several other elements in the flora which may not have an obvious economic value at present as the same has not been perceived as yet but in future may prove to be of much economic value in view of new vistas in plant research and changing patterns of our needs.

It is the sum total of such remarkable diversity which has made this state to be a 'Gene-bank' for a number of food crops, forest trees, medicinal plants, aromatic and highly ornamental plants, etc.

Endangered plants

The flora of Sikkim is at present under great pressure due to biotic factors like various developmental projects viz. Hydel power projects, road construction activities, heavy deforestation by burning and tree-felling for expansion of agricultural fields, intensive grazing, tourist-bungalows, etc. These activities have destroyed many rich diversity centres on one side and on the other side have initiated several new land slides zones due to which a large number of precious rare plants are getting lost within a very short spell of time. These include : *Acer* *hookeri* var. *majus*, *Pimpinella tongloensis*, *P. wallichii*, *Pternopetalum radiatum*, *Lactuca cooperi*, *Areneria thangoensis*, *Coelogyne treutleri*, *Cymbidium eburneum*, *C. hookerianum*, *C. whiteae*, *Cypripedium elegans*, *C. himalaicum*, *Didiciea cunninghamii*, *Diplomeris hirsuta*, *Paphipedilum venustum*, *Zerxine pulchra*, *Aconitum ferox*, *Cotoneaster simonsii*, *Picrorhiza kurrooa*, *Acronema pseudotenera*, *Angelica bulbigena*, *Ceropegia hookeri*, *C. lucida*, *Codonopsis affinis*, *Rhopalocnemis phalloides*, *Carex kingiana*, *Lloydia himalensis*, *Aphyllorchis parviflora*, *Calanthe alpina*, *Ophiorrhiza lucida*, *Nardostachys grandiflora*, *Dennstaedtia elwesii*, *Mecodium levingei*, *Panax pseudoginseng*, *Calamus inermis*, *Livistonia jenkinsiana*, *Begonia rupicola*, *B. satrapis*, *B. scutata*, *Lagerstroemia minuticarpa*, *Vanda spectabilis*, *Cyclogramma squanaestipes*, *Oreopteris elwesii*, *Christopteris tricuspis*, *Rhynchospora sikkimensis*, etc.

Endemic plants

Sikkim has comparatively less number of endemics (which are confined to present political boundaries of Sikkim) because many of them range from Nepal to Bhutan. It is estimated that the total number of endemics truly confined to present Sikkim may be *ca* 2 per cent of the total number in the floral elements. These include *Agrostis neodebilis*, *Calamagrostis tripilifera* var. *tripilifera*, *C. tripilifera* var. *cumminsii*, *Catabrosa aquatica*, *Cyathopus sikkimensis*, *Drepanostachyum intermedium*, *Poa gammieana*, *Trisetum sikkimense*, *Carex kingiana*, *Rhynchospora sikkimensis*, *Coelogyne treutleri*, *Anaphalis cavei*, *A. hookeri*, *A. subumbellata*, *Artemisia thellungiana*, *Blumea sikkimensis*, *Cremanthodium decaisnei f. clarkei*, *C. palmatum ssp. benthamii*, *Crepis atropappa*, *Gentiana glabriuscula*, *G. prainii*, *G. pluviarum*, *G. recurvata*, *Inula macrosperma*, *Jaeschkea microsperma*, *J. smithii*, *Ligularia dur*, *L. hookeri ssp. clarkei*, *L. pachycarpa*, *Saussurea forrestii*, *S. lineana*, *S. nimborum*, *S. obscura*, *S. pantlingiana*, *Swertia ramosa*, *S. rex*, etc. besides many more.

To conserve the depleting resources of this region, several attempts are being made. Kanchanjanga National Park, Fambongla Wildlife Sanctuary and Kabi sacred groove are good examples where several endangered taxa are conserved. There are some botanical gardens viz. Jawaharlal Botanic Garden, Saramsa Botanic Garden and Orchid Sanctuary, Rhododendron Sanctuary near Yumthang, etc., wherein ex-sita and in-sita conservation of many species is being attempted. Different sacred grooves situated in various parts of the state are playing a very positive role. But at present the main emphasis is to relocate or recollect the threatened taxa and attempts should be made for their *in-situ* conservation. However, in some cases the help of advance technologies viz. Tissue culture technique etc. can be used with advantage. In addition to this, the areas of diversity centre like Pangolekha range, Tendong ridge, Sakyong valley, Dambyong valley, etc. should be brought under full protection.

Medicinal plants

Sikkim Himalayan region is the abode of a large variety of medicinal plants. *Przewalskia tangutica, Nardostachys grandiflora, Picrorhiza kurrooa, Aconitum luridum, Podophyllum hexandrum, Dactylorrhiza hatagirea, Taxus wallichiana Ephedra gerardiana* and *Lycopodium clavatum* constitute the most important medicinal plants of the alpine zone. Several potential medicinal plants like *Dichroa febrifuga, Houttuynia cordata, Artemisia vulgaris, Rubia cordifolia, Panax pseudoginseng, Diosorea deltoidea, Digitalis purpurea, Bergenia ciliata* are quite common in temperate and subtemperate zones. Tropical zone is also quite rich in the medicinal flora wherein plants viz. *Costus speciosus, Vitex negundo, Solanum viarum, Cissampelos pareira, Woodfordia fruticosa, Oroxylum indicum, Alstonia scholaris, Abroma augusta* and to some extent *Rauvolfia serpentina, Terminalia chebula, Holarrhena pubescens* etc. grow in good number.

Species of Horticultural importance

As the Flora of Sikkim includes plants of tropical, temperate and alpine characters in great diversity, a large number of plants found wild in this state (or the Eastern Himalayas as such), are of great horticultural importance. Many of them have been introduced into the European gardens. These include the species like : *Hedychium gardenerianum, Luculia gratissima, Allium wallichii, Acer oblongum, Anemone vitifolia, Arisaema griffithii, Berberis aristata, B. asiatica, B. sikkimensis, Bergenia ciliata, Betula utilis, Boenninghausenia albiflora, Cautleya gracilis, C. spicata, Cymbidium cyperifolium, Daphne bholua, Juniperus recurva, Mahonia acanthifolia, Meconopsis bella, Meillia thyrsiflora, Paris polyphylla, Pleione praecox, Polygonatum oppositifolium, Prunus cerasoides, Rhododendron anthopogon, R. arboreum, R. barbatum, R. hodgsonii, R. nivale, Rosa macrophylla, R. sericea, Vandopsis undulata, Viburnum cordifolium,*species *of Corydalis, Gentiana, Pediculasis, Primula* and several others.

Food plants

There are over 350 species of flowering plants and Pteridophytes found wild in diverse localities of Sikkim which may serve as emergency life-saving food. These include : flowers of *Urtica dioca, U. parviflora* ; rhizomes of *Dioscorea* spp. (Tarul-Nep.) ; fruits of *Aisandra butyracea* (Chiwari-Nep, Yelkung-Lep.) ; *Calamus erectus* ; *Elaeagnus conferta* (Malindo-Nep.); *Heracleum lanatum* ; *Podophyllum hexandrum* (Papri-Nep.); *Machilus edulis* ; *Melia dubia* ; *Morus australis ; Terminalia chebula* , *Zanthoxylum acanthopdium* ; leaves of *Phytolacca acinosa* ; young shoots of *Rheum nobile Diplazium esculentum*, sheath from young shoots of *Polygonum molle* and *Ficus virens;* tubers of *Satyrium ciliatum* ; flower buds of *Bauhinia purpurea* ; inflorescence of *Tupistra natans*. Leaves of *Camellia kissii* and bark of *Betula* spp. are used for making tea, finger millet, *Rhododendron* (Flowers), Junipers, corn, East Himalayan cherry, etc., are brewed as local wine which are named after the source plant viz. Guras wine, Cherry brandy, Juniper wine, etc.

Fire-wood yielding species

Due to the total dependence of the rural folk on fire wood for cooking and warming of the houses, any woody plant is cut and used as a fire wood ; yet some important firewood yielding species include : *Alnus nepalensis*, *Betula cylindrostachys* *Castanopsis indica*, *Engelhardtia spicata*, *Toona ciliata*, *Cryptomeria japonica*, *Acer campbellii*, *Schima wallichii* etc. At higher elevations even the plants like *Abies densa*, *Tsuga dumosa*, *Picea smithiana*, *Rhododendron* spp., *Larix griffithiana* are also used.

Timber yielding species

Most important timber yielding species of the State include *Shorea robusta*, *Tectona grandis*, *Juglans regia*, *Castanopsis indica*, *Quercus lamellosa*, *Toona ciliata*, *Cryptomeria japonica* and *Terminalia myriocarpa*.

Dye yielding plants

Most important plants used on commercial scale include : roots of *Rumex nepalensis* stem of *Rubia munjista* bark of *Mahonia nepalensis*; fruits of *Dichroa febrifuga*; leaves of *Symplocos glomerata* bark of *Juglans regia* etc. In addition to these several other dye yielding plants viz. *Bixa orellena*, *Mallotus philippinensis*, several spp. of *Indigofera*, etc., occur wild in the state.

Fodder yielding species

Although a large number of species are employed for feeding the livestock, yet the preferred ones include *Ficus auriculata*, *F. oligodon*, *F. hirta*, *F. hispida*, *F. virens*, *F. clavata*, *F. nemoralis*, *Sauruia nepalensis*, *Morus alba*, *Brasssiopsis mitis*, *Artocarpus lakoocha*, *Grewia oppositifolio*, *Litsea polyantha*, etc.

Botanical curiocities

Several examples of biologically very interesting plants in Sikkim Flora include the insectivorous plants like *Drosera burmanii*, *Pinguicula alpina*, *Utricularia* spp. (*Lentibulariaceae*), beautiful parasites like *Aeginetia indica* (*Orobanchaceae*) etc. Several plants, which grow especially in the high alpine meadows, survive extreme adverse ecological conditions by special adaptations; e.g. woolly species of *Saussurea* (*S. gossypiphora*) or cushion like or bushy habit (species of *Arenaria*, *Festuca*, *Juniperus*, *Gaultheria*, *Saxifraga*, etc.). Some of the very primitive angiosperms viz. *Magnolia pterocarpa* (Magnoliaceae), *Tetracentron sinense* var. *himalayana* (Tetracentraceae), *Talauma hodgsonii* (Magnoliaceae) occur in this state. Several medicinal plants like *Podophyllum hexandrum*, *Panax pseudoginseng*, *Dactylorrhiza hatagirea*, *Picrorhiza kurrooa*, *Nardostachys grandiflora*, *Berberis aristata*, *B. asiatica*, *Valeriana wallichii*, *Ephedra gerardiana var. sikkimensis*, *Taxus wallichii*, *Mandragora caulescens*, *Aconitum ferox*, *A. spicatum*, *Dioscorea deltoidea*, *Rauvolfia senpentina*, etc., which created sensational news are valuable components of Sikkim Flora.

A large number of epiphytes such as foliose lichens; a variety of mosses and ferns cover available space on the bark of the trees with roots suspended in the air having the ability to absorb moisture from the atmosphare. Some species of *Rhododendron*, *Impatiens* (1 sp.), *Aeschynanthus*, *Polygonatum*. *Cautleya*, *Hedychium*, *Gonatanthus* and many orchids and aroids are epiphytic in these forests.

Sacred groves

Sacred groves are playing important role in *in-situ* conservation of the indigenous elements of the Flora and Fauna of Sikkim. Most of these are the places of worship and have a Monastery at the summit. A few like Kabi sacred grove being the place of union of Lepchas and Bhutias, are of historical importance. Many of them are declared as 'reserve forests' and are well protected from the bitotic pressure. Khetchipheri Sacred grove in West district, Mt. Mainam, Rabong, Tendong Sacred groves in South district, Churten Sacred grove in East district and Kabi Sacred grove in North district are a few good examples where a variety of precious elements of Flora and Fauna are well protected. *Cyathea spinulosa* and *C. gigantea*, the tree-ferns which are under threat due to demand for their trunks in orchid, culture and trade, are well protected in Churten Sacred grove. *Camellia kissi*, the wild tea is common in the protected woods around Khetchipheri lake. 'Red-Panda' (*Ailurus fulgens*) the State Animal of Sikkim, finds the dense thickets of Kabi Sacred grove quite suitable for its inhabitation. *Dendrobium nobile* the State Flower of Sikkim is also quite common here.

Conservation aspects

Vavilov (1951) had started that "many of the areas of centre of origin of crop plants are the areas where the tribal people live. and sooner or later the Governments of these regions, are bound to uplift them socially and economically. Once these communities are in different socio-economic milieu, the working of thousands of years of natural selection will be lost because the people would like to go in for high out-put agriculture." This statement is very true in case of Sikkim.

During the recent past a great deal of damage has been done to the rich biodiversity of Sikkim Himalayas. The forests have been denuded by the haphazard felling of trees for timber, through intense grazing, road-construction activities, etc. Rural folk of Sikkim still depend totally on firewood for cooking and also for warming their houses.Frequent landslides resulting from deforestation are eleminating several habitats of many biologically and economically important plants even before they or their utility is known to the society.

Not only deforestation, but even afforestation programmes (particularly monoculture) to a greater extent are responsible for the loss of biodiversity of Sikkim Flora. Plantation of exotic trees like *Cryptomeria japonica, Pinus patula,* etc., may have added to the green cover but the fact is that because of its impact on soil, several precious elements of the ground flora are getting lost. Actually the indigenous species like *Alnus nepalensis, Duabanga grandiflora, Terminalia myriocarpa,* etc., should be included in afforestation programme. Now a days great emphasis is being geven to promotion of Tourism in the State which is showing disruptive influence on local traditional and social mores by introducing new and undesirable life styles, and has adverse effect on biodiversity as well.

Because of large scale cultivation of large cardamom which is a major revenue yielding crop of the State, several precious elements of ground Flora (e.g. *Paphiopedilum venustum*, the lady's slipper orchid) are getting eleminated.

Another major threat to the floristic diversity is the mushroom growth of small and large scale Hydel power projects. These are causing an irrepairable damage to Flora of the State.

Being the border line state defence establishment in Sikkim cannot be avoided. But it has definitely resulted in a large scale deforestation and soil erosion because the impact of defence activities on the fragile ecosystem and geological aspects have not been taken into consideration.

Although several botanical expeditions have been made to Sikkim since 1843, yet even today any serious botanical exploration yields a number of novelties such as new taxa, new records, and many interesting plants, some of which are of great economic and botanical importance. Therefore, our present knowledge about the plant resources of Sikkim is not the last word on the real situation in this region. Still much is to be done and much is to be known about the hidden 'Green Gold' treasure of the State.

The strategy of utilization of plant resources of the Sikkim Himalayas is to be drawn after taking into consideration all the factors and to ensure that the large variety of flora of this region not only continues to survive but maintains conditions for the evolution of the flora i.e. for speciation or origin of new taxa.

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5.3b. ARUNACHAL PRADESH

(H. J. Chowdhery)

Arunachal, the land of rising sun in the extreme northeastern corner of India extends over an area of 83740 sq km lying between 26° 28' and 29° 30' North latitude and 90° 30' and 97° 30' East longtitude. It is bounded in the north by McMohan line, in the east by China and Myanmar (Burma), in the west by Bhutan and in the south by the Indian states of Nagaland and Assam.

Arunachal Pradesh has generally a hilly terrain characterised by hill ridges and valleys. The elevation of hills ranges from 200 m (the Siwalik formations) from the plains of Assam up to 7750 m (in the inner Himalayas) along the Tibet-China border. Arunachal Pradesh was earlier divided into Aka hills, Daphla hills, Miri hills, Abor hills and Mishmi hills named after the predominant hill tribes. However, physiographically the Himalayan ranges in Arunachal Pradesh can be divided into 3 divisions:

a. *The Siwalik and the foothills* : Occur along the southern border of Arunachal Pradesh along the longitudinal valleys of Kameng, Subansiri, Siang and Dibang.

b. *The Lesser Himalayas* : From the Assam plains, the Siwaliks attain a sudden rise and merges into lesser Himalayan ranges in the north.

c. *The Greater Himalayas* : Peaks as high as 6000m and above are located in this division viz., Gorichen (7300 m), Kangto (7090 m), Namcha Barwa (7756m), Kulangri (7544m), Chome Lhari (7344m) etc.

The wide ranging altitudinal variations from 100 m in the foot hills to *ca* 7800 m high Himalayan mountains, rippling water over stones and boulders of the streams and mighty rivers flowing down to the delightful valleys; high rainfall and humidity; soil conditions etc. have blessed Arunachal with a rich and very diverse flora.

HISTORY OF PLANT EXPLORATIONS

The geography, location, climate and varying topography have contributed to the characteristic, rich and diverse flora of Arunachal Pradesh. Despite its fabulous plant wealth this region has so far not been able to attract as many plant collectors, explorers as compared to other regions within Eastern Region. The extensive as well as intensive plant collection and survey work in the state was initiated after the reorganisation of Botanical Survey of India in 1955. However, there are some important explorations conducted prior to 1955 of which mention may be made of the following:

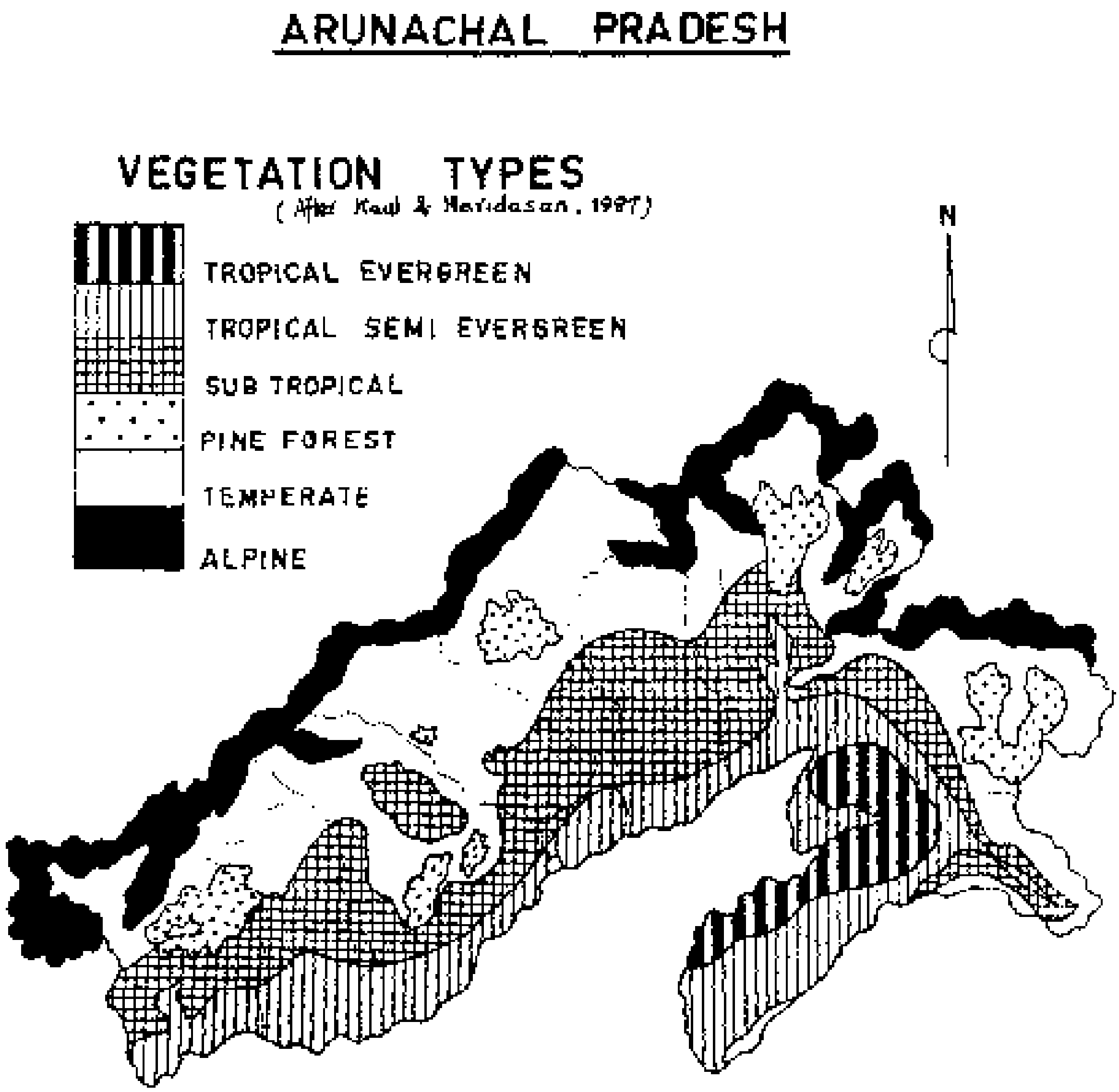
H. Wilcox was the first Botanist who for the first time explored the Mishmee hills (Dibang valley) in 1826. Subsequently, Griffith in 1836 botanized this region and his "Flora of Mishmi Hills" enumerates 900 species of flowering plants and 22 of ferns and fernallies. Thomas J. Booth undertook horticultural explorations between 1840-1850, from Bisnath (Assam) into the hills of Daphlas situated at the southern corner of Bhutan and described some Rhododendrons from this area. With the advent of 20th Century, plant explorations in this region gained momentum which resulted in the publication of some important floristic accounts of this regions such as "on the Botany of Abor Expedition" by Burkill (1924-1925); "Botanical Expedition in the Mishmi Hills' by Kingdon-Ward (1929-1931); "Lohit Valley" by Kingdon-Ward (1953) and "A sketch of the vegetation of Aka by when Hills" based on the collections of Bor (1931-1934) which enumerates 1549 species of flowering plants, 9 species of gymosperms and 58 species ferns and fernallies. S.K. Deka from Assam Forest Department in 1951 and K. Srinivasan in early 1955 missing surveyed along the Rupa valley in Kameng district. In the late 1955, R.S. Rao undertook plant explorations along the Rupa and Dirang valley up to Sela in Kameng district and Apatani valley and surrounding areas of Subansiri district.

With the inception of the Eastern Circle of Botanical Survey of India at Shillong, various parts of Arunachal viz. Kameng, Subansiri, Siang, Lohit, Tirap etc. were surveyed for its vegetational wealth of which R.S. Rao and Panigrahi (1958-1959); R.S. Rao and Joseph (1958); Panigrahi and Naik (1959); Deb (1961); Sastry (1964, 1965 & 1966); Joseph (1964, 1969); Hajra (1970, 1976) A.S. Rao (1969, 1970) and Deb and Dutta are worth mentioning. Apart from these, K.C. Sahni (1964, 1969) from Forest Research Institute, Dehradun has also made valuable contributions to the Flora of Arunachal Pradesh. Recently G.D. Pal (1978-1985) from Botanical Survey of India, surveyed the Lower Subansiri district of Arunachal Pradesh and has made significant contributions to the flora of the state.

Arunachal with its rich floristic diversity is also inhabited by the largest number of tribes and they lead an intricate life totally dependent on the forest plants. Virtually all their requirements ranging from food, fuel, fodder, medicine, cordage and various other domestic needs are met from the local vegetation. Anonymous (1976), Dam *et al.*, (1980), Pal (1984), Jain (1981), Pal and Thothathri (1987) and Haridasan *et al.*, (1990) have attempted to record such plants used by the local tribes.

VEGETATION

Based on the studies conducted by workers (Burkill, 1925; Bor, 1938; Biswas, 1941; Rao, 1972; Malhotra & Hajra, 1977; Anonymous, 1982; Roy *et*



Map 13. Vegetation types of Arunachal Pradesh

Plate 53. Riverine forests - (West Kameng)

Plate 54. ''Jhum' cultivation'' with remains of burnt trees

Plate 55. Pine forest - (West Kameng)

Plate 56. *Calamus leptospadix* Griff.

Plate 57. 'Jhum' - burning of primary forests

Plate 58. *Tacca integrifolia* Ker-Gawl. - inflorescence

Plate 59. *Curcuma* sp.

Plate 60. *Phlogacanthus curviflorus* Nees

Plate 61. *Rhododendron arboreum* Smith

Plate 62. *Sapria himalayana* Griff. (A rare root-parasite)

Plate 63. *Dendrobium fimbriatum* var. *oculata* Hook.

Plate 64. *Musa balbisiana* Colla (Wild Bannana)

Plate 65. *Amomum subulatum* Roxb. (Cardamom)

Plate 66. *Paphiopedilum fairieanum* (Lindl.) Stein ('The lost Orchid', rare and endangered)

Plate 67. *Paphiopedilum insigne* (Wall. ex Lindl.) Plitz. (Rare and Endangered)

Plate 68. *Bulbophyllum delitescens* Hance (Rare and Endangered)

al. 1983; Kaul & Haridasan, 1987) the vegetation types of Arunachal Pradesh can be broadly classified into following types (Map 13) :

1. Tropical, 2. Subtropical, 3. Temperate, 4. Alpine and 5. Secondary vegetation or forests.

1. TROPICAL VEGETATION :

This type of vegetation is found upto an elevation of 900 m in the foothill regions with heavy rainfall and high summer temperature. The tropical vegetation may be divided into 2 types :

a. Tropical Evergreen.

b. Tropical Semievergreen.

a. *Tropical Evergreen Vegetation* : Occurs in the areas receiving maximum rainfall. Some of the most commonly occurring tall tree species are: *Altingia excelsa, Amoora wallichii, Artocarpus chaplasha, Bombax ceiba, Bischofia javanica, Callicarpa arborea, Canarium bengalensis, Castanopsis indica, Chikrassia tabularis, Cinnamomum cecicodaphne, Dillenia indica. Dipterocarpus gracilis, D. macrocarpus, Duabanga grandiflora, Dysoxylum procerum, Echinocarpus* sp., *Kayea assamica, Lagerstroemia speciosa, Magnolia campbellii, Mesua ferrea, Pterospermum acerifolium, Quercus glauca, Q. mellosa, Shorea assamica, S. robusta, Terminalia chebula, T. myriocarpa* and *Tetrameles nudiflora* etc. whereas the most common small trees and shrubs met within this type are: *Abroma augusta, Actephila excelsa, Anplectrum assamicum, Ardisia humilis, A. undulata, Baliospermum corymbiferum, Bauhinia purpuea, Boehmeria macrophylla, B. platyphylla, Boeica fulva, Buddleja asiatica, Clerodendrum bracteatum, C. glandulosum, C. serratum, C. venosum, Coffea bengalensis, Ficus hispida. Goniothalamus sesquipedalis, Grewia multiflora, Illicium manipurense, Laportea crenulata, L. pterostigma, Leea robusta, Michelia doltsopa, Micromelum minutum, Mussaenda roxburghii, Oxymitra fornicata, Oxyspora paniculata, Phlogacanthus* spp., *Rhus semialata, Sambucus hookeri, Solanum torvum, Sterculia indica, Strobilanthes coloratus, Syzygium pseudoformosum, Talauma hodgsonii* and *Triumfetta bartramia.* Canes like *Calamus erectus* and *C. leptospadix* occur in swampy areas and form impenetrable thickets. Palm species like *Livistona jenkinsiana, Wallichia densiflora* and *Phoenix sylvestris* grow commonly scattered on the drier hill slopes whereas, *Pandanus furcatus*, species of *Cyathea*, (the tree ferns) and large-leaved fern like *Angiopteris evecta* are also seen growing along the streams and moist places. Species of wild bannana, (*Musa* spp.) are one of the most important features of these forests.

The forest trees are densely covered with numerous climbers and epiphytes like species of *Acacia, Bauhinia, Entada, Gnetum, Hodgsonia, Mucuna,* *Mezoneurom, Piper, Raphidophora, Thunbergia, Toddalia, Unona* and *Vitis.* While, species of *Calamus* are found stretching with long stems from one tree to another.

Some of the most common epiphytes are species of orchids like, *Aerides, Coelogyne, Cymbidium, Dendrobium, Eria, Oberonia, Pholidota, Rhyncostylis, Saccolabium* etc. and a variety of ferns. *Aeschynanthes spp., Chonemorpha griffithii, Dischidia rafflesiana, Gymnostemma pedata, Naravelia zeylanica, Pueraria phaseoloides, Rhaphidophora* sp., *Scindapsus officinalis, Tetrastigma bracteolatum, Trichosanthes cordata* and species of *Hoya, Ipomoea, Clematis, Jasminum, Piper, Pothos, Thunbergia, Dioscorea* are some of the comon climbers seen growing on trees and on top of bushes and shrubs. Stem parasites like species of *Cuscuta reflexa, Cassytha capillaris* and several members of the family Loranthaceae are also quite common. *Asystasia neesiana, Exacum tetragonum, Floscopa scandens, Hydrocotyle javanica, Lindenbergia indica, Lobelia succulenta, Murdannia nudiflora, Oxalis corniculata,* species of *Begonia, Globba, Hedychium, Impatiens* and *Polygonum* are common herbaceous elements. *Arundina graminifolia,* the bamboo orchid with its attractive lilac-red flowers may be seen growing alongwith tall grasses on the open cut slopes of the hills on the road sides. *Tacca* spp. with their showy floral bracts are also conspicuous in shady places along the streams and moist places at lower elevations. Several species of terrestrial orchids like *Goodyera, Habenaria, Liparis, Malaxis, Phaius* etc., fern species like *Asplenium, Onychium, Polypodium,* and fern allies mainly the sepcies of *Equisetum, Lycopodium* and *Selaginella* are quite common. Among the interesting root parasites *Balanophora dioica* infesting the roots of many tree species is worth mentioning. The saprophytic species like *Monotropa uniflora, Epipogium* spp. and species of *Galeola* the giant orchid occur in moist, shady, humus rich soils under these forests.

The conspicuous rhizomatous Monocotyledons forming a green-belt at lower elevations alongwith bamboos and wild bannanas are species of *Amomum, Arisaema, Colocasia, Curcuma, Gonatanthus, Hedychium, Zingiber, Boesenbergia longiflora, Forrestia mollisima, Homalomena aromatica, Molineria* etc. *Clerodendrum squamatum* var. *urticifolia* with beautiful red flowers in large terminal bunches is occasionally seen associated near the forest edges.

b. *Tropical Semi evergreen Vegetation* : Occurs along the foothills and river banks and is of two types :

b.1. Low Hills & Plains Semi evergreen Type.

b.2. Riverine Semi evergreen type.

b. 1. *Low Hills & Plains Semi evergreen type* : This type is dominated by tall tree species like *Adina oligeocephala, Ailanthus grandis, Altingia excelsa, Amoora wallichii, Anthocephalus chinensis, Artocarpus lakoocha, Bischofia* *javanica*, *Bombax ceiba*, Canarium strictum, Castanopsis sp., *Chukrassia tabularis*, *Cinnamomum cecicodaphne*, *Duabanga grandiflora*, *Dysoxylum binectariferum*, *Eleocarpus aristatus*, *Firmiana colorata*, *Phoebe goalparensis*, *Pterospermum* sp., *Sterculia alata*, *Storculia villosa*, *Stereospermum chelonoides*, *Terminalia myriocarpa*, *Tetrameles nudiflora* etc. while, *Crateva nurvala*, *Croton oblongifolium*, *Ficus* spp., *Gynocardia odorata*, *Litsea panamonja*, *Meliosma simplicifolia*, *Picrasma javanica*, *Saurauia cerea*, *Syzygium* sp., *Talauma hodgsonii*, *Turpinia nepalensis* etc. are the dominant small tree species and species of *Ardisia*, *Boehmeria*, *Capparis Clerodendrum*, *Phlogacanthus*, *Strobilanthes* are some common shrubs. The ground floor is dominated by weedy species of *Ageratum*, *Amorphophallus*, *Arisaema*, *Colocasia*, *Costus*, *Impatiens*, *Strobilanthes* and common climbers like *Conocephalus cochinchinensis*, *Gouania tiliaefolia*, *Roydsia suaveolens*, *Thunbergia* spp. etc. Epiphytic species like *Dendrobium*, *Hoya*, *Papilionanthe* and several species of ferns may also be seen in this vegetation type.

b. 2. *Riverine Semi evergreen Type:*

Such vegetation exists along the river banks, riverine plains and swamps. The trees in this vegetation type are generally deciduous, buttressed and lack dense canopy. The top canopy is dominated by *Albizia* spp., *Artocarpus chaplasha*, *Bischofia javanica*, *Bombax ceiba*, *Canarium resiniferum*, *Castanopsis* sp., *Dalbergia sissoo*, *Dillenia indica*, *Duabanga grandiflora*, *Lagerstroemea parviflora*, *L. speciosa*, *Radermachera gigantea*, *Sterculia villosa*, *Terminalia bellerica*, *T. myriocarpa* etc. The second storey, if present, generally consists of species of *Ficus*, *Litsea*, *Talauma*, *Turpinia*, *Villebrunea etc. Calamus*, *Murraya* and *Randia* spp. often form dense covering at the ground level mixed with *Costus*, *Hedychium* spp. and common grass species of *Phragmities* and *Saccharum*. Climbers and epiphytes are not very common in this vegetation type.

2. SUBTROPICAL VEGETATION

This vegetation type occurs between 900-2000m and the dominant tree species are *Acer oblongum*, *Actinodaphne obovata*, *Alnus nepalensis*, *Beilshmiedia roxburghiana*, *Byttneria aspera*, *Callicarpa arborea*, *Castanopsis armata*, *C.indica*, *C. hystrix*, *Dichroa febrifuga*, *Engelhardia spicata*, *Evodia fraxinifolia*, *Ficus gasperriniana*, *Garcinia acuminata*, *Gynocardia odorata*, *Kydia calycina*, *Magnolia pterocarpa*, *Manglietia insignis*, *Michelia oblonga*, *Ostodes paniculata*, *Quercus fenestrata*, *Q. glauca*, *Q.griffithii*, *Q. lamellosa*, *Q.semiserrata*, *Q. spicata*, *Saurauia cerea*, *S. punduana*, *Schima khasiana*, *S. wallichii*, *Stachyurus himalaicus*, *Sterculia indica* and *Ulmus lancifolia*. Among the small trees, *Capparis multiflora*, *Photinia notonianaa*, *Sapindus attenuatus* etc. are common alongwith shrubs like *Ardisia* sp., *Artemisia vulgaris*, *Berberis wallichiana*, *Camellia caduca*, *Cassia mimosoides*, *Dianella encifolia*, *Drymaria cordata*, *Eurya acuminata*, *E. japonica*, *Lasianthus longicauda*, *Mahonia acanthifolia*, *M.*

nepalensis, Plectranthus ternifolius, P. undulata, Rosa indica, Solanum verbascifolium, Sophora acuminata, Stellaria uliginosa, Symplocos sp., *Tephrosia candida, Triumfetta pilosa, Urena lobata, Vernonia saligna, Vibernum foetidum* and *V. mullaha. Clematis acuminata, Holboellia latifolia* and *Tinospora malabarica* are some of the common woody climbers. The common straggling shrubs met within are *Actinida callosa, Argyreia wallichii, Clematis gouriana, Clitoria mariana, Combretum pilosum, Dioscorea pentaphylla, Jasminum* sp., *Lagenaria vulgaris, Rubus moluccanus, Rubia cordifolia, Toddalia asiatica, Thunbergia* spp. etc. The herbaceous flora is mainly composed of species like *Anaphalis adnata, A. araneosa, A. odorata, Anemone vitifolia, Astile* sp., *Campanula colorata, Cardamine hirsuta, Cynoglossum glochidiatum, Exacum tetragonum, Inula cappa, Justicia khasiana, Leucas ciliata, Osbeckia stellata, Oxalis* sp., *Plantago major, Polygonum* sp., *Potentilla* sp., *Valeriana hardwickii, Viola betonicifolia, V. diffusa, V. distance* and *V. serpens* alongwith several species of terrestrial orchids and ferns. Apart from these some common herbaceous climbers like *Clitoria mariana, Parabaena sagittata, Pericampylus incanus* and *Stephania rotunda* may also be seen. A variety of orchids and ferns form the epiphytic flora. *Peperomia reflexa* also commonly occurs as an epiphyte on mossy tree trunks.

2b. PINE FORESTS

Pine forests occur between 1000-1800m in subtropical and temperate regions and are dominated by *Pinus merkusii, P. roxburghii* and *P. wallichiana* in association with tree species like *Alnus nepalensis, Betula alnoides, Lyonia ovalifolia, Quercus* sp., *Rhus javanica, Tsuga dumosa* and shrubby and herbaceous species of *Ajuga, Coriaria, Desmodium, Elsholtzia, Indigofera, Luculia, Pogostemon, Potentilla, Rubus* and *Pteridium aquilinum, Plectranthus japonica* etc. The epiphytes are of rare occurrence in Pine forests.

3a. TEMPERATE VEGETATION

This type is further divided into 2 distinct subtypes.

3a. *Temperate Broad-leaved :*

This type is generally found between 1800 to 2800m in the cold climatic regions having severe winter and moderately high rainfall. The top canopy is represented by tall tree species like *Acer hookeri, A. oblongum, A. pectinatum, Alnus nepalensis, Betula alnoides, Exbucklandia populnea, Castanopsis indica, Euonymus sp., Magnolia campbellii, M. obovata, Photinia* sp., *Populus ciliata, P. gamblei, Rhododendron* spp. whereas. *Ardisia* sp., *Berberis wallichii, Corylopsis himalayana, Debregeasia longifolia, Illicium griffithii, Lyonia ovalifolia, Mahonia* spp., *Myrsine semiserratta, Rhododendron* spp., *Vaccinium donianum* etc. are dominant small trees and shrubs. Ground floor is mostly occupied by gregarious growth of species of *Begonia, Corydalis, Drymaria, Fragaria, Geranium, Polygonum, Potentilla, Sedum, Thalictrum* etc. The climbers are of rare occurrence. This vegetation type abounds in various epiphytes of which species *Rhododendron, Agapetes, Vaccinium* are more common alongwith many orchid, fern and lichen species.

3b. *Temperate Coniferous:*

Distributed between 2800-3500m altitudes above temperate broad leaved vegetation, it experiences heavy snowfall during winter months. The dominant trees are the species of *Abies, Cupressus, Pinus, Rhododendron, Taxus, Juniperus, Larix, Picea* etc.

4. ALPINE VEGETATION

The alpine vegetation occurs between 4000-5500m and just below 4000m between 3500 to 4000m there exists a zone often termed as sub-alpine zone and the vegetation there is referred as sub alpine vegetation characterised by tree species like *Abies spectabilis, Cupressus torulosa, 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 notoniana* and *Vaccium venosum*.

The alpine zone above 4000m is covered by snow for a major period of the year. The tree species in this zone are replaced by shrubby Rhodedendrons and herbaceous elements with brilliantly coloured attractive flowers having a very specialized habit to suit the inhospitable alpine climatic conditions. Various species of *Aconitum, Arenaria, Gentiana, Polygonum, Primula, Rhodiola, Saussurea, Saxifraga, Sedum* etc. dominate the alpine vegetation. Above alpine zone virtually there is no plant life and only barren peaks are seen.

5. SECONDARY FORESTS

The primary forests due to the impact of various adverse biotic and abiotic factors like shifting agriculture or Jhumming ; developmental activities and urbanization; land slides, fires etc. are destructed and gradually develop into secondary forests. These secondary forests based on their floral components are of 3 types:

5a. *Degraded forests* : As compared to the original primary forestrs the degraded ones have a very low species diversity and are generally dominated by weedy shrubs and inferior quality of tree species of *Bauhinia, Callicarpa, Glochidion, Macaranga, Mallotus*; whereas, *Capparis, Clerodendrum, Croton, Eurya, Randia, Rubus, Viburnum* species are common shrubs alongwith weedy species like *Ageratum, Eupatorium, Mikania* etc.

5b. *Bamboo forests* : This type mostly occurs in areas which were abandoned after "*Jhum*" cultivation upto the elevation of 2000 meters. The common bamboo species are : *Arundinaria* sp., *Bambusa pallida, B. tulda, Bambusa* sp., *Cephalostachyum latifolium, Chimonobambusa callosa, Dendrocalamus hamiltonii, D.hookeri, D.strictus, Phyllostachys* sp., *Pseudostachyum polymorphum.*

5c. *Grasslands* : There are generally formed as a result of "*Jhum*" cultivation, fires at higher altitudes or due to over grazing. The commonly seen grasses are *Arundinella bengalensis, Chrysopogon aciculatus, Eragrostis tenella, E. unioloides, Hackelochloa granularis, Imperata cylindrica, Paspalum* sp., *Saccharum arundinaceum, S. spontaneum, Saccolepis interrupta, Setaria palmifolia, Themeda caudata* and *Thysanolaena maxima* found in association with sedges like species of *Cyperus, Fimbristylis, Scirpus* etc. Certain tree species viz., *Bombax ceiba, Duabanga grandiflora, Macranga denticulata* etc. are also found scattered amidst the grasslands at lower altitudes.

6. AQUATIC VEGETATION

Alisma plantago, Eriocaulon puzulaefolium, Monocharia vaginalis, Polygonum alatum, Potamogeton nodosus, Sagittaria sagittifolia, Sanicula europea, Utricularia bifida etc. are some common hydrophytes growing in the marshes, roadside pools, *canals* and paddy fields. *Zeylandidium*, the liverwort-like plant of the family Podostemaceae grows under water on the stones and boulders in the fast running streams at lower altitudes. *Lagenandra undulata*, an interesting aroid is restricted and grows on submerged rock boulders in swiftly flowing waters near Amji in Subansiri district.

7. WEEDS

In areas where the primary vegetation has been destroyed or modified due to various factors or lands abondoned after "Jhum" cultivation, a variety of weedy species colonize. Some of the most common weeds in such places are ; *Adenostema lavenia, Ageratum conyzoides, Bidens biternata, Cuphea salicifolia, Cuscuta reflexa, Cyperus brevifolius, C. iria, C. pilosa,* Emila *sonchifolia, Erigeron bonariensis, E.pusillus, Eupatorium odoratum, Galinsoga parviflora, Gynura crepidioides, Hedyotis scandens, Laggera crispata, Lantana camara, Ludwigia octovalvis, Mikania cordata, Mitracarpus verticillatus, Polygonum* spp *Raichardia scabra, Scoparia dulcis, Sida rhombifolia, Solanum khasianum, S.nigrum, Spilanthes culva, S.paniculata, Urena lobata, Vernonia cinerea* etc.

INTERESTING ELEMENTS OF ARUNACHAL PRADESH FLORA

a. *Biologically curious plants*

Among the interesting and biologically curious plants mention may be made of *Sapria himalayana*, one of the largest root parasites is first reported from

Mishmi hills and subsequently from Aka hills in Kameng district by Bor (1938). Other root parasites of importance are *Ropalocnemis phalloides* from Namdapha, *Balanophora dioica* on roots of several tree species in dense humid forests, *Aeginetia indica* on roots of *Rhododendron* species in alpine meadows. *Monotropa uniflora*, species of orchid genera like *Epipogium* and *Galeola* are some of the interesting and curious saprophytes found in dense humid forests on organic matter and humus rich soil.

b. *Endemic species*

A number of endemic plant species have been reported from Arunachal Pradesh. Some such species are : *Acer oblongum* var. *microcarpum*, *A. sikkimense* var. *serrulatum*, *Aconogonum pangianum*, *Agapetes refracta*, *A.subansirica*, *Aneilema glanduliferum*, *Begonia aborensis*, *B.scintillum*, *Capparis pachyphylla*, *Coptis teeta*, *Hedychium longipedunculatum*, *Lysimachia santapaui*, *Measa arunachalensis*, *M.castaneifolia*, *M.truncata*, *Merrilliopanax cordifolia*, *Paphiopedilum wardii*, *Pholidota wattii*, *Primula subansirica*, *Pternopetalum serii*, *Pueraria bella*, *Rhynchoglossum lazulinum*, *Schefflera venulosa* var. *macrophylla*, *Wallichia triandra*, *Eurya arunachalensis*, *Skimmia kamengensis*, *Albizia arunachalensis*, *Spiraea arunachalensis*, *Rhododendron subansiriense*, *R.santapaui*, *Lithocarpus kamengensis*, *Epipogium indicum*, *E. sessamum*, *Eria lohitensis*, *Zeuxine lindleyana*, *Sonerila arunachalensis*, *Sadiria erecta*, *Ophiorrhiza talevallensis* etc.

c. *Rare and Endangered species*

Shifting cultivation, over exploitation of medicinal and other useful economic plants, various developmental activities are some of the major threats to the flora of Arunachal Pradesh. As a result of the impact of these biotic and abiotic factors, a number of species have become rare, vulnerable, threatened or endangered. *Alniphyllum fortunei*, *Ardisia rhynchophylla*, *Boehmeria tirapensis*, *Bulbophyllum depressum*, *B.mishmeense*, *B.virens*, *Cymbidium hookerianum*, *C.eburneum*, *Buddleja yunnanensis*, *Dioscorea laurifolia*, *D. orbiculata*, *Diplomeris hirsuta*, *Eria discolor*, *E.ferruginea*, *Ilex venulosa*, *Leptodermis scabrida*, *Luisia inconspicuum*, *Nertera sinensis*, *Nomocharis synaptica*, *Oberonia sulcata*, *Paphiopedilum fairieanum*, *Rauia belladona*, *Rhododendron nuttalli*, *R.santapaui*, *R.subansiriensis*, *Ropalocnemis phalloides*, *Sapria himalayana*, *Saurauia griffithii* etc. are some of the species which fall under these categories.

d. *Primitive Flowering plants*

The occurrence of primitive angiosperms like, *Alnus nepalensis*, *Altingia excelsa*, *Betula alnoides*, *Exbucklandia populnea*, *Holboellia latifolia* var. *angustifolia*, *Houttuynia cordata*, *Magnolia griffithii*, *M.pterocarpa*, *Manglietia caveana*, *Talauma hodgsonii*, *Tetracentron sinense* etc. suggests the distinct phytogeographical position of Arunachal Pradesh within Indian subcontinent.

PHYTOGEOGRAPHICAL AFFINITIES OF ARUNACHAL PRADESH FLORA

Hooker (1855) attempted phytogeographical analysis of the Flora of former Indian Empire. Subsequently Clarke (1898) on the basis of his studies on the distribution of the family Cyperaceae (*Carex*) suggested that Eastern Himalaya and Assam to be distinct subareas. Hooker (1906) in his botanical divisions of India treated Eastern Himalaya as a separate area while he placed major parts of Assam in Gangetic Plains and merged remaining hilly parts of Assam, Shillong plateu, Naga and Manipur hills with Burma. He concluded that the rich floristic diversity of the Indian subcontinent is mainly due to the migration of plant species from different adjoining countries, like Chinese and Malayan in eastern and southern side; European, Siberian and Tibetan in northern and African, Oriental and European species in the western region. He recognized 3 main phytogeographical divisions of India

1. Himalayan division — with European, Siberian elements.
2. Eastern division — with Chinese, Malayan elements.
3. Western division — with African, Oriental and European elements.

Arunachal Pradesh, formerly known NEFA (North East Frontier Agency) was phytogeographically considered to be a part of Assam flora, Rao (1974) has drawn close affinities between the flora of Assam and Burma and treated them as a part of the Eastern border lands comprising mostly the tertiary mountains with highly humid tropical climate and remarkably diverse flora and vegetation. Biogeographically Assam and north Burma represent a highly transitional region where large scale comingling of the Asiatic and Indian Peninsular Floras has occurred. Recently Takhtajan (1986) placed Arunachal Pradesh in the Eastern Himalayan Province within Eastern Asiatic region of Boreal sub-kingdom alongwith parts of eastern Nepal in the west up to Kali river valley, Darjeeling, Sikkim, Bhutan, large parts of Assam Himalaya, certain extreme south and southern parts of Tibet.

Recent studies have shown that the flora of Arunachal Pradesh has close affinities with tropical South-East Asian-Malayan, temperate Himalayan-Chinese and Japanese floras and has some elements common with peninsular India, Sri Lanka, Tibetan and Euro-Siberian region.

a. *South-East Asian-Malaysian affinities*:

The flora of Arunachal Pradesh abounds in species which are typical of tropical South-East Asian region viz., Mynmar (Burma), Thailand, Indo-China, Malaysia and Indonesia. These elements gradually decline as one moves westwards. Following are some of the species which occur in Arunachal Pradesh as well as South-East Asian region :

Actinidia callosa, Ampelocissus barbata, Antidesma acuminatum, Bauhinia purpurea, Bischofia javanica, Brassaiopsis glomerulata, Carallia brachiata, Crateva religiosa, Debregeasia longifolia, Dendrobium aggregatum, Duabanga grandiflora, Engelhardia spicata, Eria paniculata, Exbucklandia populnea, Firmiana colorata, Garuga pinnata, Hedychium coccineum, Hodgsonia macrocarpa, Lepisanthes senegalensis, Lithocarpus elegans, Mangifera indica, Meliosma simplicifolia, Michelia champaca, Mucuna nigricans, Musa balbisiana, Oroxylum indicum, Procris crenata, Raphidophora peepla, Spondias pinnata, Talauma hodgsonii, Tetrameles nudiflora, Toona sureni, Trevesia palmata, Vernonia volkameriifolia etc.

b. *Himalayan-Chinese-Japanese affinities*

Arunachal Pradesh harbours many 'Himalayan, 'Chinese' and 'Japanese' elements of phytogeographic affinity which overlap between these regions making it difficult to draw clearcut boundaries. Stainton (1972) has shown that even within the Himalayan region there exist distinct 'Eastern' and 'Western' elements. The eastern elements are mostly confined to the Eastern Himalaya and have many species common with China and the number of such species increases eastwards and sharply decreases westwards. Species like *Betula alnoides, Callicarpa rubella, Cardamine griffithii, Cinnamomum obtusifolium, Dalbergia mimosoides, Helwingia himalaica, Litsea cubeba, L. kingii, L. sericea, Lonicera adenophora, Magnolia campbellii, Meconopsis napaulensis, Michelica doltsopa, Millettia cinerea, M. pachycarpa, Neillia rubiflora, Osmanthus suavis, Panax pseudoginseng, Potentilla griffithii, Rhododendron micromeres, R. neriflorum, Rubus fragarioides, Salix sikkimensis, Shuteria hirsuta, Smilax ferox, Tetracentron* etc., are common with *China*, while *Cornus controversa, Mucuna macrocarpa, Taxillus kaempferi, Stachyurus, Helwingia, Tetracentron* etc. extend as far as into Japan. Species like *Anisadenia saxatilis, Arisaema intermedium, Dalbergia sericea, Eriobotrya dubia, Gardneria angustifolia, Lindera pulcherrima, Mahonia napaulensis, Michelia kisopa, Pinus roxburghii, P. wallichiana, Premna interrupta, Rhododendron anthopogon, R. barbatum, R. campanulatum, Rhus wallichii, Rosa macrophylla, Rubus nepalensis, Sorbus cuspidata, Spiraea canescens, Tsuga dumosa* etc. are of common occurrence between North-Western Himalaya and Eastern Himalaya but unknown from China and Japan; however, there are several species which are distributed from North-Western Himalaya into China and even up to Japan. Apart from these common elements there are many species which are restricted to Eastern Himalayas only. Some of these species which also occur in Arunachal Pradesh are, *Agapetes serpens, Capparis sikkimensis, Elatostema imbricans, Eriobotrya hookeriana, Inchnorcarpus himalacicus, Impatients longipes, Primula whitei, Rhododendron camellifolorum, R. falconeri, R. fulgens, R. glaucophyllum, R. grande, R. hodgsonii, R. keysii, R. lindleyi, R. pendulum, R.smithii, R. succothii, R. wallichii, R. wightii, Rubus fragariodes* etc.

As compared to very close links with China, Burma, Malaya the flora of Arunachal Pradesh also has some elements common with Peninsular India, Sri Lanka, Tibet, Europe and Siberia. *Capparis olacifolia, Casearia zeylanica, Dendrophthoe falcata, Ficus benghalensis, F. drupacea, Leucas ciliata, Murraya koenigii, Plumbago zeylanica, Pterolobium hexapetalum, Tamarix indica, Thunbergia coccinea, Tylophora rotundifolia, Woodfordia fruticosa* etc. are typical 'Deccan' elements occurring in Arunachal Pradesh. *Goodyera repens, Hedera* sp., *Juncus inflexus, Lithospermum officinale, Polygala sibirica, Prunella vulgaris, Ranunculus scleratus, Stellaria uliginosa, Thlaspi arvense, Veronica anagallis-aquatica, Viola biflora* etc. are characteristic Euro-Siberian elements which are found in Arunachal Pradesh.

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5.4. NORTH-EASTERN INDIA AND NORTH BENGAL

(A.S. Chauhan)

INTRODUCTION

In this chapter the vegetation and plant diversity of North-eastern India embracing the states of Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura and a part of the North Bengal (Jalpaiguri, Cooch Behar and Darjeeling districts) have been presented. Phytogeographically, the region has two distinct regions *i.e.* Assam and the Eastern Himalayas (Clarke, 1889). Hooker (1906) in his botanical divisions of India, included plains of Assam in the Gangetic plains, treating the Eastern Himalayas as a separate area by itself and considered the hilly areas of Assam including Shillong plateau, Patkoi, Nagaland, Manipur, Mizoram and Tripura as an integral part of botanical province of North Burma. Chatterjee (1962) followed Clarke and treated Assam as an area distinct from the Eastern Himalayas, because of its unique flora. A definite conclusion can not be drawn till the full knowledge of plant distribution of the present and the past is fully understood (Ridley, 1942). There has been a difference of opinion regarding the inclusion of the plains of Arunachal Pradesh and the part of North Bengal as a whole in Darjeeling division in particular. Phytogeographical affinities in the flora and vegetation have revealed that the plains of Arunachal Pradesh should be included in the North-eastern India or Assam. The Darjeeling and Kalimpong hilly tract is definitely an integral part of Himalayas, hence it should be included in the botanical regions of Eastern Himalayas. The composition of the flora and vegetation of foot hills and plains of Darjeeling, Jalpaiguri and Cooch Behar forest areas is inconclusive due to the intermingling of taxa at different ecological zones. Therefore, whether it should be included in Eastern India or in the Gangetic plains has become a matter of opinion at this juncture.

A wide range of physiography and eco-climatic conditions have adquately expressed themselves in giving rise to rich gene pool both of wild and cultivated plant species, which are growing profusely in this richest phytogeographical region. Also many elements having affinity to nearby Sino-Himalayan, Bhutan, Burma, Malesian and to a lesser extent of the peninsular India could be collected from this region as they biogeographically belong to a single natural mountain land, the Indo-Chinese sub-Chinese sub-region (Mani, 1974). However, in recent times the combined factors of population growth, unplanned utilization of plant resources, slash and burn mode of agriculture, introduction of alien species and spread of harmful chemicals etc. have threatened to destroy the delicate equilibrium that exists in these forest ecosystems. As a result, the rich genetic diversity has been depleted and many plant species are facing threat in their natural habitats (Jain & Sastry, 1980; Sastry *et al,* 1983; Haridasan & Rao, 1985, 1987; Nayar & Sastry, 1987, 1988, 1990). Besides, these factors have not only aggravated natural calamities such as landslides, erosion and floods in catchment areas but also rendered vast areas of the land barren and unproductive wastelands. Recently, a massive programme of aforestation, social forestry and other land utilization programmes have been launched to bridge the gap between demand and supply on natural resources arising from heavy population growth and live-stock pressure in this region. These factors have considerably affected the original species composition and floristic diversity of these tropical evergreen rain forest and have brought about qualitative changes to certain extent. It is of grave concern that the reduction in the forest cover is still going on unabated in some states viz. Assam, Mizoram Tripura and Meghalaya.

VEGETATION AND PLANT DIVERSITY

The North-eastern Indian region is characterised by high rainfall and humidity. The annual rainfall is usually above 2,000 mm, although, there are rain shadow belts also. Similarly the relative humidity is usually 80% during the morning hours. The altitude is also varied from near sea-level to 4,500 meters; the climate ranges from that of tropical plains to temperate and sub-alpine hills. The soils too range from new alluvial, old alluvial to laterite and in general are rich in organic matters, iron contents and very low or sometimes deficient in Boron, Calcium and Zinc. The pH of soil usually ranges from 4.5 to 5.5. Due to these various factors, the region represents one of the richest botanical regions in the Indian subcontinent (Chatterjee, 1962; Clarke, 1898; Hooker, 1906; Hooker & Thomson, 1855; Rao, 1968, 1974; Joseph, 1982) and has been considered a paradise for botanists. Though several plant explorers both Indian as well as foreign have frequently botanised this region from time to time (See Burkill, 1916, 1965; Hooker, 1849, 1850; Cowan, 1927, 1929; Gamble, 1875, 1878; Prain, 1903; Rao, 1974; Balakrishnan, 1981, 1983; Deb, 1981, 1983; Haridasan & Rao 1985, 1987; Kataki, 1986; Baishya & Rao, 1982; Jamir & Rao, 1984), even the states of Manipur and Mizoram received comparatively less attention. Prior to explorations by the Botanical Survey of India, the only noteworthy ones were those by Bor, 1942; Clarke, 1889; Fischer, 1938 and Kingdon-Ward, 1940, 1948. Hooker who made huge collection of plants from Khasi & Jaintia hills during 1851, remarks that the vegetation of Khasi hills in Meghalaya is the richest in India and probobly in the whole of Asia. This statement seems to hold good for the entire North-eastern India, which abounds in forests, meadows, marshes and swamps, each with its own characteristic plants and ecology. Being one of the difficult and inaccessible terrain, a considerable portion of forest area still remains *terra incongnita* botanically, as a result the vegetation types of whole North-eastern India are not fully demarcated.

During the last thirty years, botanists have trekked through all the hilly states of this region in different seasons and have made collections from different ecological nitches. The vegetation of this region is fairly well known through the contributions of Kanjilal *et al.* 1934-40; Biswas, 1940, 1943, 1967; Chaudhury, 1960, 1969, 1970; Deb, 1961, 1981, 1983; Dutta, 1964; Mahapatra *et al.* 1965; Mathew, 1966, 1969; Mukerjee, 1965, 1972; Rao & Panigrahi, 1961; Rakhowa, 1961; Sain, 1958, 1959; Sen, 1963; Sharma & Ghose, 1970; Shebbeare, 1941, 1961; Mehra *et al,* 1983. There is usually a distrinct correlation between altitude and vegetation. Form this point of view, the vegetation may be broadly classified into three major types viz. (a) Tropical, (b) Temperate, (c) Alpine, with intermediate types. Sahni (1969) while highlighting the the floral wealth of Eastern Himalayas discussed the following forest types viz. (1) Tropical evergreen (2) Sub-tropical, (3) Temperate, (4) Sub-alpine, and (5) Alpine to arctic, following Champion & Seth (1968). Later, Mehra *et al* (1983) also followed the same system of classification. However, their observations are based on the all previous works on the classification of the forest types of this region and the personal observations, the forest types of the North-eastern India are classified into the following types :

1) Tropical moist and dry deciduous forests,

2) Tropical grasslands,

3) Tropical evergreen and semievergreen forests,

4) Sub-tropical pine forests,

6) Sub-tropical to temperate grasslands,

7) Temperate forests, and

8) Sub-alpine forests, etc.

Tropical moist and dry deciduous forests :

The tropical moist and dry deciduous forests are distributed up to an altitude of 900 m, where the annual rainfall is 150-200 cm and having a definite dry period from December to March. It is imperative to mention here that typical natural deciduous forests do not occur anywhere in these states but are only subclimax or manmade forests. These types of forests are confined in parts of Goalpara, Nowgong, Darrang and Kocharigaon in Assam; northern slopes of Meghalaya, northern and North-western parts of Garo hills; Amarpur, Sonamura, Dharamnagar, Belona, Udaipur and Sadar subdivision in Tripura; northern side of the forest areas of Kawnpuri, Hortaki, Bhairabi, Kolasib, Vairentee and western part of Mizoram bordering Tripura etc.; Jiri, Morch, Vangoi and Tamenglong forest areas in Manipur and terai as well as on the hill slopes of Jalpaiguri, Cooch Behar, Rangit valley, Sukna and Tista valley etc. in North Bengal. These forests are characterised by seasonal leaf shedding and profuse flowering of the trees.

The Sal (*Shorea robusta*), the most predominant tree crop, forms extensive reserves over hundreds of acres in all these forests. These manmade deciduous forests are much extensive in their distribution in these states and include many economically important tree species like *Acacia catechu, Albizia lebbeck, A. lucida, A. procera, Artocarpus chama, Ailanthus integrifolia* ssp. *calycina, Alstonia scholaris, Anthocephalus chinense, Bischofia javanica, Bombax ceiba, Duabanga grandiflora, Ehretia wallichianna, Euodia glabrifolia, Garuga pinnata, Gmelina arborea, Haldina cordifolia, Kydia calycina, Lagerstroemia parviflora, L. reginae, Lannea coromandelica, Litsea monopetala, Spondias pinnata, Salmalia malabarica, Stereospermum colais, Sterculia villosa, Tectona grandis, Tetramales nudiflora.* etc. The second storey is composed of *Agandis perviridis, Amoora hieronii, Bauhinia purpurea, B. variegata. Callicarpa arborea, Canarium strictum, Careya arborea, Chukrassia tabularis, Cryptocarya amygdalina, Dalbergia sissoo, D. stipulacea, Dillenia pentagyna, Dysoxylum alliaria, D. binectari-ferum, Grewia disperma, Macaranga denticulata, Persea villosa, Stereospermum personatum* and *Turpinia pumifera etc.*

The shrubby layer is often gregarious and forms an impenetrable thicket during rainy season. The main components of this layer are *Allophyllus cobbe, Costus speciousus, Clerodendrum kaempferi, Desmodium pulchellum, Flemingia macrophylla, Indigofera cassiodes, Leea alata, L. compactiflora, L. indica, Micromelum integerrimum, Murraya paniculata* etc. Lianas are fewer but species of scandent shrubs like *Aspidopteris, Bridelia, Combretum, Entada, Hiptage, Mussaenda, Phanera, Spatholobus, Tinospora* etc., along with the species belonging to the families Vitaceae and Menispermaceae are frequent. The undergrowth of these forests vary from place to place according to changes in rainfall and soil composition. In most of the places species of *Desmodium, Licuala, Phlogacanthes, Impatiens, Oxalis* etc. form dominant undergrowth. In open areas, species of *Eupatorium, Lantana* and *Mikania* grow profusely without any competition. Bamboo thickets are also found everywhere in these forests as successional vegetation in cleared areas, abandoned after jhum cultivation.

It is imperative to mention here that the species composition differ in different ecological niches, based on the geology, soil and topography as well as climatic conditions, etc. In lower hills of Darjeeling division, *Acrocarpus fraxinifolius, Ailanthus integrifolia* ssp. *calycina, Anthocephalus chinensis, Duabanga grandi flora* and *Tetrameles nudiflora* predominate over other species. In the Kurseong forest areas, in addition to the above mentioned species, *Castanopsis indica, C.*

tribuloides, *Haldinia cordifolia* and *Terminalia bellirica* etc. are in profusion. Besides, in the climatic climax forests of Jalpaiguri district *Meusa ferrea* predominates over other flora. In the reserved forests of Tripura adjoining Cherilam and Radhakishorepur, in addition to *Careya arborea*, *Lagerstroemia parviflora* and *Terminalia* spp., *Garuga pinnata*, *Albizia procera*, *Lannea coromandelica* and *Schima wallichii* etc. form conspicuous flora. These species are generally not met in corresponding forests in other parts of North-eastern India.

Tropical grasslands :

The grasslands met within this region are also not a climax type but are due to the combined effects of frequent heavy floods, forests fire, indiscriminate felling of trees and overgrazing etc. The grassland of Motharguri, Orang and in the foot hills of Mikir hills are same as along hill slopes of Darjeeling and Kalimpong areas of North Bengal may be termed as secondary, arrested at a sub-climax stage due to intensive operation of biotic factors, whereas the extensive grasslands of Kaziranga, Cooch Behar and Jalpaiguri districts are an edaphic climax combined and influenced by flood waters of mountain rivers e.g. Brahmaputra, Mahanadi, Tista and their tributaries etc. The wildlife sancuraries, viz. Kaziranga in Assam and Jaldapara in Jalapaiguri district of North Bengal are swamps with *Saccharum spontaneum* and *Sclerostachya fusca* as the most prominent species. Other prominent, tall grasses of *ca* 5 m height are *Arundinella decampedalis*, *Arundo donax*, *Imperata cylindrica*, *Phragmites australis*, *Saccharum griffithii*, *S. naranga*, *Themeda villosa*, *Thysanolaena maxima*, and *Vetiveria zizanioides* etc., which extend over several kilometers and provide a suitable habitat for *Rhinoceros unicornis*, one of the most rare species of animals. There are few isolated trees of *Albizia* spp., *Dalbergia* spp. *Dillenia indica*, *Lagerstroemia fhos-reginae*, and *Duabanga grandiflora* etc. The shrubby and herbaceous species met in the reserve are *Acacia*, *Alternanthera*, *Crotalaria*, *Cyanotis*, *Desmodium*, *Eclipta*, *Flugga* and *Ziziphus* etc. Besides, there are several small puddles or ponds, which are quite common, supporting either a gregarious growth of the water hyacinth *Echhornia crassipes* or other aquatic herbs like *Jussieua*, *Monochoria*, *Nymphaea*, *Ottelia* and some other prominent sedges e.g. *Cyperus*, *Kyllinga* etc. The aroids *Lasia spinosa* forms rich association with *Colocasia esculenta* and *Typhonium flagelliforme*. The grassland at the foothills of Mikir hills is sparse, and harbours stunted trees and shrubs of *Artocarpus*, *Ficus*, *Styrax*, *Antidesma* and *Wattia*, apart from the ferns, grasses and bamboos, etc.

The marshes and swamps of this region have also developed as a result of the destruction of the original semi-evergreen or the moist deciduous forests. These areas are also covered by extensive grasslands consisting of species of *Apluda*, *Cymbopogon*, *Imperata*, *Saccharum*, *Sclerostachya*, *Themeda* and *Vetivaria* etc, mixed with a few tall herbaceous species of *Ageratum*, *Clerodendrum*, *Eupatorium*, *Leea*, *Melastoma*, *Mikania* etc. They are also common along the roadsides, railway tracks through forests and other open lands. *Cymbopogon nardus* and *Arunadinella* spp. are quite common in the Bagdogra, Pankhabari and Sukna ranges, especially in the areas adjoining foothills. There are several swampy or marshy areas with tropical vgegetation in the warm humid regions of Assam valley. The flora in these swamps or stagnant water beels comprises mainly the members of Araceae, Cyperaceae, Eriocaulaceae, Lemnaceae and Najadaceae etc., mixed with *Arundo donax, Phragmites australis, Typha elephantina* etc. In certain regions, the tree growth with the species of *Acacia, Careya, Crataeva, Dillenia, Homonia, Lagerstroemia, Salix, Syzygium, Terminalia* and others is quite dense.

Tropical evergreen and semievergreen forests :

Such forests are confined up to an elevation of *ca* 1200 m above sea level, with an average rainfall of 300 500 cm per annum coupled with high relative humidity. Due to the effect of physiographic, edaphic and other exogenous factors, these forests seldom form continuous belts in any of these states, but harbour rich species diversity. Such forests are now restricted to inaccessible hills as well as near catchment areas, unsuitable for cultivation or to areas protected as reserved forests. Accordingly, these forests are confined to the plains of Arunachal Pradesh, Assam valley, northern and south-western foot hills, the western and north-western parts of Nagaland and Manipur forest areas adjacent to Burma, southern and northern slopes of Meghalaya and Dharamnagar, Kailashahr, Belonia and Sadar sub-division of Tripura. It is imperative to mention here that tropical wet evergreen forests are not extensive in any part of North Bengal area. These forests display a clear zonation of components where dense areas display the climatic climax. These forests display bewildering wealth of species not all of them common to all the areas. Even the dominant species also differ areawise. Two major areas *i.e.* Brahmaputra valley and Surma valley have been clearly demarcated based on the species composition coupled by the annual rainfall etc. Several species are confined themselves in these two distinct regions probably due to the different microclimatic conditions. The top canopy of vegetation is composed of the trees like *Acrocarpus fraxinifolius, Aglaia hiernii, Ailanthus integrifolia* ssp. *calycina, Anthocephalus chinensis, Artocarpus chama, A. heterophyllus, Canarium strictum, Castanopsis echinocarpa, C. kurzii, C. tribuloides, Celtis tetrandra, Cinamomum glaucescens, Dipterocarpus retusus, D. turbinatus, Duabanga grandiflora, Elaeocarpus aristatus, E. sphaericus, Endospermum diadenum, Manitoa polyandra, Mesua ferrea, Polyalthia cerasoides, Premna benghalensis Shorea assamica, Spondias pinnata* and *Xeroxpermum glabratum* etc. The middle storey, which is almost obscure is comprised of *Alstonia scholaris, Aporusa dioica, Antidesma acuminatum, Atlingia excelsa, Bischofia javanica, Bridelia monoica, Bruinsmia polysperma, Castanopsis indica, Cryptocarya andersonii, Dalbergia assamica, Dillenia indica, D. pentagyna, Dysoxylum binectariferum, D. gobara* Merr, *Ficus*

Plate 9. View of Deban forest and Noa-Dihing river (North-East India)

Plate 10. *Nepenthes khasiana* Hook.f. (Jaintia hills)

Plate 11. *Paphiopedilum insigne* (Wall. ex Lindl.) Pfitz. (North-East India)

Plate 12. *Dendrobium wardianum* Warner

Plate 13. *Dendrobium secundum* Lindl.

Plate 14. *Dendrobium devonianum* Paxt.

Plate 15. *Dendrobium sulcatum* Sw.

Plate 16. *Cycas pectinata* Griffith

Plate 17. *Cyathea gigantea* (Wall. ex Hook.f.) Holtt.

Plate 18. A view of tropical forest of North-East India

Plate 19. *Renanthera imschootiana* Rolfe

Plate 20. *Paphiopedilum hirsutissimum* (Lindl. ex Hook. f.) Stein.

Plate 21. *Dendrobium chrysanthum* Lindl.

Plate 22. *Asplenium nidus* L.

racemosa, Garcinia cowa, G. paniculata, Gmelina arborea, Gynocardia odorata, Heritiera macrophylla, Magnolia griffthii, Mangifera sylvatica, Michelia champaca, Phoebe attenuata, P. goalparensis, Premna bracteata, Pterospermum lancifolium, Sapium baccatum, Schima wallichii, Syzygium cumini, S. operculatum, Sterculia hamiltonii and *Vitica lancaefolia* etc. The lowermost storey of trees in these forests is represented by such species as *Actephila excelsa, Alangium chinense, Alchornea tiliifolia, Antidesma bunius, Boehmeria hamiltoniana, Brassiopsis glomerulata, Callicarpa arborea, Cinnamomum glucescens, Goniothalamus simonsii, Litsea cubeba, Macaranga denticulata, Macropanax undulatus, Magnolia hodgsonii, Phoebe lanceolata, Premna barbata, Styrax serrulatum, Trevesia palmata* vis. etc.

Of the various large shrubs or small trees which inhabit these forests, the prominent ones are *Abroma augusta, Acacia sinuata, Ampelocissus latifolia, Aralia armata, Ardisia floribunda, A. paniculata, A. thomsonii, Boehmeria macrophylla, Callicarpa nudiflora, Camellia caudata., Canthium angustifolium Coffea khasiana, Lasianthus hookeri, Leea edgeworthii, Maesa indica, Microtropis discolor, Mimosa himalayana, Murraya paniculata, Phlogacanthus thyrsiflorus, Randia griffithii, Solanum kurzii* and *Syzygium cuneatum* etc. The conspicuous lianas intertwining the trees in these forests are *Acacia pennata, Ampelocissus latifolia, Beaumontia grandiflora, Cayratia pedata, Cissus assamica, Dioscorea* spp., *Combretum roxburghii, Entada pursaetha., Gnetum gnemon, G. ula Hodgsonia macrocarpa, Lasiobema scandens, Mastersia assamica, Paederia scandens, Phanera khasiana, Tetrastigma* spp., and *Thunbergia glandiflora* etc.

The soil in these forests is dark and moist due to shade of lofty trees with thick canopy and has a thick layer of undisturbed humus, and has many fleshy fungi as well as saprophytic flowering plants. The common herbs in these forests are *Allophylus cobbe, Alpinia nigra, Andrographis paniculata, Amomum aromaticum., Blumea fistulosa, Costus speciosus., Crassocephalum crepidioides, Curcuma* spp., *Glycosmis arborea, Hedychium* spp., *Hedyotis auricularia Ophiorrhiza nutans, Panax pseudoginseng.* and species belonging to the families Acanthaceae, Asteraceae, Balsaminaceae, Begoniaceae, Fabaceae, Lauraceae, Oxalidaceae and Poaceae etc. Besides, *Apostasia wallichii, Galeola falconeri, Habenaria* spp., *Hataeria rubens, Paphiopedilum* spp., *Phaius flavus, P. mishmensis, P. tankervilliae, Tropidia angulosa* and *Zeuxine* spp. etc. grow scattered in the ground layer.

Epiphytes and other climbers are : *Aeschynanthes acuminatus, A. bracteautus, A. superba, Agapetes variegata, Piper* spp., *Pothos cathcartii, P. scandens, Procris crenata, Rhaphidophora decursiva, R. hookeri, R. lancifolia* etc., and the stem parasites viz. *Cascuta reflexa, Dendrophthoe falcata, Helixanthera ligustrina, Loranthus scurula, Taxillus* spp., etc. Besides, the tree trunks in these forests are moss-laden and harbour multitudes of epiphytic orchids, ferns, fern-allies, bryophytes and lichens.

Tropical semi-evergreen forests are found in many parts of North-eastern region including North-Bengal, typically up to elevations of *ca* 1200 m. The rainfall is from 150-300 cm per annum with a dry period of 2-3 months from February to April. These forests display less species diversity than those in the wet evergreen forest zone. However, besides the upper storey, the zonation of trees can easily be demarcated in these forests. *Callicarpa arborea*, *Careya arborea*, *Dillenia pentagyna*, *Garcinia lancifolia*, *Rhus acuminata*, etc. which are deciduous in nature and shed their leaves during dry season. The trees are tall and scattered with buttressed trunks. The undergrowth composed of shrubs and herbs is not very dense as compared with evergreen forests. However, in certain humus rich forest floors the undergrowth is dense and luxuriant. The lianas are scarce in these forests, *Entada rheedei* and *Mucuna macrocarpa* are seen occasionally. The tree trunks are covered by epiphytic flora of poor diversity due to seasonally dry period. Besides, hemiparasites viz. *Helixanthera parasitica*, *Loranthus scurrula*, and *Taxillus* spp. are common.

Sub-tropical mixed forests :

Sub-tropical broad leaved forests are confined in the altitudes from 1000-1600 m. Rainfall also varies from 150-400 cm or more in certain areas. Almost every state of this region has such montane forests, especially in the Darjeeling and Kalimpong divisions of North Bengal, hilly regions of Assam, slopes of Meghalaya, Koupru hills, Nongmaijing, areas bordering to Burma, Manipur and Mizoram, and Patkoi ranges in Nagaland etc. The floral constituents are quite varied from place to place based on the local climatic and edaphic factors. These climatic climax forests are seen scattered and never form a continuous stretch of vegetation. The trees are generally dwarf and bushy in appearance as compared with the tropical evergreen type. The reduction in tree strata is in direct proportion with the increase in altitude. Plank buttresed trees are rare in these forests. Shrubs and herbaceous layers are well marked foming impenetrable thickets in certain places. The tree height in general is up to 20 m, with evergreen to semi-evergreen appearance depending on the multitude of rainfall in that area. The trees of upper storey are : *Alnus nepalensis*, *Albizia chinesis*, *Alcimandra cathcartii*, *Artocarpus dadah*, *Betula alnoides*, *Castanopsis indica*, *C. tribuloides*, *Cinnamomum glanduliferum*, *Cryptocarya amygdalina*, *Elaeocarpus* spp., *Engelhardtia spicata*, *Euodia trichotoma*, *Erythrina fusca*, *Dysoxylum binectariferum*, *Manglietia & insignis*, *Exbucklandia populnea* and *Terminalia myriocarpa* etc. Occasionally, *Schima walichii* can also be seen in certain forests, however, this species prefer association with pines. Besides certain taxa viz. *Acer thomsonii*, *Aglaia pervirides*, *Betula cylindrostachys*, *Macarenga pustulata*., *Quercus gambleana*, *Toona ciliata* var. *listeri*, *T. ciliata* and *Poupartia axillaris* etc. are confined in the North Bengal area in this region.

The second storey is composed of *Acer oblongum*, *Alangium chinense*, *Albizia odoratissima*, *Bischofia javanica*, *Brucea mollis*, *Chisochetron cumingianus*

Corylopis himalayana, *Dysoxylum gobara*, *Itea chinensis*, *I. macrophylla*, *Ixora nigricans*, *Lithocarpus elegans*, *Litsea khasiana*, *Neolitsea umbrosa*, *Persea parviflora*, *Rhus semialata*, *Picrasma javanica*, *Styrax serrulatum*, *Syzygium praecoxum* and *Ternstroemia gymnanthera*, *Anneslea fragrans* confines only in Manipur and Nagaland areas in India.

These forests are especially rich in shrubby and herbaceous layer. The common shrubby species are *Ardisia floribunda*, *A. paniculata*, *Baliospermum micranthum*, *Berynia retusa*, *Clerodendrum viscosum*, *Debregeasia longifolia*, *Eurya nitida*, *Gomthalamus sesquipedalis*, *Leucosceptrum canum*, *Maesa indica*, *Micromelum minutum*, *Mussaenda glabra*, *Neillia thyrsiflora*, *Randia griffithii*, *Rubus ellipticus*, *Toddalia asiatica* and *Zanthoxylum scandens*, and various species of Acanthaceae and Araliaceae etc. The forest floor is densely covered with fungi, mosses and various herbaceous angiosperms belonging to the families : Araceae, Balsaminaceae, Begoniaceae, Commelinaceae, Zingiberaceae etc. Both in the evergreen to semi-evergreen forests, the tree trunks are covered with multitude of orchid flora different humid ecological niches in these states.

Sub-tropical pine forests :

These forests occur at elevation from 900-1800 m, with moderate rainfall areas in the Khasi & Janintia hills of Meghalaya, Ukhrul, eastern and south-eastern parts of Tuensang and Phek districts in Nagaland, Mao and Sugnu areas in Manipur, hilly tracts around Champhai, Northial and Phawngpui in Mizoram and can also be noticed near Darjeeling and Kalimpong areas of North Bengal. These pine forests are interspersed by a few tree species such as *Acacia dealbata*, *Cinnamomum* spp., *Engelhardtia spicata*, *Erythrina arvescens*., *Lithocarpus dealbatus*, *Myrica esculenta*, *Persea duthiei*, *Quercus griffithii*, *Schima khasiana* *S. wallichii*, *Symplocos spp.*, *Ternstroemia gymnanthera* etc. In the Eastern India, *Pinus kesiya* (Khasi pine) occurs in pure patches with the undergrowth of broad leaved species viz. *Eupatorium aderophorum*, *Daphne papyracea*, *Lyonia ovalifolia*, *Myrsine semiserrata*, *Rhus* spp., *Rubus ellipticus* *Viburnum* spp., etc. As it is one of the fast growing trees of this region, the state forest department has introduced is at high altitude in almost all the states of North-eastern India under aforestation programme. Likewise *Pinus roxburghii* forms the conspicuous flora of hilly tract of Darjeeling and Kalimpong areas of North Bengal.

The floor with a thick carpet of pine needles is devoid of any plant growth except in small clearings where *Agrimonia nepalensis*, *Anemon rivularis*, *Artemisia nilairica*, *Elscholzia blanda*, *Potentilla fulgens*, *Ranunculus cantonensis* etc. grow profusely during rainy season. Besides, plants like *Crotalaria ferruginea*, *Desmodium heterocarpum*, *Smithia blanda*, *Trifolium repens* etc. enrich the soil in these forests. Most of this herbaceous flora is either dried up or remain dormant during winter. The orchid species belonging to *Bulbophyllum*, *Cymbidium*, *Dendrobium, Eria, Lusia, Otochilus, Pholidota, Vanda* and others are quite common in these forests. A saprophytic orchid *Cymbidium macrorhizon* can also be seen in certain climatic climax pine forests. Several terrestrial and epiphytic ferns also form gregarious patches, some of them are *Discranopteris linearis, Lepisorus excavatus, L. kashyapii L. loriformis, L. thunbergianus, Pteridium aquilinum, Pyrosia mannii* and *P. mollis.* Grasslands or savanahs that occur in riparian flats, slopes are not of a climax type. These grasslands have developed only as a result of removal of original forest cover.

Sub-tropical to temperate grasslands :

The grasslands wherever present are a biotic climax due to removal of original forest cover. The rolling grasslands around Nongstoin, Riangdo, Ranikor, Mawsynram, Mawphlong, Mawsmai, Cherrapunji, Jowai, Sutnga, Haflong and major parts of Garo hills in Meghalaya, Ukhrul and Kurseong and Darjeeling forest division of North Bengal etc. can be seen throughout this region. The dominant grasses in these grasslands are composed of *Arundinella bengalenis, Axonopus compress., Chrysopogon aciculatus, Imperata cylindrica, Neyraudia ryaudiana, Oplismenus burmanii, Panicum atrosanguineum, P. khasianum, Pennisetum glaucum, Saccharum* spp. and *Thysanolaena maxima* in Meghalaya; *Agrostic micrantha, Brachypodium sylvaticum, Coelorachis striata, Cymbopogon khasianus, Eragrostis nigra* and *Phacelurus zea* in Manipur and Nagaland.

So far the grasslands in North Bengal are concerned, the taxa viz., *Arundinella decampedalis, Cymbopogon pospischilii, Eulalia fastigiata, Imperata cylindrica, Saccharum narenga, Themeda arundinacea, T. villosa* and *Vetiveria zizanioides* form predominant flora. These grasses are associated with sedges like *Carex speciousa, C. phacota, C. fedia, Fimbristylis dichotoma, Cyperus rotundus, C. tenuiculmis, Pycreus flavidus, Scleria terestris,* and species of the families Burmanniaceae, Eriocaulaceae, Juncaceae, Liliaceae and Zingiberaceae and others with a few species of Asteraceae, Balsaminaceae, Melastomaceae, Polygonaceae, etc. Apart from these, some insectivorous plants like *Drosera burmanni, D. peltata, Nepenthes khasiana* and *Utricularia* spp., also grow in these grasslands.

In certain places, pockets of mixed forests are found in some hill slopes which are unsuitable for jhuming and human exploitation because of their steep nature and inaccessibility. The rest of the country presents almost a pure grassland vegetation attaining about 1 m height at different places.

Temperate forests :

The temperate vegetation in the North-eastern Indian region is usually found in the altitudes ranging from 1400 to 2500 m and is confined to small pockets along the southern slopes of the Khasi & Jaintia hills, especially the sacred groves, viz. Shillong peak, Law Lyngdoh at Maphlang and Lawkyntang at Mawsmai etc. in Meghalaya; Ukhrul, Chingsaw, Mao and Koupur etc. in Manipur ; Japvo, Saramati and Patkoi ranges in Nagaland; Champhai and Phawngpuitlang forest areas in Mizoram and southern foothills of Darjeeling and Kalimpong forest division in North Bengal. These evergreen forests of medium height trees form a closed canopy and the trees more than 25 m in height are rarely met within these forests. Large and old trunks are festooned with mosses, ferns and other epiphytic growth. At lower elevations in the North-eastern India, the forests show an intermixing of elemens from tropical and sub-tropical zones and the species composition changes gradually with increase in the altitude. It is pertinet to point out that sub-tropical vegetation and temperate vegetation sometimes appear side by side. Under identicle environmental conditions where subtropical and temperate zones are not well defined (Mehra *et al, l.c.*), such situation is not found in any parts of North Bengal. Besides, the species composition of North Bengal is also quite different from that of North-eastern India region. The dominant species in Meghalaya are *Acer laevigatum*, *Alnus nepalensis*, *Beilschmiedia gemmiflora*, *Betula alnoides*, *Castanopsis armata*, *C. kurzii*, *Cinnamomum bejolghota*, *Echinocarpus dasycarpus*, *Elaeocarpus braceanus*, *Engelhardtia spicata*, *Eurya acuminata*, *E. nitida*, *Exbucklandia populnea*, *Ilex excelsa*, *Lithocarpus dealbatus*, *Magnolia insignis*, *Myrica esculenta*, *Persea duthiei*, *P. gamblei*, *Pinus kesiya*, *Prunus cerasoides*, *Quercus griffithii*, *Q. kamroopii*, *Rhododendron arboreum*, *R. formosum*, *Schima khasiana*, *S. wallichii* and *Symplocos glomerata*. The once rich vegetation at Cherrapunji now looks disappointingly bleak and devoid of wooded vegetation, due to the poor soil cover. All the soil cover has been leached out by the heavy rains. Small forest patches are only confined to the saucer-shaped depressions at Mamloo and Mawsmai, where there is a deposit of soil and humus; otherwise it looks like a vast area of grassland. In some places *Acer campbellii*, *Alcimandra cathcartii* and species of *Albizia*, *Cinnamomum*, *Juglans*, *Magnolia*, *Persea*, *Pinus*, *Quercus*, *Rhododendron*, *Rubus*, *Symplocos*, and a few others are present. The other trees are *Ehretia acuminata*, *Erythroxylon kunthianum*, *Euonymus grandiflorus*, *Helicia nilagirica*, *Ilex khasiana*, *I. embelioides*, *I. odorata*, *I. triflora*, *Lindera assamica*, *Ligusturm robustum*, *Viburnum* spp., *Zanthoxylum* spp. etc. There is a gradual change in the composition and diversity of the species with the increase in altitude. Species of *Rhodendron* predominate mixed with *Eriobotrya*, *Prunus*, *Pyrus*, *Spirea* and some other members of Rosaceae. The mountain bamboo brakes composed of *Yushania maling* are found throughout the moist temperate forests. In the shrubby layer *Ardisia orispa*, *Clerodendrum wallichii*, *Desmodium* spp., *Luculia pinceana*, *Maesa indica*, and species of *Vibernum* are predominant. Many species of ferns and fern-allies like *Dryopteris*, *Selaginella*, *Plagiogyria* and some herbaceous members of Ranunculaceae, Rosaceae, Begoinaceae, Asteraceae and Poaceae form thick growth of ground flora.

In North Bengal forests *Acer campbellii*, *A. laevigatum*, *A. oblongum*, *Alcimandra cathcartii*, *Cinnamomum impressinervium*, *Lithocarpus fenestratus*, *Meliosma pinnata* spp. *barbulata*, *Persea fructifer*, *P. gammieana*, *Alnus nepalensis*, *Betula alnoides*, *Eriobotrya bengalensis*, *Eurya acuminata*, *Evodia fraxinifolia*, *Exbucklandia populnea*, *Itea macropylla* and *Quercus kamroopii* etc. grow as dominant species. In certain forest areas *Acer hookeri*, *A. sikkimense*, *Castanopsis tribuloides*, *C. purpurella*, *Cinnamomum impressinervium*, *Glochidion acuminatum*, *Ilex insignis*, *Litsea sericea*, *Persea odoratissima*, *Styrax hookeri*, *Symplocos lucida*, *Vibernum* spp. and *Zanthoxylum* spp. etc. are commonly observed. At higer elevations, the Oak forests become predominant with the association of *Acer pectinatum*, *Hydrangia vestita*, *Ilex fragilis*, *Lindera heterophylla*, *Litsea orephila*, *Magnolia campbellii*, *Persea gammieana*, *Quercus lamellosa*, *Rhododendron arboreum*, *Skimmia laurecola* and *Vibernum erubescens*. Interestingly, in the Kalimpong forest division *Castanopsis* spp. predominate along with *Persea ganmmieana*, *P. fructifera*, *Litsea elongata* and species of *Quercus* and *Acer*, while in Kurseong division *Betula cylindrostachys* occurs along with *Exbucklandia populnea*, *Michelia doltsopa*, *Persea odoratissima*, *Terminalia myriocarpa* and *Toona* spp.

The Undergrowth is usually very dense and comprises many shrubs including *Strobilanthes*, *Potentilla*, *Rubus* and other members of Rosaceae, etc. The forest floor has often a gregarious growth of ferns like *Asplenium ensiformae*, *Diplazium stoliczkae*, *Hymenophyllum simonsianum*, *Lepisorus kashyapii*, *Lycopodium jamonicum*, *Oleandra wallichii*, *Phymatodes melacodon* and *Pteris wallichii*.

Sub-alpine forests :

The sub-alpine vegetation occurs from altitude of 2800 to 4500 m in Saramati and Japvo hills in Nagaland; Chingsaw, Japvo, Kowpur, Sirohee and Somra hill ranges of Manipur; Darjeeling and Kalimpong hill ranges in North Bengal, where the vegetation changes from the temperate to the sub-alpine type. It is characterized by a typical dense growth of small crooked, gnarled and stunted trees and shrubs. Tall trees of *Abies densa* form the dominant component for most of this type of vegetation and is composed of shruby species of *Rhododendron*, *Berberis*, *Juniperus*, *Salix Tsuga*, *Astragalus*, *Cassiope*, *Cotoneaster*, *Daphniphyllum*, *Lonicera*, *Polygonum*, *Pyrus*, *Rosa*, *Rubus*, *Taxus* and a few others. Besides, other economic plants such as *Gaultheria fragrantissima*, *Nardostachys grandiflora*, *Picrorrhiza scrophulariflora* and *Aconitum* spp., also occur in this zone. The forest floor is covered by a few herbaceous species of Rosaceae, Primulaceae, Gentianaceae, Polygalaceae, Papaveraceae, Brassicaceae, Asteraceae, and Saxifragaceae etc., as small or sometimes stunted clumps.

Hooker *(l.c.)* recognizes the following ten as the most dominant families of flowering plants in India, based on the total number of species : Orchidaceae, Leguminosae *(sensu lato)*, Poaceae, Asteraceae, Rubiaceae, Acanthaceae, Euphorbiaceae, Lamiaceae, Cyperaceae and Scrophulariaceae. In comparision to this, the first ten families in the Eastern India are : Orchidaceae (*ca 550* spp.), Poaceae (*ca* 440 spp.), Leguminosae (*ca* 320 spp.), Asteraceae (*ca* 216 spp.), Cyperaceae (*ca* 185 spp.), Euphorbiaceae (*ca* 168 spp.), Rubiaceae (*ca* 160 spp.), Lamiaceae (*ca* 102 spp.), Acanthaceae (*ca* 90 spp.) and Zingiberaceae (*ca* 74 spp.). The largest genera include *Dendrobium* with 58 species and 2 varieties, followed by *Rhododendron* with 35 species, 1 subspecies and 4 varieties, *Bulbophllum* with 37 species and 5 varieties and *Impatiens* with 38 species, etc. In this region the dicot flora is spread over 182 families. None of the angiosperm families are either endemic to this region or to whole of India. Even though it is beyond the scope of the present discussion to give a detailed familywise statistical analysis, details of some families and their distribution are given below. The dicot families Buxaceae, Cannabaceae, Ceratophyllaceae, Datiscaceae, Erythropalaceae, Lardizabalaceae, Moringaceae, Myricaceae, Nyctaginaceae, Rhizophoraceae, Saurauiaceae etc. are represented by a single genus with a single species each. Some other families Actinidiaceae, Chloranthaceae, Crypteroniaceae, Erythroxylaceae and Plantaginaceae, are represented by a single genus with two species each. Each of the families Balanophoraceae, Betulaceae, Hydrophyllaceae, Phytolaccaceae, Polymoniaceae, Rafflesiaceae and Tamaricaceae have two genera with two species. The family Nepenthaceae with about 67 species in the world has a solitary member *Nepenthes khasiana* Hook. f., endemic to Meghalaya representing the northern most limit of this family, with a general range of distribution from Madagascar to Malaysia, N. Queensland and New Caledonia through Sri Lanka and Meghalaya (India).

The herbaceous family Ranunculaceae is well represented in this region, with endemic species like *Aconitum laciniatum*, *A. nagarum*, *Clematis apiculata*, *C. fulvicoma*, *C. meyeniana*, and *C. tongluensis* var. *khasiana* etc. Primitive families like Magnoliaceae, Annonaceae, Schisandraceae, Lardizabalaceae, Hamamelidaceae, Chloranthaceae, Tetracentraceae, and Lauraceae show their maximum concentration only in this region within India. *Berberis* and *Mahonia* (Berberidaceae) are also well represented, the former with several endemic species at higher elevations. One of the most important timber yielding families Dipterocarpaceae is represented by several species of *Dipterocarpus*, *Shorea* and *Vatica*. The lowland tropical evergreen forests in this region are perhaps the largest remaining *Dipterocarpus* forests in the whole of India.

The family Balsaminaceae is representd by two genera viz. *Impatiens* and *Tytonia* in this region. *Impatiens* is represented by 200 species in India, out of *ca* 600 so far known in the world. These plants are water loving and are very much ornamental with varied flower colours. About 44 species of this genus occur in North-eastern India, out of which, *Impatiens acuminata*, *I. assamica*, *I. bracteolata*, *I. cothurnoides*, *I. depauperata*, *I. gibbisepala.*, *I. khasiana*, *I. lavevigata.*, *I. longirama*. *I. odontosepala*, *I. porrecta*. and *I. racemulosa*, *I. rubro-*

lineata, *I. scitula*, *I. spiciflora* and *I. terniflra* are endemic to this region (Chauhan, 1982 a). *Tylonia triflora*, the only species of the genus in this area has been collected from Goalpara, Kamrup district of Assam, is rare and endangered. The family Rosaceae is well represented by species of *Argimonia, Cotoneaster, Crataegus, Docinia, Eriobotrya, Fragaria, Geum, Kerria, Micromeles, Niellia, Photinia, Potentilla, Poterium, Prinsepia, Prunus, Pygeum, Pyrus, Rosa, Rubus,* and *Spiraea*. Many of these are available in Eastern India while some are common to the western Himalayas also. The family Begoniaceae is very well represented wtih several species of which *Begonia adscendens, B. foveolata, B. obversa, B. palmata* var. *gamblei, B. surculigera B. wattii* and *B. wingeri* are endemic to this region. Similarly, the Cucurbitaceae is represented by more than 45 species and few of them are of great economic importance. Vacciniaceae and Ericaceae are also well represented. There are 70 species of which more than sixty are endemic to Assam-Burma. *Agapetes, Vaccinium* and closely related *Pentapterygium* are quite common and are represented by several species. In Ericaceae, a remarkable feature observed is the gregarious formations of numerous species of *Rhododendron* at higher altitude. These are with showy flowers of differenrt colours and attractive foliage. About 80 species of *Rhododendron* are reported from India, out of which, North Bengal and Eastern India can take pride of having *ca* 35 species, 1 sub-species and 4 varieties. Some species are endemic to this area, though many others show distinct affinity to the Chinese species. Besides, several species have their range fo distribution in Nepal, Bhutan, North-eastern India, Burma, China and Vietnam. Due to several reasons, *ca* 50% species of Rhododendrons are under threat (Sastry & Hajra, 1983). Mention may be made about few rare, endemic and ornamental species, whose population has been depleted considerably in nature; these are : *Rhododendrone elliotii, R. triflorum* var. *bauhiniflorum* and *R. wattii*.

Primula (Primulaceae) is well represented at high altitudes, many of them being endemics. Amongst Asclepiadaceae, *Hoya* and *Pentasacme* are dominant, while *Dischidia rafflesiana*, an interesting species occurs at lower elevation in tropical forests. The family Podostemonaceae with liverwort-like plants are represented by *Dicraeae acuminata, D. minor, Hydrobryum grifithii, Polypleurm filifolium, P. stylpsum, P. wallichii* etc. *Aristolochia* (Aristolochiaceae) with curioly shaped beautiful flowers is represented by five species. *Ficus* (Moraceae) with more than 45 species and *Quercus* (Fagaceae) with over 22 species are also dominant genera of this region.

The monocots are represented by 38 families. The family Orchidaceae is the largest one not only amongst the Moncotyledons but also among the Phanerogams as a whole. This is followed by Poaceae and Cyperaceae. The family Zingiberaceae is richly represented in this region. The genus *Hedychium* has a number of medicinally important plants. Some species of the genus are with showy flowers and foliage and has thus great potential as ornamental plants. Out of the total 60 *Hedychium* species in the world, *ca* 32 are known from Eastern India (Srivastava, 1983) of which 10 species viz. *Hedychium flavescene, H. flavum, H. elwesii, H. grantum, H. hookeri, H. luteum, H. marginatum, H. speciosum, H. tenuiflorum* and *H. wardii* and other members of the family viz. *Amomum pauciflorum, Boesenbergia rubroluta, Globba marantina, Mantisia wengeri* and *Zingiber intermedium* etc. are also endemic to North-eastern India. The family Arecaceae is represented by 44 species and 5 varieties, of which *Areca, Arenga, Calamus, Didymosperma, Livistonia, Pinanga* and *Phoenix* are predominant. Pandanaceae has five species. The families Aponogetonaceae, Bromeliaceae, Burmanniaceae, Butomaceae, Cannaceae, Dioscoreceae, Eriocaulaceae, Flagellariaceae, Najadaceae, Potamogetonaceae, Sparginiaceae, Trilliaceae, Triuridaceae and Xyridaceae are represented by a single genus each, of which the families Bromeliaceae, Butomaceae, Flagellariaceae, Sparganiaceae, Trilliaceae and Triuridaceae have all one species each in this region. Agavaceae, Iridaceae, Juncaceae, Marantaceae, Musaceae, Pontederiaceae and Stemonaceae have two genera each, Hypoxidaceae and Lemnaceae are the families with three genera each. Alismataceae and Amaryllidaceae have four genera each. Hydrocharitaceae is represented by seven genera. Commelinaceae by fourteen genera with fortyone species and the family Araceae has twentyone genera with sixtyone species. Liliaceae is represented by twentyfour genera and fiftyfour species. Besides, some economically important group of plants viz. bamboos and orchids need special mention.

Bamboos : This region has large populations of bamboos, which are well known for their multipurpose economic uses. Bamboos are used in house making, preparation of baskets, brooms, mats, poles, fencing, water pipes, bows and arrows, and for other cottage industries. It is even used for the preparation of salt. Besides, the tender shoots are eaten as vegetable by the local inhabitants. Out of about 116 taxa of bamboos reported from India, *ca* 61 are known from North Bengal and Eastern India (Majumdar, 1989). Some of the important bamboo specis of common local use are *Bambusa balcooa,* B. *glaucescens, B. khasiana, B. pollida, B. tulda,* B. *vulgaris, Chimonobambusa callosa, Chimonocalamus griffithiana, Dendrocalamus giganteus, D. hamiltonii, D. strictus, Drepanostachyum khasianum, D. polystachyum, D. suberectum, Gigantochloa macrostachya, G. nigrociliata, Phyllostachys mannii, Schizostachyum capitatum, S. pallidum, Yushania elegans,* Y. hirsuta etc.

Orchids : We are generally very much fascinated by orchids, because of their beautiful long-lasting ornamental flowers. The North-eastern region is prolific with many epiphytic and terrestrial orchids of immense horticultural value. Some of these are the progenitors of the modern commercial horticultural hybrids and deserve multiplication and protection for further hybridisation programmes. There is some controversy as the exact number of orchid species available in India (Pradhan, *ca* 800 ; Bose & Bhattacharya, *ca* 860 ; Rao, *ca* 1300 ; Das & Deori, over 1000 ; Mukerjee, *ca 1250* ; Jain & Mehrotra, *ca* 925 ; Hegde, *ca* 1000 ; Khushoo, 1300 and Karthikeyan *et al.*, 1075 spp. 2 subsp. 107 varieties and 6 forma). Out of these about 600 species flourish in this region which include some tiny species like *Trias pusila*, tall ones like *Galeola falconeri* (5 m or more) ; ephemerals of few hours life span like *Epipogium roseum* (D. Don) Lindl. and perennials. A very detailed study of this group is yet to be accomplished.

Some of the major components of this highly ornamental group of plants are as follows ; *Bulbophyllum* (37 spp. 5 var.), *Coelogyne* (25 spp. 3 var), *Cymbidium* (15 spp. 1 var.), *Dendrobium* (58 spp. 3 var.) *Eria* (23 spp., 3 var.), *Habenaria* (24 spp. 4 var.) , *Liparis* (17 spp. 2 var.), *Oberonia* (10 spp. 3 var.), *Paphiopedilum* (6 spp.), *Pleione* (3 spp. 2 var.) and 9 species of *Vanda*. A few of the important ornamental species, which are prized all over the world are : *Aeridis fieldingii*, *A. multiflorum*, *A. odoratum*, *Arundina graminifolia*, *Calanthe massuca*, *Coelogyne barbata*, *C. corymbosa*, *C. cristata*, *C. giganteum*, *C. lowianum*, *C. mastersii*, *C. tigrinum*, *Dendrobium chrysanthum*, *D. chrysotoxum*, *D. densiflorum*, D. *devonianum*, *D. falconeri*, *D. formosum*, *D. moschatum*, *D. nobile*, *D. wardianum*, *Esmeralda clarkei*, *Katherinea ampla*, *Paphiopedilum hirsutissimum*, *P. insigne*, *P. venustum*, *P. villosum*, *Phaius flavus*, *P. mishmensis*, *P. tankervilliae*, *Pleione maculata*, *P. praecox*, *Renanthera imschootiana*, *Rhynchostylis retusa*, *Vanda coerulea* and several others. Due to over exploitation, most of the orchids are becoming rare in their natural habitats and several are seen only in Orchidaria.

Primitive angiosperms : The North-eastern region also inhabits primitive flowering plants (Table-I). Takhatajan (1969) considers the Eastern Himalayas, Assam, Yunnan, Upper Burma, North Vietnam and Eastern Asia as the primary centre of origin of the temperate angiospermic flora due to the concentration of maximum number of primitive flowering plants. If this view is accepted, one has to believe that the flora of this region is quite primitive and indigenous. On the other hand Smith (1970) indicated that the countries bordering Pacific Ocean as the centre of origin of Angiosperms based on the presence of few primitive families, along the shores of the Pacific Ocean countries. It is suggested that the South-east Asian flora which is a part of the Gondwanaland flora brought through the Burmese and Malaysian portion of Indian block joining with the Asian mainland and the inaccessible terrain of the Himalayas helped in the preservation of the remnants of few primitive families. Hence, according to him it is appropriate to consider the South-east Asia plexus with numerous folds of mountains as a "refugium" and not a cradle of flowering plants. van Steenis (1971) too considers that the Yunnan-Queensland area is the probable cradle of Fagaceae and also "critical theatre" in which angiosperms evolved.

Table I

Some Primitive flowering plants occurring in North Bengal & North-eastern India

Name of the species	Family	Distribution
Actinodaphne angustifolia Nees	Lauraceae	North Bengal, North eastern India & Malaya
A. longipes Kostern.	-do-	North Bengal, Sikkim, Nagaland, Nepal
A obovata (Nees) Bl.	-do-	North-eastern India, E. Himalaya, Bangladesh
A. obovata (Nees) Bl. var. *wattii* King	-do-	Manipur
Alcimandra cathcartii (Hook. f. & Thoms.) Dandy	Magnoliaceae	Meghalaya, Nagaland & Sikkim
Alseodaphne dumicola W.W. Smith	Lauraceae	Nagaland
A. khasyana (Meissn) Koster.	-do-	Endemic to Meghalaya
Artabotrys caudatus Wall. ex Hook. f. & Thoms.	Annonaceae	-do-
A. cubittii Chatterjee	-do-	Assam, Manipur
Beilschmiedia assamica Meissn.	Lauracae	North-eastern India and Burma
B. fagifolia Nees	-do-	North-eastern India
B. roxburghiana Nees	-do-	North-eastern India and Burma
Betula alnoides Buch.-Ham.	Betulaceae	North-eastern India, Temp. Himalaya and Burma
Chloranthus elatior R. Br.	Chloranthaceae	North-eastern India, E. Himalaya, Andaman and Malaya
C. glaber (Thunb.) Makino	-do-	North-eastern & South India, Malaya
Corylopsis himalayana Griff.	Hamamelidaceae	North-eastern India & S. China
C. himalayana Griff. var. *griffithii* (Hemsl.) Morley & Chao	-do-	Meghalaya
Cryptocarya amygdaline Nees	Lauraceae	North-eastern India, E. Himalaya & Andamans
C. andersonii King	-do-	North-eastern India
Desmos longiflours (Roxb.) Safford.	Annonaceae	North-eastern India, Malaya
Dillenia mansonii (Gage) Hoogl.	Dilleniaceae	Assam
Dillenia scabrella (D. Don) Roxb. ex Wall.	Dilleniaceae	Assam, Meghalaya, Eastern India

Name of the species	Family	Distribution
Distylium indicum Benth. ex C.B. Clarke	Hamamelidaceae	Endemic to Meghalaya
Exbucklandia populnea (R. Br. ex Griff.) R.W. Brown	-do-	North Bengal, North-eastern India, E. Himalaya & Sumatra
Fissistigma santapaui D. Das	Annonaceae	Assam
F. verrucosum (Hook. f. & Thoms.) Merr.	-do-	Endemic to North-eastern India
F. wallichii (Hook.f. & Thoms.) Merr.	-do-	North-eastern India and E. Himalayas
Goniothalamus sesquipedalis (Wall.) Hook. f. & Thoms.	-do-	North-eastern India, Indo-Burma
G. simonsii Hook. f. & Thoms.	-do-	Endemic to Meghalaya
Helicia exelsa Bl.	Proteaceae	North-eastern India, Burma
H. nilagirica Bedd.	-do-	-do-
Holboellia khasiana Paul & Nayar	Lardizabalaceae	Meghalaya
H. latifolia Wall.	-do-	Khasi & Jaintia hills, North-eastern India
Horsfieldia amygdalina (Wall.) Warb.	Myristicaceae	North-eastern India, Bangladesh & Burma
H. kingii (Hook. f.) Warb.	-do-	E. Himalaya
Illicium griffithii Hook. f.	Illiciaceae	North-eastern India, E. Himalaya
I. manipurensis Watt ex King	-do-	Manipur, Arunachal Pradesh
I. simonsii Maxim.	-do-	Assam, Manipur, Nagaland.
Kadsura heteroclita (Roxb.) C.B. Clarke	Schisandraceae	North-eastern India, E. Himalaya, Bangladesh
K. wattii Craib	-do-	Endemic to Manipur
Knema angustifolia (Roxb.) Warb.	Myristicaceae	North-eastern India & Bangladesh
Loropetalum indicum Tong	Hamamelidaceae	Meghalaya
L. chinense (R. Br.) Oliver	-do-	Khasi & Jaintia hills & S. China
Magnolia griffithii Hook. f. & Thoms.	Magnoliaceae	Endemic to North-eastern India
M. gustavii King	-do-	Endemic to Lakhimpur, Assam
M. pealiana King	-do-	Endemic to Assam
M. pterocarpa Roxb.	-do-	North-eastern India and Burma
M. hookeri (Cubit & Smith) Raju & Nayar	-do-	North-eastern India, E. Himalaya, China, Thailand, Java
M. caveana Hook. f. & Thoms.	-do	North-eastern India

Name of the species	Family	Distribution
M. insignis (Wall.) Bl.	-do-	North-eastern India, E. Himalaya, China, Thailand, Java
Michelia doltsopa Buch. Ham.	-do-	North-eastern India & Temperate Himalaya
M. kingii Dandy	-do-	North Bengal, Sikkim
M. mannii King	-do-	North-eastern India
M. oblonga Wall. ex Hook. f. & Thoms.	-do-	-do-
M. punduana Hook. f. & Thoms.	-do-	Endemic to North-eastern India & Himalaya
Myrica esculenta Buch.-Ham.	Myricaceae	North-eastern, South India & Indo-Malaya
Pachylarnax pleiocarpa Dandy	Magnoliaceae	Assam, Nagaland
Paramichelia baillonii Hook. f. & Thoms.	-do-	Meghalaya & Other parts of North-eastern India
Polyalthia cerrasoides (Roxb.) Bedd.	Annonaceae	Arunachal Pradesh & Meghalaya
P. jenkinsii Benth. & Hook. f.	-do-	North-eastern India & Indo-Malaya
P. simiarum (Hook. f. & Thoms.) Hook. f. & Thoms.	Annonaceae	North Bengal, North-eastern India & E. Himalaya, Burma
Sycopsis griffithiana Oliv.	Hamamelidaceae	Endemic to Khasi hills, very rare
Talauma hodgsonii Hook. f. & Thoms.	Magnoliaeceae	North-eastern India, E. Himalaya & Bangladesh
T. rabaniana Hook. f. & Thoms.	-do-	North-eastern India
Tetrameles nudiflora R. Br.	Tetramelaceae	North-eastern India, Burma, China & Malaya
Trivalvaria argentia (Hook. f. & Thoms.) Sinclair	Annonaceae	Assam, Meghalaya & Bangladesh
T. kanjilalii D. Das.	-do-	Endemic to Jaintia hills of Meghalaya
Uvaria lurida Hook. f. & Thoms.	-do-	North-eastern India & Burma

FLORISTIC ELEMENTS OF OTHER COUNTRIES

Though the flora of this region exhibits an Indo-Malayan affinity, the floral elements of others parts of India, the neighbouring and far off countries have also contributed to its richness and diversity. These affinities are best illustrated by an enumeration of some of the common elements. The Chinese, Bhutanese and Himalayan genera are *Acanthopanax, Actinidia, Anthocephalus, Atlanita, Bruinsmia, Bulbophyllum, Camellia, Cymbidium, Epigenium, Kadsura,* etc. Malayan elements occurring in the North-eastern India are genera like *Balanophora*, *Engelhardtia*, *Exbucklandia*, *Milliusa*, *Rubus*, *Talauma* and *Vaccinium* etc. Besides, some of the common species having the affinities with Tibet are *Anemone griffithi*, *A. trullifolia*, *Rhododendron anthopogon*, *R. ciliatum*, *Primula concina*, *P. griffithii*, *P. tibetica* and *P. vaginata* etc. *Eurya acuminata*, *E. nitida*, *Hypericum laxum*, *Mitrastemone yamamotoi*, *Pericampylus glaucus*, *Viola diffusa* etc. are the best examples of Sino-Japanese affinity distributed through Burma and China. The floristic elements common with peninsular India are *Apodites benthamiana*, *Dillenia indica.*, *D. pentagyna*, *Eurya acuminata.*, *Mahonia pycnophlla*, *Ternstroemia gymnanthera*, etc. The American elements met within are *Elatostema sessile*, *Grewia disperma* *Ochna integerima*, *Phoenix humilis* and some others. The genus *Asarum* may serve as an example of North American element in the North-eastern Indian flora. Besides, the affinity is exhibited generally by weeds of agricultural lands *e.g. Chromolaena odorata*, *Eichhornia crassipes*, *Eupatorium adenophorum*, *Lantana camara*, *Mikania micrantha*, *Parthenium hysterophorus* etc. Besides *Boschniackia himalaica*, a root parasite of Orbanichaceae and *Pyrularia edulis* (Santalaceae) which have one species in N.E. India and Eastern Himalayas and another solitary one in America are the best example of transpecific distriburtion. *Polystachya* with its maximum number of species in tropical America was hithero known in India only from Peninsula by *P. flavescense* and its occurrence in Nongpho, Meghalaya is another interesting instance of discontinuous distribution. Besides, a number of exotics have been introduced on Indian soil and have become permanent denzens. Some of them have not only masked the native elements, but have also replaced them probably because of their allelopathic effects (Rao, 1977). Many of them have become adventive in nature and have altered the floristic composition of the indigenous flora (Maheshwari, 1960; Rao & Dam, 1979).

Botanical curiosities : The region has been admired by the botanists and other scientists not only for its economic plants but also for the botanical curiosities. Some of these curiosities get collected frequently thereby rendenring them endangered/rare or threatended categories.

Aristolochia griffithii, a plant with curiously shaped flowers occurs in temperate and alpine forests. *Aeginitia indica*, *Balanophora dioica*, *Boschniackia himalaica*, *Mitrastemon yamamotai*, *Sapria himalayana* etc. are common root parasites, *Epipogioum roseun*, *Erardia asraoa*, *Galeola falconeri*, *G. lindleyana* and *Monotropa uniflora* which grow on dead organic matter in dense forests, are excellent example for saprophytes.

Among the insectivorous plants mention may be made of the pitcher plant *Nepenthes khasiana*, *Drosera burmannii*, D. *peltata* and ten species of *Utricularia* (Joseph & Joseph, 1986) occurring in this region. Another interesting plant *Aldrovanda vesiculosa* with the leaves similar to those of the venus fly-trap has been reported from Manipur (Deb, 1957). Among the other interesting taxa, mention may be made of *Cycas pectinata* occurring scattered in Kamrup and *Eurale ferox* with giant floating leaves and a near ally of the *Victoria regia* of South America seen in several places of Assam and Meghalaya *Ephedra* sp., *Gnetum gnemon G. ula*, *Podocarpus nerifolia*, *Pinguicuala alpine*, *Taxus wallihii* have been reported from different parts of this region. Probably the most remarkable among the Indian fresh water plants are the Podostemonads, which clothe rocks and stones in rapidly flowing streams with submerged spreading fronds and resemble green Lichens or Liverworts.

Medicinal and aromatic plants : It is imperative to mention here that this region has always served as a storehouse of medicinal and aromatic plants. The tribal populations inhabiting different parts of N.E. region solely depend upon these plants for the cure of diseases from the time immemorial. In spite of the influx and encroachment of modern civilization and missionary activities to provide modern medical facilities to these people, the rural folk to a great extent and a determined minority among the literates, hold their faith in the indigenous type of medication. A detailed account on this is beyond the scope of this paper, but mention may be made some of the important plants such as : *Abroma angusta, Aconitum nagarum, Acorus calamus, Alpinia nigra, Alysicarpus monilifer, Amomum* spp., *Aquilaria malaccensis, Aristolochia saccata, Berberis* spp., *Brucea mollis, Clerodendron colebrookianum, Costus speciosus, Cyathula prostrata, Dioscorea prazeri, Equisetum diffusum, Galinsoga parviflora, Garcinia cowa, Gaultheria fragrantissima, Gynocardia odorata, Hoya globosa, Hydnocarpus kurzii, Imperata cylindrica, Leucas linifolia, Lycopodium clavatum, Milletia caudata, M. pachycarpa, Nardostachys grandiflora, Nepenthes khasiana, Nicotiana tabacum, Paederia foetida, Panax pseudo-ginseng, Picrorhiza scrophulariflora, Piper* spp., *Rauvolfia serpentina, Rheum australe, Solanum myriacanthum, S. spirale, Swertia chirayita, Tacca integrifolia, Viola serpens, Zanthoxylum acanthopodium* etc. that are used to cure different ailments by the tribals.

Primitive cultivars and land races : The region abounds a rich gene pool of primitive cultivars and land races of crop plants also. Recently a traditional rice cultivar having useful gene was collected by the scientists of I. A. R. I. in localities ranging from 1800 2700 m in different states of this region. The collections consisted of 6730 different sets of this cultivar, out of which 5000 came from the hills (Borthakur, 1984). These collections are known as A. R. C. and form the base for improvement of rice not only in this country, but also abroad. This is because of the fact that they possess desirable genes for various characters including genes for resistace to pests and diseases. Unfortunately, these traditional races are fast getting eliminated by the introduction of high yielding varieties. Recently, exploration in the Himalayan foothills of North-eastern India has yielded many such rice cultivars resistant to major diseases (IUCN, 1984). Besides these crops, there are numerous wild relatives of cultivated plants in these forests, mention may be made of *Alpinia, Alocasia, Amomum, Malus, Mucuna, Trichosanthes, Vigna,* etc. Moreovers, variability in *Amorphophyllus, Cajanus,* *Camellia, Canvallia, Fagopyrum, Prunus, Pyrus, Rubus* etc. are prolific. The genus *Dioscorea* represented by 18 species and *Piper* with 23 species. The wild species of banana viz. *Ensete glaucum, Musa acuminata, M. assamica, M. aurantiaca, M. balabisiana, M. cheesmanii, M. flaviflora, M. itinerense, M. mannii, M. nagensium, M. sapientum* var. *dubia, M. sikkimensis, M. velutina* etc. have been recorded, some of them are endemic to this region. Besides, about 64 species of *Citrus* have also been recorded from this part of the country (Bagh Singh, 1981). He further concluded that the concentration of several most primitive species of wild *Citrus* viz. *C. assamensis, C. inchanganisis, C. indica, C. latiped* and *C. macroptera* in Nokrek, Meghalaya ; Assam and Nagaland furnished a strong evidence that this region must be called the centre of origin of *Citrus*. Verma and Ghosh (1979) explored the major *Citrus* growing belt of Arunachal Pradesh, Meghalaya, Nagaland and Sikkim and have described several native variants of *Citrus*.

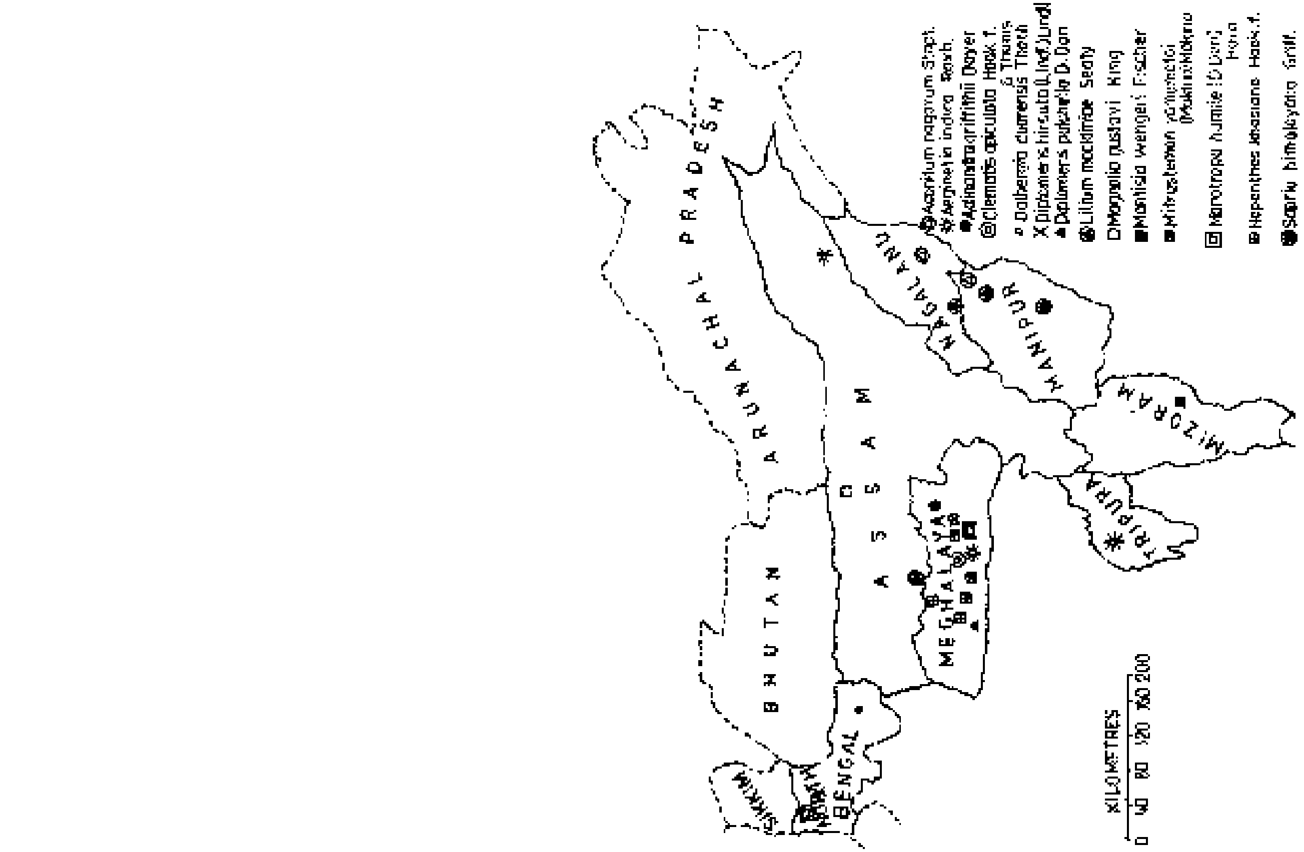
So far as the fibre crops are concerned, this region is also an important centre for many variant forms of jute belonging to the genus *Corchorus*. Many land races of jute have been found in Garo hills of Meghalaya and Tripura. Other fibre yielding plants viz *Canabis, Crotalaria, Sesbania* and *Sida* with their variant forms grow profusely in this region. Besides, the wild relatives of sugarcane such as *Saccharum barber, S. robustum, S. spontaneum* and *Erianthus* spp. also hail from North-eastern India, other taxa like *Costus, Curocuma, Hedychium, Mantisia, Zingiber* etc. have great potential for commercial exploitation and hybridization programme.

Endemics : The term `endemic' is generally applied to a taxon viz. species, genus or other group confined to a small area. Chatterjee (1940) has emphasized the richness of flora of this region and has estimated that 3109 species of dicots and 1000 species of monocots are endemic to this region. But no up-to-date analysis is available for endemic plants in easter Himalayas including Assam, though the Himalayas taken as a whole have more than 50% of endemic plants in India. Rich endemism in any area indicates antiquity of its flora, special condition of climate of micro-climate in the ecosystem, and natural or geographical barriers around the area. No definite conclusion on the percentage of endemic taxa of North-eastern India can be drawn at this juncture. Even though *ca* 30% species appears to be endemic. Some of the genera which are endemic to this region are : *Asroa, Biswarea, Bryocarpum, Hymenandra, Jejosephia, Lepidostemon, Neolufffa, Pauia, Parajaeschkea, Pleaurospermospsis, Treutlera* etc.

ENDANGERED TAXA OF N.E. INDIA

The rich plant diversity of Eastern India is at present in great danger of alteration and depauperisation due to several biotic as well as abiotic factors. The climatic fluctuations, evolutionary changes and the introduction or extinction of species etc. have contributed to some extent for this. But the major threat for the depletion of flora and vegetation is drastic environmental changes brought about by man himself in these forests. By far the most important cause of destruction in this region is the increased pressure on land for Jhum cultivation. Besides, overgrazing, excessive use of firewood as fuel, forest fires and various socio-econmic developmental activites are bringing about the destruction of natural forests at a greater pace. Due to population pressure, the period of jhum cycle has reduced to 4-5 years in Megalaya, 5-10 years in Mizoram and Tripura, 6-15 years in Manipur and Nagaland, providing practically no chance for natural regeneration of soil fertility. Jhumias prefer the secondary growth of bamboos over primary or secondary wooded forests, as these can be cut, dried and finally burnt easily thereby getting plenty of ashes rich in posatium suitable for a better and healthy growth of crops. But with shorter jhum cycle, obnoxious weeds like *Chromoleana, Eupatorium, Lantana, Mikania* etc. spread widely if the soild profile is rich, and it tends the growth of *Imperata cylindrica*. But once *Imperata* invades the badly degraded land, restoration of forests is time consuming and expensive. In certain places, the soil has been eroded completely, thereby making these areas barren and unproductive waste lands. Recently, introduction of crop like Cardamum, Coffee, Rubber, Tea, Tapicoa etc. at different altitudes has also contributed a lot towards fast deforestation. A comparison of the vegetational study in the past and the present reveals the speed at which the vegetal wealth of the region is being destroyed. For instance, Hooker *(l.c.)* mentioned that the flora of Khasi & Jaintia hills was the richest in the whole of Asia, both in number of species and in number of individuals in each species at that time. He collected 7 head loads of *Vanda coerulea* (Blue Vanda) which was once so abundant in Jaintia hills of Meghalaya for cultivation in Kew Gardens. Now this species has become a rare and threathened one in nature. Similarly, a large number of other species have also fallen in different categories of threat and few of them have already said good-bye to this world. Besides, in the afforestation programmes, more emphasis has been given either to monoculture or to mixed forests, comprising mostly exotic species. As a result primary forests are fast disappearing and close canopied indigenous trees are being replaced by straight boled *Alnus.*, *Cryptomeria, Eucalyptus, Pinus* etc. Similarly, under water management programmes initiated by different organisations, a number of exotics including grasses etc. have been prefered over native species due to their known high productivity and better nutritional value. All these factors have resulted in major qualitative and quantitative changes in the flora of this region.

During the present century, man with his anthropogenic associates and other factors or practices such as fire, 'slash and burn' shifting cultivation, grazing by cattle and by several other mechanical means has suddently accelerated the disastrous conditions in the natural ecosystems. Consequently, *ca* 700 taxa of plants in this region have fallen under different categories of threat (Lucas &



Map 12. Distribution of some interesting plants in Eastern India and North Bengal

Synge, 1978; Jain & Sastry, 1980) due to several factors and unjudicious exploitation (Ansari & Thothathri, 1988; Ansari, 1988; Arora, 1983; Bahadur, 1983; Basu, 1990; Veena Chandra, 1990; Chauhan, 1982 b, 1983, 1985, 1987 a-g, 1988b, 1990; Chauhan & Singh, 1992; Das & Deori, 1983; Deb, 1957, 1988 a; Deb & Mondal, 1987, 1988 a-d; Deb & Rout, 1990; Deb & Dutta, 1990; Deb & Basu, 1990; Deori, 1988; Dutta & Nayar, 1987; Gangopadhyaya, 1990 a-c; Hajra, 1987; Haridasan & Mukherjee, 1988; Hedge, 1987; Kammathy, 1987, 1988; Karthikeyan, 1983; Kataki, 1987 a-d; Kumar & Rao, 1983; Kumar & Bhattacharya, 1990a-i; Majumdar, 1990a-b; Mathur, 1990a-b; Mukherjee, 1987, 1988 a-b; Murti, 1990; Myrthong & Rao, 1983; Naithani & Bahadur, 1983; Nayar & Sastry, 1987 a-b; 1988, 1990; Phukan, 1987 a-c; Raghavan, 1988, 1990, Ramamurthy, 1987 a-b; Sanjappa, 1990; Sastry *et al.*, 1983; Srivastava, 1988; Srivastava, 1983; Trivedi & Tripathi, 1984; Verma, 1987a-d). Besides, a number of species have not been collected after their type collection. (Table II, Map 12).

Table II

Some rare, theatened and endemic plants of North Bengal & North-eastern India, whose population have been depauperised considerably in the natural habitats. Plants with an asterisk (*) have not been collected after their type collection.

Name of taxa	Family	Range of distribution
Acanthephippium sylhetense Lindl.	Orchidaceae	N.E. India, Burma, Thailand
Acer hookeri Miq. var. *majus* Pax	Acceraceae	Endemic to North Bengal,
A. osmastonii Gamble	-do	-do
Aconitum laciniatum (Bruhl) Stapf	Ranuculaceae	N. Bengal, Sikkim, Nepal
A. nagarum Stapf	-do	Endemit Manipur,Nagaland
A. novoluridum Munz	-do-	N. Bengal, Sikkim Arunachal Pd., Nepal
A. spicatum (Bruhl) Stapf	-do	N. Bengal, Sikkim, Nepal
Acranthera tomentosa R. Br.	Rubiaceae	Endemic to N.E. India
Adinandra griffithii Dyer	Theaceae	Endemic to N.E. India
Agrostis wardii Bor	Poaceae	Endemic to Manipur
**Albertisia mecistophylla* (Miers.) Forman	Magnoliaceae	Endemic to Assam & Meghalaya
Alcimandra cathcartii (Hook. f.) Dandy	Magnoliaceae	Sikkim, N.E. India
Alseodaphne khasyana (Meissn.) Kosterm.	Lauraceae	Endemic to Meghalaya
Alsodeia racemosa Hook. f. & Thoms.	Violaceae	-do-
Amblyanthus multiflorus Mez	Myrsinaceae	Endemic to Assam
Anneslea fragrans Wall.	Theaceae	Manipur, Nagaland & Burma
Anoectochilus tetrapteris Hook. f.	Orchidaceae	Endemic to Manipur
Aphyllorchis vaginata Hook. f.	-do-	Endemic to Maghalaya
Apios carnea Benth.	Fabaceae	Meghalaya & Nepal

Contd.

Name of taxa	Family	Range of distribution
Ardisia quinquangularis A. DC.	Myrsinaceae	Endemic to Meghalaya
A. rhynchophylla Clarke	-do-	Endemic to N.E. India
Artabotrys burmanicus A. DC.	Annonaceae	Manipur
A. cubittii Chatterjee	-do-	Assam, Manipur
Aspidopterous oxphylla (Wall.) Juss.	Malphighiaceae	Endemic to Meghalaya
Begonia adscendens Clarke	Begoniaceae	Nagaland & Manipur
**B. brevicaulis* DC.	-do-	Meghalaya
B. foveolata Irmsch.	Begoniaceae	North Bengal
**B. obversa* Clarke	-do-	Endemic to Mizoram
B. obversa Clarke	-do-	Manipur
B. palmata D. Don var. *gamblei* (Irmsch.) Hara	-do-	N. Bangal, Sikkim
B. rubrovenia Hook. f. var *meisneri* Clarke	-do-	Endemic to Meghalaya
B. satrapis Clarke	-do-	Endemic to Darjeeling, Sikkim
B. scutala Wall. ex DC.	-do-	Darjeeling, Sikkim, Peninsular India, Nepal
B. surculigera Kurz	-do-	Mizoram & Tripura
B. tessaricarpa Clarke	-do-	Endemic to Assam
**B. wattii* Clarke	-do-	Endemic to Nagaland
**B. wengeri* Fischer	-do-	Endemic to Mizoram
Beilschmiedea pseudomicropora (Purkay.) Koesterm.	Lauraceae	N.E. India
Berberis collettii Schneid	Berberidaceae	Meghalaya, Bhutan, Nepal
B. griffithiana Schneid	-do-	-do-
B. manipurana Ahrendt	-do-	Manipur
B. micropetala Schneid	-do	Nagaland
Bulpoppylum mishmense Hook. f.	Orchidaceae	Endemic to Arunachal Pradesh, Assam
B. viresn Hook. f.	-do	-do
Bulleyia yunnanensis Schltr.	Orchidaceae	N. Bengal, Arunachal Pradesh, Bhutan, China
Calanthe anthropophora Ridley	-do-	Meghalaya, Thailand
C. odora Griff.	-do-	Assam
Campylotropis prainii (Coll. & Hemsl.) Schind.	Fabaceae	Mizoram
Capillipedium nagense Bor	Poaceae	Endemic to Nagaland
C. planipedicellatum Bor	-do-	Endemic to Manipur
C. pteropechys (Clarke) Stapf	-do-	Endemic to Nagaland
Capparis cinerea Jacobs	Capparaceae	Endemic to Meghalaya
C. pachyphylla Jacobs	-do-	Arunachal Pradesh, Manipur, Nagaland
C. sikkimensis Jacobs ssp. *sikkimensis*	-do-	North Bengal, Sikkim, Manipur, Nagaland
Carex fusifruca Clarke	Cyperaceae	Endemic to Assam

Contd.

Name of taxa	Family	Range of distribution
C. repanda Clarke	-do-	Endemic to Meghalaya
Casearia sikkimensis Mukerjee		India, Bangladesh
Ceropegia arnottiana Wight	Asclepiadaceae	Meghalaya, S.E. Asia
C. lucida Wall.	-do-	Sikkim, N.E. India, Bangladesh
Chaerophyllum orientalis (Clarke) Mukh.	Apiaceae	Endemic to Nagaland
Christiopteris tricuspis (Hook.) Chist.	Polyodiaceae	Endemic to Darjeeling, Sikkim
Chryssoglossum assamicum Hook. f.	Orchidaceae	Endemic to Assam
Christoperis corifolia Jeffery & Chen	Asteraceae	N. Bengal, Sikkim
Citrus assamensis Dutta & Bhattacharya	Rutaceae	Endemic to N.E. India
C. ichagensis Swingle	-do-	Assam, China
C. indica Tanaka	-do-	Endemic to N.E. India
C. latips Tanaka	-do-	-do-
C. macroptera Montrous	-do-	Assam, N. Caledonia
Clematis acuminata DC. ssp. *sikkimensis* var. *clarkei* Kuntz.	Ranunculaceae	Assam, Sikkim
C. apiculata Hook. f. & Thoms.	-do-	Endemic to Meghalaya
C. fulvicoma Rehder & Wilson	-do-	Assam, Meghalaya
C. meyeniana Walp.	-do-	Nagaland
C. meyeniana Walp. var. *insularis* Sprague	-do-	Nagaland
C. tongluensis var. *khasiana* (Bruhl) Kapon	-do-	Meghalaya
Cleyera japonica Thunb. var. *grandiflora* (Wall. ex Choisy) Kobuski	Theaceae	Endemic to Meghalaya
Cocculus prainianus (Diels) Pramanik & Thoth.	Menispermaceae	Nagaland
Codonopsis affinis Hook. f. & Thoms.	Campanulaceae	Endemic to Darjeeling,
Coelogyne fuscescens Lindl. var *viridiflorum* Pradhan	Orchidaceae	North Bengal
C. griffithii Hook. f.	-do-	N.E. India
C. hitendrae Das & Jain	-do-	Nagaland
C. rossiana Rchb. f.	-do-	N.E. India, Burma
C. viscosa Rchb. f.	-do-	Endemic to Meghalaya
**C. purpurea* Joseph & Yog.	-do-	-do-
Corydalis borii Fischer	Fumariaceae	Nagaland
Cotoneaster franchetii Boiss	Rosaceae	Darjeeling
C. khasiensis Klotz.	-do-	Meghalaya
C. nagaensis Klotz.	-do-	Nagaland
C. pannosus Franch	-do-	Darjeeling
Cotylanthera tenues Bl.	Gentianaceae	Meghalaya, Java
Crotolaria meeboldii Bl.	Fabaceae	Nagaland
C. noveiloides Griff.	-do-	Endemic to Meghalaya
Cyclea debiliflora Meirs.	Menispermaceae	Endemic to Meghalaya

Contd

Name of taxa	Family	Range of distribution
C. meeboldii Diels	-do-	Endemic to Meghalaya
**C. wattii* Diels	-do-	Endemic to Nagaland
Cymbidium eburneum Lindl.	Orchidaceae	Endemic to N.E. India, Eastern Himalaya
C. tigrinum Parish	-do-	Nagaland, Burma, Thailand
C. whiteae King & Pantl.	-do-	Endemic to N.E. India, Sikkim
Cymbopogon jwarancusa (Jones) Schult. var. *assamensis* B.K. Gupta	Poaceae	Endemic to Assam
C. traninhensis (A. Camus) Soenarko	-do-	Endemic to N.E. India
Dalbergia duarensis Thoth.	Fabaceae	North Bengal
D. volubilis Roxb. var. *assamica* Thoth.	-do-	Meghalaya
D. wattii Clarke	-do-	Manipur
Delphinium stapeliosum Bruhl ex Huth.	Ranunculaceae	Meghalaya, Bhutan, Nepal
Daphne shillong Benerjee	Thymelaeaceae	Meghalaya
D. sureil W.W. Smith	-do-	N. Bengal, Sikkim, Mizoram, Bhutan, Nepal
Dendrobium arachnites Rchb. f.	Orchidaceae	Manipur, Burma
D. darjeelingensis Pradhan	-do-	North Bengal
Derris cuneifolia Benth var. *longipedicellata* Thoth.	Fabaceae	N. Bengal, Sikkim, Nepal
Deyeuxia borii Sundanda & Jain	Poaceae	Endemic to Nagaland
Deyeuxia nagarum Bor	Poaceae	Endemic to Nagaland
Dicentra paucinervis Stern	Fumariaceae	Noth Bengal, Arunachal Pradesh, Sikkim, Meghalaya, Nagaland
Digitaria jubata (Griseb.) Henr.	Poaceae	Enademic to Meghalaya
Dillenia mansonii (Gage) Hoogl.	Dilleniaceae	Assam
Diplocrum caricinum (Benth.) R.Br.	Cyperaceae	N.Bengal, Sikkim, N.E. India
D. pulchella D. Don	-do-	Endemic to Arunachal Pradesh, Meghalaya
Dipsacus asper Wall. ex D. Don	Dipsacaceae	Endemic to Meghalaya
Distylium indicum Benth.	Hamamelidaceae	-do-
Drepanostachyum jainianum (Das & Pal) R. Majumdar		North Bengal
Dysoxylum khasianum Brace ex Purkaya.	Meliaceae	Meghalaya
Elaeagnus conferta ssp. *dendrodea* Servettas ex Mast	Elaeagnaceae	Endemic to N.E. India
Elaeocarpus acuminatus Wall.	Elaeocarpaceae	Meghalaya, Bangladesh
Engelhardtia walichiana Lindl.	Junglandaceae	Meghalaya
Epipogium roseum Lindl.	Orchideaceae	Meghalaya, E. Himalayas
Epirixanthes elongata Bl.	Polygalaceae	Meghalaya, Burma, Malaya
Eria barbata Reihb. f.	Orchidaceae	Maghalaya, Burma, Thailand
E. crassicaulis Hook. f.	-do-	Endemic to Meghalaya
E. pumila Lindl.	-do-	Endemic to N.E. India

Contd.

Name of taxa	Family	Range of distribution
**Euonymus assamicus* Blakelock	Celastraceae	Endemic to Assam
E. viburnoides Prain	-do-	N. Bengal, Sikkim
Festuca rubra Linn. ssp. *clarkei* (Stapf) St. Yves	Poaceae	Endemic to Meghalaya
Fibraurea trotteri Miers	Menispermaceae	Manipur
Fissistigma santapaui Das	Annonaceae	Assam
Galeola altissima (Bl.) Rchb.f.	Ericaceae	Endemic to Assam
G. lindleyana Rchb. f.	-do-	Sikkim, N.E. India
Gastrodia exilis Hook. f.	-do-	Endemic to Meghalaya
Gaultheria recurva Lindl.	Orobanchaceae	Tirap, Arunachal Pradesh
Galium asperifolium Wall ex Roxb. var. *sikkimensis* (Godoger)Cufodontis	Rubiaceae	N. Bengal, Sikkim Endemic to N.E. India
Gleditsia assamica Bor	Fabaceae	Endemic to Arunachal Pradesh
Gymnocladus assamicus Kanjilal f.	-do-	Meghalaya
Goniothalamus simonsii Hook.f. & Thomas	Annonaceae	-do-
Goodyera prainii Hook.f.	Orchidaceae	Endemic to Assam, Nagaland
Hedychium calcaratum A.S. Rao & Verma	Zingiberaceae	Endemic to Meghalaya
H. dekianum A.S. Rao & D.M. Verma	-do-	-do-
H. gratum Wall.	-do-	Arunachal Pradesh, Meghalaya
H. greenii Sm.	-do-	N.E. India
H. hookeri Clarke ex Baker	-do-	Endemic to N.E. India
H.marginatum Clarke	-do-	Endemic to Nagaland
H. rubrum A.S. Rao & D.M. Verma	-do-	Endemic to Maghalaya
Herminium kalimpogensis Pradhan	-do-	North Bengal
Hiptage jacobbii Srivastava	Malpighiaceae	Mizoram
Holboellia khasiana Paul & Nayar	Lardizabalaceae	Meghalaya
Homalium schilichtii Kurz	Flacourtiaceae	N.E. India, Burma
Hydrocotyle himalaica Mukh.	Apiaceae	North Bengal
Hymenachne assamica (Hook.f.) Hitchc.	Poaceae	Endemic to N.E. India
Hyparrhenia griffithii Bor	-do-	Endemic to N.E. India
Hypericum assamicum S.N. Biswas	Hypericaceae	N. Bengal, Assam, Arunachal Pradesh
H. eledoides Choisy ssp. *wardii* Robson	-do-	Manipur, Arunachal Pradesh
Ilex clarkei loes	Aquifoliaceae	Manipur
I. embelioides Hook.f.	-do-	Endemic to N.E. India
I. khasiana Purkh.	-do-	-do-
I. wattii Loes	-do-	Manipur
Illicium manipurensis Watt ex King	Illiciaceae	Manipur, Arunachal Pradesh
I. simonsii Maxim	-do-	Assam, Manipur, Nagaland
Indopolysolenia wallichii (Hook.f.) Bennet	Rubiaceae	Manipur
Inula kalapani clarke	Asteraceae	Endemic to Khasi hills
Iodes cirrhosa Turez	Icacinaceae	Meghalaya, Nicobar Is.
I. hookeriana Baill.	-do-	N.E. India, Bangaladesh
Ischaemum hubbardii Bor	Poaceae	Endemic to Meghalaya
Ixonanthes khasiana Hook.f.	Ixonanthaceae	-do-

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Name of taxa	Family	Range of distribution
Kalanchoe roseus Clarke	Crassulaceae	Endemic to N.E. India
Lagerstroemia minuticarpa Debbar. ex Kanjilal f.	Lythraceae	Endemic to Assam, Sikkim
Lilium devidii Duchar.	Liliaceae	Endemic to Manipur
Lilium macklineae Sealy	-do-	Endemic to Manipur & Zukoo valley of Nagaland
Maesa neocoriacea Bennet	Myrsinaceae	North Bengal
M. wardii Nayar & Giri	-do-	Nagaland
Magnolia baillonii Pierre	Magnoliaceae	Assam
M. gustavii King	-do-	Endemic to Assam
M hookeri (Cubit & Smith) Raju & Nayar	-do-	Assam
M. griffithii Hook.f. & Thomas.	-do-	-do-
M. pealiana King	-do-	-do-
Maytenus sikkimensis (Prain) Raju & Babu	Celastraceae	North Bengal, Sikkim
M. thomsonii (Kurz) Raju & Babu	-do-	-do-
Mesua assamica (King & Prain) Kosterm.	Guttiferae	Assam
Michelia kingii Dandy	Magnoliaceae	N. Bengal, Sikkim
M. mannii King	-do-	Assam
M. montana Bl.	-do-	-do-
M. punduana Hook.f.	-do-	-do-
Microula duthiei Baner.	Boraginaceae	North Bengal
Miquelia kleinii Meisn.	Icacinaceae	N.E. India
Miscanthus wardii Bor	Poaceae	Endemic to N.E. India
Mitrastemon yamamotoi (Makino) Makino	Rafflesiaceae	Meghalaya, Japan
Monotropa uniflora L.	Monotropaceae	Eastern Himalayas, N.E. India, Japan
Mussaenda mastersii King	Rubiaceae	North Bengal
Mycetia mukerjiana Deb & Dutta	-do-	Endemic to Assam
Neanotis oxyphylla (G. Don) Lewis	-do-	Endemic to Meghalya
Neotainiopsis barbata (Lindl.) Bennet & Raiz.	Orchidaceae	N.E. India
Nepenthes khasiana Hook.f.	Nepenthaceae	Endemic to Meghalaya
Nymphaea tetragona Gregori	Nymphaeaceae	Meghalaya, Siberia, N. China
Ophiorrhiza gracilis Kurz	Rubiaceae	Nagaland, Burma
**O. griffithii* Hook.f.	-do-	-do-
O. lurida Hook.f.	-do-	N. Bengal, Sikkim, N.E. India Tibet & S. China
O. subcapitata Wall. ex Hook.f.	-do-	Endemic to Meghalaya
O. wattii Fischer	-do-	Endemic to N.E. India
Oraphea polycarpa A.DC.	Annonaceae	N.E. India, Burma
Paphiopedilum charlesworthii (Rolfe.) Pfitz.	Orchidaceae	Mizoram, Burma
P. spierianum (Rchb.f.) Pfitz.	-do-	Endemic to Manipur

Contd.

Name of taxa	Family	Range of distribution
P. venustum (Lindl.ex Sims.) Pfitz.	-do-	Meghalaya, Sikkim, Bangladesh
P. villosum (Lindl.) Stein	Orchidaceae	Mizoram, Burma
Paramignya scandens Craib	Rutaceae	Assam
Pholidota imbricata (Roxb.) Lindl. var. *sessilis* Hook.f.	Orchiaceae	Nagaland
**Pimpinella evgoluta* (Clarke) Mukh.	Apiaceae	Endemic to Nagaland
**P. flaccida* Clarke	-do-	-do-
P. tongloensis Mukh.	-do-	Endemic to Darjeeling
Pleione lagenaria Lindl.	Orchidaceae	Endemic to N.E. India
Poa wardiana Bor	Poaceae	Endemic to Assam
Podochilus khasiana Hook. f	Orchidaceae	Endemic to N.E. region.
P. pentasperma Clarke	Commelinaceae	-do-
Polygonum surbhunganicum Subba Rao	Polygonaceae	Endemic to Assam
Prunus wattii Ghora & Panigrahi	Rosacea	Manipur
Psychotria aborensis Dunn	Rubiaceae	Endemic to Arunachal Pradesh
**Pternopetalum senii* Deb & Dutta	Apiaceae	-do-
Pueraria anabaptista Kurz	Fabaceae	North Bengal
P. bella Prain	-do-	N.E. India, Burma
P. sikkemensis Prain	-do-	N.Bengal, Sikkim, Bhutan
**Pyrenaria diospyricarpa* Kurz	Theaceae	Assam
P. khasiana R.N. Paul	-do-	Endemic to Meghalaya
Pyrus wattii (Koehne) Bennet	Rosaceae	Manipur
Quercus gambleana. A. Cam.	Fagaceae	North Bengal
Rhododendron decipiens Lacaite	Ericaceae	North Bengal
R. elliotii Watt & Brandis	-do-	Manipur, Nagaland
R. johnstoneanum Watt ex Hutch.	-do-	Endemic to Manipur Mizoram
R. macabeanum Watt ex Balf.	-do-	Endemic to Manipur, Nagaland
R. triflorum Hook. f. var. bauhiniflorum (Watt ex Hutch.) Cullen	-do-	Endemic to Manipur
R. vitchianum Hook. f.	-do-	Mizoram
R. wattii Cowan	-do-	Endemic to Manipur
Robynsiochloa goulparensis (Bor) Clayton	Poaceae	Endemic to N.E. India
Rhynchosia meeboldii Satyan. & Thoth.	Fabaceae	Nagaland
**Salacia jenkinsii* Kurz	Celastraceae	Endemic to Assam
Sapria himalayana Griff.	Rafflesiaceae	Arunachal Pradesh, Assam, E. Himalya
Saurauia griffithii Dyer	Saurauiaceae	Endemic to Assam
**Scleria alata* Boeck	Asteraceae	Endemic to N.E. India
**Senecio mishmi* Clarke	-do-	-do-
Silene khasiana Roxb.	Caryophyllaceae	Endemic to Meghalaya
S. vagans Clarke	-do-	Endemic to Nagaland
**Sterculia khasiana* Debbar.	Sterculiaceae	Endemic to Meghalaya
S. kingii Prain	-do-	N. Bengal, Manipur
Stylidium kunthii Wall. ex DC.	Stylidiaceae	N. E., India
Sycopsis griffithiana Oliv.	Hammamelidaceae	Endemic to Khasi hills

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Name of taxa	Family	Range of distribution
Synotis simonsii (Clarke) Jeffry and Chen	Asteraceae	Assam
Toona ciliata Roem var. *listeri* (C.D.C.) Bahadur	Meliaceae	North Bengal
T. ciliata Roem. var. *candollei* Bahadur	-do-	-do-
T. microcarpa (C. D.C.) Harms var *sahnii* Bahadur	-do-	N. Bengal, Bhutan
Trachelospermum auritum Sch.	Apocynaceae	Endemic to Manipur, Meghalaya
Trichosanthes himalensis Clarke var. *sikkimensis* (Kundu) Thoth.	*Cucurbitaceae*	North Bengal, Sikkim
Trivalvaria kanjilalii D. Das	Annonaceae	Endemic to Meghalaya
Uvaria lurida Hook f. & Thoms	-do-	-do-
Vigna clarkei Prain	Fabaceae	North Bengal, Sikkim
Wendlandia puberula DC.	Rubiaceae	North Bengal, Sikkim, Nepal
Zanthoxylum pseudoxyphyllum Babu	Rutaceae	Manipur
Zeuxine pulchera King & Pantl.	Orchidaceae	Endemic to N.E. India Sikkim

CONSERVATION

Conservation means preservation plus regeneration (Joseph, 1981). This is easily possible in many states of Eastern India, as there are many virgin forests still intact. They can be preserved by law at present, with least resistance and with minimum compensation. There are two approaches for the conservation of genetic diversity i.e. *in situ* and *ex situ* conservation. The conservation of genetic resources through their maintenance within natural ecosystems in which they grow, is the most ideal system as this permits natural evolution to take place, safeguarding ecological integrity. Accordingly, several sanctuaries, national parks and reserve forests have been created within this region. However, it is not feasible, to instutute gene sanctuaries for every economic or threatened species as *Citrus* and *Nepenthes* etc. So far the biosphere reserves are concerned only with three potential sites. Kaziranga, Manas and Nokrek have so far been identified. As 60% of the whole of India's forests are in northest India, it is imperative that more such reserves at different ecological niches are to be identified within this region. Such reserves can be established at Dzukou Valley and Shiroy - Kharasom areas of Manipur and Nagaland and Phawngpuitlang (Blue Mountain) in Mizoram etc. as these sites are still harbouring pristine vegetation with a minimum human interference.

Another viable means for preservation of selected taxa is their *ex situ* conservation in botanic gardens where they can be rehabilitated not only for future research but also for multiplication and commercial exploitation. Besides, seed gene banks, pollen storage, genetic gardens and tissue culture techniques etc have been used successfully for preservation of certain species. One disadvantage in this sort of conservation is that only a small number of individuals which may represent a smal fraction of the total genetic variability can be preserved.

The Botanical Survey of India - the apex organisation concerned with floristic resources of the country and its cónservation is actively engaged in an exhaustive inventorisation of the plants of the region and its conservation. The inventorisation of rare, threatened and endemic taxa is being published in the Red Data Book of Indian Plants, with data on their ecology, distribution, present status, causes of threat and conservation measures etc. Besides the Green Data Book pertaining to rare, threatened and endemic taxa which have been brought successfully under cultivation in different botanical/experimental gardens, Orchidaria etc. is being prepared for publication. The judicious exploitation of bio-resources will help us in the long run in improving the welfare of humanity and at the same time it will also facilitate to conserve this natural pristine glory for the posterity.

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5.5. CENTRAL INDIA

(D.M. Verma)

The phyto-geographical region of Central India almost synchronizes with the political boundaries of the state of Madhya Pradesh. It is a large rugged territory, south of the tropic of Cancer, mainly consisting of low rising hills, valleys and plateaus in between the Gangetic Plains in the north and the Deccan Peninsula in the south. It lies roughly between 18°N to 26°N latitudes and 74° E to 85° E longitudes, and covers an area of about 4,50,000 sq. km. Bordering and traversing it are two hill ranges of moderate elevation, the Vindhyas and the Satpuras, both running from the north-east to south-west direction with the river Narmada (Narbada) flowing in between and forming the Narmada valley. The outcrops of the Vindhya and Satpura ranges meet each other in the eastern part of the Central India forming a conglomerate of hills and plateaus known as the Maikal hills. In the north-west of the Vindhyas is the Chambal valley and its ravines which continue northwards in to the Upper Gangetic Plains and yet beyond another table-land, the Malwa Plateau which has a more or less level ground diversified with small conical or flat-topped hills and occasional low ridges. On the north-east corner there is another intrusion of hilly terrain, the Ramgarh hills which are actually some outcrops of the Rajmahal hills of Bihar. On the eastern front, south and south-east of the Vindhyas and the Maikal hills lies the vast expanse of Chhattisgarh Plains, drained by Mahanadi which gradually passes through Orissa into the hills of Eastern Ghats in the east, and the Bailadila hills of Bastar in the south-east. The western boundary of Central India is more or less bordered by the Aravalli hills, leaving a gap in the south-west through which the famed Narmada river continues its tortuous westerly flow to Gujarat and falls into the Bay of Cambay. Thus Vindhya Hills, Satpura Hills, Maikal Hills, Ramgarh Hills, Malwa Plateau, Chambal Valley, Narmada Valley and Chhattisgarh Plains are the major land marks in Central India. The general elevation of the plains is between 200-250 m above mean sea level and that of the hills between 600-800 m with the highest peak of 1340 m at Dhupgarh in Pachmari hills in the Satpura ranges.

Some of the other names covering small regions that are found in the earlier botanical gatherings are the Panna hills which is a branch of the Vindhyas which strikes across Bundelkhand and famous for yielding precious stones, the Kaimur hills which is another branch of the Vindhyas running north of the Son river; the Bastar hills in the south-east which are the outcrops of the Eastern ghats; the Jashpur pats in the north eastern parts; the Gird region comprising the low lying areas around Gwalior in the north-west; and Bundelkhand and Baghelkhand regions in the north.

Politically, the region includes southern fringes of Uttar Pradesh with parts of Jhansi, Banda and Mirzapur, parts of eastern borders of Bharatpur, Tonk, Udaipur and Kota belonging to Rajasthan; almost the whole of Madhya Pradesh with 44 districts except for a part of its large south eastern district of Bastar which falls under Deccan Peninsula, and parts of Sambalpur and Angul belonging to Orissa. Madhya Pradesh, which forms the major part of Central India, has been divided into seven Commissioner's division viz. (1) *Indore* including the districts of Jhabua, Mandasor, Ratlam, Dhar, Ujjain, Indore, Dewas, East Nimar and West Nimar, (ii) *Gwalior* including the districts of Morena, Bhind, Gwalior, Datia, Shivpuri and Guna ; (iii) *Bhopal* including districts of Rajgarh, Shajapur, Sehore, Bhopal, Vidisha, Raisen, Hoshangabad and Betul ; (iv) *Jabalpur* including districts of Sagar, Damoh, Narsimhapur, Jabalpur, Chindwara, Seoni, Mandla and Balaghat, (v) *Rewa* including districts of Tikamgarh, Chhatarpur, Panna, Satna, Rewa, Sidhi and Shahdol ; (vi) *Surguja* including districts of Surguja, Bilaspur and Raigarh and (vii) *Raipur* including districts of Rajnandgaon, Durg, Raipur and Bastar.

The whole of Central India is criss-crossed with innumerable rain-fed streams, rivulets and rivers which become raging torrents during the monsoon season, overflowing most of the cause-ways, culverts and bridges, and thus disrupting normal traffic from a few hours to several days at a stretch. The same dry and shrink during post-monsoon and dry seasons to the extent that one can easily walk through their sandy beds. Among the main rivers flowing in north and north-easterly directions are : Chambal, originating at Mhow in Dhar and meeting the Yamuna near Hamirpur in Uttar Pradesh; Ken, originating at Raisen and meeting the Yamuna near Fatehpur in Uttar Pradesh; and the Tons, originating in the Kaimur hills and meeting the Ganga near Mirzapur in Uttar Pradesh. While Kali Sind, Parbati and Sind are the important tributaries of Chambal, Dhasan is that of Betwa and Sonar is that of Ken. Similarly the river Son originating at Amarkantak, after some south-western curves flows to the north-east and meets the Ganga near Patna in Bihar. Rihand is one of its important tributary. All these rivers contribute waters to the fertile Northern Gangetic Plains. Mahanadi originating at Mainpur Khurd in Raipur, first flows westwards into north Bastar then curving north and east through Raipur enters Orissa and ultimately falls into the Bay of Bengal. Seonath and Hasdo are its main tributaries.

The most important river of Central India is the Narmada (Narbada) which originates at Amarkantak alongwith the river Son, in Maikal hills in the central - eastern part of Madhya Pradesh where the Vindhya and the Satpura hill ranges meet each other. It flows westwards in between the Vindhya and the Satpura hill ranges forming a long narrow strip known as the Narmada valley, later curving southwards and through Gujarat falling into the Bay of Cambay connecting the Arabian sea. The Narmada valley is about 350 km long with an average width of about 32 km.

Central India represents almost all the pre-Cambrian rock systems namely Archaean, Dharwar, Cuddapah and Vindhyan, while Cambrian to middle Carboniferous strata are absent here. The Gondwana system which ranges in age from the upper Carboniferous up to the Jurassic, derived its name from the ancient Gond kingdoms existing in places south of the Narmada where these formations were first discovered. *Archaean* rock outcrops are mainly found in Gwalior, Tikamgarh, Chhattarpur, Surguja, Balaghat and Bastar districts. Outcrops of *Dharwar* rocks are found in Rewa, Jabalpur, Chhindwara and Balaghat districts, yielding most of India's manganese ores. *Cuddapah* rocks are found in the Raigarh, Bilaspur, Raipur, Durg Rajnandgaon and Bastar districts. The *Vindhyan* rock system which derived its name from the Vindhyan range of hills are found particularly in Malwa, Bundelkhand, Baghelkhand, Panna hills and Chhattisgarh regions. The famous Panna diamond beds lie in these rocks. Many of historical monuments and buildings have been built by the Vindhyan Sandstones. *Lower Gondwana* rocks are found in the Mahadeo and Pachmarhi hills in Satpura range and *Upper Gondwana* in Jabalpur region.

Deccan Trap a step-like successive volcanic eruption that occurred in Eocine, originally covered almost all the earlier rock formations in western and central parts of Central India. However, since denudation has been going on for ages, a number of out-crops of the older systems have been exposed at different places. Much of the cotton soil or the *regur* is due to the subaerial weathering of the basalts *in situ* and a subsequent admixtures of the weathered products with iron and organic matter.

Central India has very rich reserves of iron, manganese, coal, limestones, bauxite, clays, ochres, corundum, sillimanite, silica sand, dolomate, steatite (talc), red oxide of iron ore, mica, graphite, feldspar, diamond and lepidolite. A very high-grade iron ore occurs in Durg, Bailadila range in Bastar, and in Jabalpur and Gwalior districts. Manganese is mainly found in Balaghat and Chhindwara districts. Bauxite occurs widely in Balaghat, Mandla, Jabalpur, Surguja, Bilaspur and Raigarh districts. There are vast reserves of limestone in Jabalpur, Satna, Morena, Raipur, Durg, Bilaspur, Mandasor, Dhar, Hoshangabad, Damoh, Panna, Raisen and Sehore districts. Fire-clay and China-clay are also of wide occurrence. Talc and soap-stone occur in the marble rocks of Jabalpur, and also in Durg and Jhabua districts. Diamonds are found in Panna district in two types of deposits, *viz.* (i) conglomerate and gravel and (ii) pipe deposits. Marble is found at Gorapahad in Morena and at Bheraghat in Jabalpur districts. A deposit of Shale suitable for making slate pencil occurs in the Mandasor district.

There are five major soil groups in Central India. These; are the fertile *alluvial soils* in the north-west; the *black soils* widely distributed throughout the Malwa Plateau, Narmada Valley and the Satpura Ridge which are loam to clay in texture and mostly with calcareous concretions, also called black-cotton or regur soil, and are further divided into deep black soils, medium black soils and shallow black soils; the *mixed red and black soils* in eastern parts of Gird region and in Bundelkhand and Baghelkhand which are mainly light textured sandy clay and are further divided into black clayey soils, less dark clayey soils, light medium deep yellowish soils, shallow gravelly red soils and some alluvial soils in river beds; the *red and yellow soils* in the eastern region, mainly in the Chhattisgarh plains which are generally light sandy in texture but frequently silty loam to silty clay; and the *skeletal soils* found in the Vindhya and Satpura ranges which are poor and gravelly in texture.

The region enjoys the widespread Indian monsoon climate having a rainy season with maximum rainfall between the end of June and September, a post-monsoon period in October-November, a winter season from December to March, sometimes with a few winter showers, and a dry hot summer season from April to June. The average annual rainfall varies from 700-2000 mm. A narrow strip starting from the western districts of Vidisha and Bhopal gradually broadening towards south-east and covering the districts of Sagar, Damoh, Narsimhapur, Jabalpur, Shahdol, Sindhi, Rewa, Surguja, Raigarh, Mandla, Bilaspur, Balaghat, Seoni, Durg, Rajnandgaon and Raipur in Madhya Pradesh, and Sambalpur, Angul and Rourkela in Orissa has a higher rainfall between 1200-2000 mm. Surguja, Raigarh and Pachmarhi hills in Hoshangabad in particular receive the highest rainfall. The regions with minimum rainfall occur in the south-western districts of Kota, Mandasor, Ratlam, Jhabua, Dhar, Indore and West Nimar, and in the north western districts of Tonk, Bharatpur, Morena, Bhind, Gwalior and Shivpuri. The mean daily maximum temperature during May-June is around 42^0 C in the drier north-western regions, while the same in the more humid south-eastern regions varies form 37^0C - 40^0C. The mean daily minimum temperature in January varies from 7^0C to 10^0 C in the northern regions and between 10^0C to 15^0C in the southern regions. However, the highest temperature may shoot up to 47^0C and the lowest may fall to 1^0C for a few days. Hail storms and fog, though sometimes occur are not very common.

Central India is predominantly a land of forests and agriculture. Almost 32% of the region is under forest cover which incidentally also measures to about one-fourth of the total forest cover of India. The more densely forested districts are Surguja, Balaghat, Mandla, East Nimar, Shahdol, Sidhi, Raipur, Raigarh, Bilaspur and Chhindwara in Madhya Pradesh and Sambalpur and Angul in Orissa. Agriculture occupies about 43% of the land area. The main crops are millets and wheat in the central and northern regions, paddy in the eastern and south-eastern regions, and cotton in the south-western regions. The remaining land area is either lying fallow or is under other uses.

The people in the northern parts, including the Narmada valley are mainly the descendents from the *Indo-Aryan stock* and those in the southern and eastern reigions have a good mixture of the *aboriginal tribes*, the *Gond* and the *Indo-Dravidian stock*. The rest of the area was formerly occupied by the *Gonds* and other primitive tribes such as the *Korwas*, the *Marias* and the *Baigas*. The Adivasis include the *Muria, Maria, Paria* and *Bhatara* in Bastar, the *Pondos* and *Kerwas* in Surguja, the *Uraons* in Jashpur, the *Mundas* and *Korkus* in Betul, the *Gonds* and *Baigas* in Mandla, and the *Bheels* in Jashpur, Bhopal, Jhabua, Dhar and Nimar. About 18% of the total population is engaged in agriculture. The chief agricultural classes are the *Ahirs, Gaderias, Kachhis* and *Lodhia* in Bundelkhand and Baghelkhand regions and *Gujars, Malis* and *Kunbis* in the Malwa. *Pawars* dominate in the Balaghat region. *Kurmis, Telies, Chamara* and *Parkas* are the main cultivators in the Chhattisgarh plains. The *Hill Marias* and the *Bison-Horn-Marias* of Bastar district practice shifting cultivation.

VEGETATION

Central India, generally considered to be forest heart-land of India, has actually only about 31% of its area under loosely or densely timbered tropical forests, and the remaining under cultivation or other land-use or is just lying barren. While dealing with the heterogenous vegetation of this large area, any fine lines of distinctions between its divisions or sub-divisions are neither possible nor attempted here. The following information has been organised to give an over all picture of the vegetation in the area fully realizing that here and there all kinds of variations and overlappings exist in its composition. It has been divided into Forests, Aquatic plants, Vegetation of special habitats, Plantations and Important crops.

1. Forests

The forests in Central India cover about 32% of its total area, and these like in other tropical region, have been subjected to misuse and over-exploitation. Shifting cultivation, fire, grazing and lopping have been going on for ages and the pressure on the forests has naturally been increasing due to multiplication and migration of human populations and gradual improvement in transportation to formerly inaccessible areas. Fortunately, for Central Indian forests, the human population has always been less than the adjoining Gangetic Plains for several reason. This has helped in the preservation of forest heart-land of India. The age-old practice of preserving patches of forests by the numerous rulers of the land for maintaining a reasonable population of big and small animals and birds for hunting, or sometimes out of some religious faiths of the local tribals, or even the general inaccessibility to some regions have all aided in maintaining some good forest patches. Post-independence era witnessed rapid urbanization and industrialization in Central India, construction of dams and canals and development of road-transport systems, all affecting in its own way on the forests and vegetation of this region. However, some of the possible adverse effects have been nullified through progressive social and legislative measures undertaken by the Government, improved forest management, large-scale plantations, public awareness, and declaration of several areas as National Parks and Game Sanctuaries. The role of these factors alongwith climate, topography, available moisture, geology, soil and micro-organisms in development of a complex ecosystem of which vegetation is a part, even though not much understood, is well appreciated today. Hence, neither any definite prediction is possible on the kind of forest that should develop in any region, nor it is possible to satisfactorily explain at present some of the wild variations like existence of patches of dry deciduous forests or scrub in moist deciduous forest zones, or patches of almost pure stands of some species in the midst of mixed forests. Generally speaking, however, the forests in the southern, central-eastern and eastern part of Central India receiving higher rainfall are more moist and green than its western, north-western and central-western drier regions.

According to classification given by Champion and Seth in Forest Types of India (1968), two main forest types occur in Central India, *viz.* tropical forests and montane subtropical forests. Except for some hill tops like Pachmarhi and Bailadila supporting montane subtropical forests, the entire Central Indian region falls under tropical forests, and these have been further divided into northern semi-evergreen forests, moist deciduous forests, dry deciduous forests and thorn forests. Its further subdivisions and recognition of North Indian forms and South Indian forms are too hazy and ill-defined in Central India to merit any consideration in the following account.

I. *TROPICAL FORESTS* :

a. Northern tropical semi-evergreen forests :

These are dense forests and as far as the Central Indian forests are concerned, the richest in species composition. Its canopy reaches a height of about 25-35 m with its top canopy formed by several basically deciduous species. However, the leaves of all these plants never fall simultaneously and the new leaves also appear within a short period. Hence, the top canopy is never entirely leafless. Morever, the second storey formed by smaller trees and shrubs consists of a number of evergreen species, and these together with numerous lianas, woody climbers, sarmentose shrubs, epiphytic orchids, ferns and a lush green forest floor gives the appearance of an almost dense evergreen forest. These semi-evergreen forests are found in some south eastern parts of Madhya Pradesh and the adjoining Orissa state receiving an annual rainfall of 1400-1800 mm, in small patches only. Its slightly denuded form so much resembles the commonly found moist deciduous forests of Central India that it becomes extremely difficult to distinguish the two types.

The top storey is generally formed by *Shorea robusta, Terminalia alata, Stereospermum chelonoides, Tetrameles nudiflora, Pterocarpus marsupium, Dalbergia paniculata* and *Hymenodictyon orixense,* and the often planted *Tectona* *grandis*. The next storey is formed of smaller mostly evergreen trees and shrub like *Artocarpus lakoocha, Michelia champaca, Celtis tetrandra, Bridelia squamosa, Dillenia pentagyna, D. indica, D. aurea, Ficus hispida, F. heterophylla, F. semicordata, Glochidion* spp., *Phoebe lanceolata, Litsea monopetala, Schrebera swietenoides, Diospyros malabarica, D. montana, Vitex peduncularis, V. leucoxylon, Adina cordifolia, Gmelina arborea, Antidesma acidum, Berberis asiatica, B. lycium, Pittosporum napaulense Ardisia solanacea, Cholroxylon swietenia, Ochna obtusata, Eriolaena candollei, Rhus paniculata, Leea crispa* and *L. macrophylla*. Bamboo brakes or clumps formed by *Bambusa arundinacea, B. vulgaris, Cephalostachyum pergracile* and *Gigantochloa hasskarliana* are a common feature. Sometime some cane plants belonging to *Calamus viminalis* and *C. tenuis* also occur.

Among the lianas specific mention may be made of *Gnetum ula* and *Entada rheedei* which in Central India appear to be confined to the well protected semi-evergreen forests. Other woody climbers commonly occurring in these forests are *Millettia extensa, Dalbergia volubilis, Bauhinia vahlii, Acacia torta, Vallaris solanacea, Olax scandens, Inchnocarpus frutescens, Hemidesmus indicus, Combretum album, Argyreia involucrata, Ipomoea sericea, I. setosa, Erycibe paniculata, Smilax zeylanica* and several species of *Dioscorea* like *D. bulbifera, D. glabra, D. oppositifolia, D. pentaphylla, D. pubera* and *D. wallichii*. A thick undergrowth of Zingiberacea members like *Curcuma aromatica, C. zedoaria, Zingiber capitatum, Z. casumunar, Z. roseum* and *Costus speciosus* very often covers the forest floor. Small openings and forest margins have a variety of undershrubs like *Desmodium dichotomum, D. gangeticum, D. heterocarpon, D. pulchellum, D. laxiflorum, Flemingia macrophylla, F. strobilifera, Eranthemum purpurascens, Perilepta edgeworthiana, Petalidium barlerioides,* and *Semicarpus anacardium*.

In Central India, the largest concentration of orchids are found in these semi-evergreen forests. There are several species of ground orchids found in the rich humus soil of which mention my be made of *Eulophia explanata, E. flava, E. graminea, E. herbacea, E. nuda, Geodorum densiflorum, Goodyera procera, Habeneria commelinifolia, H. digitata, H. furcifera, H. plantaginea, Peristylis constrictus, Pecteilis gigantea, Microstylis congesta* and *Liparis bituberculata*. The common epiphytic orchids are *Dendrobium macrostachyum, D. moschatum, Aerides multiflora, Luisia trichorhiza, Oberonia falconeri, Rhynchostylis retusa, Sarcanthus insectifer, Thunia venosa, Vanda tessellata* and *V. testacea*.

Ferns and fern allies are other important constituents of these Central Indian semi-evergreen forests. These are represented here by about 70-80 species, including the tree ferns like *Angiopteris evecta, Cyathea gigantea* and *C. spinulosa* in the valleys and gorges. Some of the other species growing in the humid rock crevices or as epiphytes are *Actiniopteris radiata, Adiantum incisum, A. philippense, Ampelopteris prolifera, Asplenium cheilosorum, A. indicum, A.*

laciniatum, Blechnum orientale, Botrychium daucifolium, B. lanuginosum, Ceratopteris thalictroides, Cheilanthes anceps, Christella dentata, C. parasitica, Drynaria quercifolia, D. cochleata, Equisetum debile, E. diffusum, Huperzia hamiltonii, Isoetes coromandelica, Leptochilus axillaris, Lygodium flexuosum, L. microphyllum, Microsorium membranaceum, Nephrolepis cordifolia, N. exaltata, Ophioglossum costatum, O. gramineum, O. reticulatum, Osmunda regalis, Plhinhaea cernua, Psilotum nudum, Pteris biaurita, P. vittata, Selaginella bryopteris, S. ciliaris, S. repanda, S. rupestris and *Tectaria polymorpha. Azolla pinnata* with its small pinkish fronds and *Marsilea minuta* are commonly seen floating in pools and slow moving shallow streams.

b. Tropical moist deciduous forests :

These forests are mainly characterized by an open top canopy of scattered mixed deciduous species reaching a height of 25 m or more and a combination of deciduous and evergreen smaller trees and shrubs forming the second storey. The presence of evergreen species in the lower storey, frequently accompanied by a rich growth of undershrubs and perennial herbs gives the forests as a whole a more or less luxurient green outlook. Several species of lianas or stout climbers, climbing shrubs, epiphytic and ground orchids and ferns add to the beauty and density of these forests. The greater part of this kind of forests occur on the lower hill-slopes and ravines receiving an average annual rainfall of about 1500 mm or more in the eastern, central and southern Madhya Pradesh and the adjoining western regions of Orissa. An almost leafless period of taller trees during March-April is very characteristic. Some of these forests are very near to tropical semi-evergreen type in composition.

In the mixed type of these moist deciduous forests the top storey is formed by *Shorea robusta, Pterocarpus marsupium, Terminalia alata, T. bellirica, T. chebula, Lannea coromandelica, Cochlospermum religiosum, Adina cordifolia, Dalbergia paniculata, Bombax ceiba, Hymenodictyon orixense, Hardwickia binata, Stereospermum chelonoides, Garuga pinnata, Soymida febrifuga,* and the usually planted *Tectona grandis*. However, very often the number of these tree species is very few in different regions, sometimes limited to two or three only. Sometimes *Shorea robusta, Tectona grandis* or *Terminalia elliptica* are the lone species forming the top storey. At some places scattered trees of *Dalbergia paniculata* surpass all other trees and the canopy of almost all the scattered individual trees of this species conspicuously stand out in the otherwise dense mixed forests. *Lagerstroemia parviflora* and *Anogeissus latifolia* though usually of medium height also sometimes become very tall thus forming part of the top storey.

The comon smaller trees and shrubs are *Bridelia squamosa, Cleistanthus collinus, Mallotus philippinensis, Kydia calycina, Xylia xylocarpa, Schleichera* *oleosa, Ougeinia oojeinensis, Miliusa tomentosa, Schrebera swietenoides, Diospyros melanoxylon, Dillenia pentagyna, Ficus hispida, F. heterophylla, F. semicordata, F. tinctoria* var. *parasitica, F. virens, Boswellia serrata, Bauhinia malabarica, B. purpurea, B. racemosa, B. semla, Cassia fistula, Grewia abutilifolia, G. tiliaefolia, Helicteres isora, Antidesma acidum, A. ghesaembilla, Ardisia solanacea, Vitex peduncularis, V. leucoxylon, Holarrhena antidysenterica, Celtis tetrandra, Linociera ramiflora, Litsea monopetala, Chloroxylon swietenia, Ochna obtusata, Ziziphus glaberrima, Z. rugosa, Z. xylopyrus, Eriolaena candollei, Gardenia gummifera, G. latifolia, G. turgida, Xeromphis uliginosa, Breynia vitis-idaea, Thespesia lampas, Embelia tsjeriam-cottam, Grewia helectrifolia, G. hirsuta, G. rothii, G. serrulata, Casearia graveolens, C. elliptica, Semecarpus anacardium, Leea crispa* and *L. macrophylla.* The common Central Indian bamboo *Dendrocalamus strictus* forms dense thickets, and its culms are stouter and longer than those found in the dry deciduous forests. While a pure dense stand of *Shorea robusta* does not permit much of undergrowth, the somewhat open mixed moist deciduous forests have a dense varied undergrowth of annual or perennial herbs or undershrubs comprising of species like *Eranthemum purpurascens,, Petalidium barlerioides, Perilepta edgeworthiana, Desmodium dichotomum, D. gangeticum, D. heterocarpon, D. laxiflorum, D. pulchellum, D. triangulare, D. velutinum, Indigofera cassioides, Flemingia macrophylla, F. strobilifera, Nelsonia canescens, Chlorophytum tuberosum, Phoenix acaulis* and *Carex speciosa.* Besides, a number of Zingiberaceae members like *Curcuma aromatica, C. zedoaria, C. pseudo-montana, Globba racemosa, G. bulbifera, Zingiber capitatum, Z. casumunar, Z. roseum* and *Costus speciosus* also sometimes form dense undergrowth.

These mixed forests are infested with several species of lianas or woody climbers and climbing shrubs. The more common ones are *Millettia extensa, M. racemosa, Dalbergia volubilis, Ventilago denticulaa, Bauhinia vahlii, Acacia pennata, A. torta, Vallaris solanacea, Olax scandens, Thunbergia fragrans, Ichnocarpus frutescens, Celastrus paniculata, Hemidesmus indicus, Combretum album, C. albidum, Ampelocissus latifolia, A. tomentosa, Cayratia auriculata, C. repanda, Argyreia involucrata, A. sericea, A. setosa, Erycibe paniculata, Ziziphus oenoplia, Smilax zeylanica, Dioscorea bulbifera, D. pentaphylla, D. pubera* and *D. oppositifolia.* While the above are stout species found more or less climbing the trees inside the forests there are a number of additional slender climbers found on the forest margins and on the roadside bushes. The common ones among these are *Cissampelos pareira* var. *hirsuta, Cocculus hirsutus, Abrus precatorius, Atylosia scarabaeoides, Rhynchosia minima, Mucuna pruriens, Diplocyclos palmatus, Momordica dioica, Mukia maderaspatana, Cryptolepis buchananii, Holostemma adakodien, Ceropegia candelabrum, C. hirsuta, Oxystelma secamone* and *Pupalia lappacea.*

There are several species of orchids, both terrestrial and epiphytic, commonly occuring in these areas which are indicative of a rich moist forest. Some of the ground orchids found as an undergrowth are *Eulophia explanata, E. flava, E. graminea, E. herbacea, E. nuda, Geodorum densiflorum, Habenaria commelinifolia, H. digitata, H. furcifera, H. plantaginea, Peristylus constrictus* and *Pecteilis gigantea. Vanda tessellata* and *V. testacea* are the two common widespread epiphytic orchids found perched on the branches of *Mangifera indica, Madhuca longifolia* var. *latifolia, Terminalia elliptica, T. bellirica, Diospyros melanoxylon* and *Butea monosperma.*

Several species of ferns and fern-allies also make their mark as a prominent part of the flora as we look into more moist, humid and protected areas. While the pinkish fronds of *Azolla pinnata* and the green digitate leaves of *Marsilea minuta* are a common sight in stagnant pools or shallow slow moving streams, the others like *Selaginella bryopteris, S. repanda, Ceratopteris thalictroides, Cheilanthes farniosa, C. tenuifolia, Lygodium flexuosum, Christella dentata, Adiantum caudatum* and *A. lunulatum* are usually found in the rock-crevices or forest floors. *Ophioglossum nudicaule* and *O. reticulatum* are some of the short-lived slender species in the forest floors likely to be over-looked. Some species like *Equisetum debile, E. diffusum* and *Isoetes coromandelina* prefer a somewhat open habitat.

These moist deciduous forests are often further divided on the basis of predominance of a particular species, or according to ecological degradation into *moist peninsular sal forests; moist mixed deciduous forests; Terminalia elliptica forests; secondary moist mixed deciduous forests* and *moist sal savannah.* Sometimes these appear to be distinct entities but, more often due to variations in species composition, dominance and overlappings, these cannot be properly differentiated.

c. Tropical dry deciduous forests :

In this kind of forests the taller dominant trees are almost entirely deciduous and most of the smaller trees and shrubs are also deciduous thus giving the whole forest a look of dryness. The top canopy is invariably open and light, usually between 8-20 m in height, and frequently indistinct. Several species of moist deciduous forests may also be found here particularly in sheltered places but, they lack the finer development seen in the moist type. Lianas or large woody climbers and epiphytes are few, and orchids and ferns are almost entirely absent. The trees are almost leafless during March-April. These forests are mostly found in areas with low rising hills, flat countries or plateaus receiving an average annual rainfall of 850-1300 mm with long dry periods of almost 6 months from February to July. These dry deciduous forests are generally found in the northern, western and central western regions of Madhya Pradesh in the districts of Sidhi, Rewa, Satna, Panna, Tikamgarh, Chhatarpur, Sagar, Damoh, Vidisha, Guna, Morena, Shivpuri, Gwalior, Datia, Raisen, Mandasor, Ratlam, Ujjain, Indore, Dhar, East Nimar, West Nimar and Jabalpur, in southern Uttar Pradesh in the districts of Jhansi and Banda and in the regions comprising parts of the Aravalli hill ranges in eastern Rajasthan in the districts of Bharatpur, Tonk, Udaipur and Kota. Sometimes due to other ecological factors, as also due to degradation, patches of dry deciduous forests are also found in other regions receiving higher rainfall like in parts of Raipur, Bastar, Surguja, Balaghat, Seoni and Mandla.

The common constituents of these forests are the taller and dominant trees of *Terminalia elliptica, T. bellirica, T. chebula, Tectona grandis, Pterocarpus marsupium, Bombax ceiba, Madhuca longifolia* var. *latifolia, Garuga pinnata, Cochlospermum religiosum, Soymida febrifuga, Lannea coromandelica, Butea monosperma, Diospyros melanoxylon, Phoenix sylvestris, Lagerstroemia parviflora, Anogeissus latifolia, A. pendula, Buchanania lanzan, Mitragyna parviflora, Emblica offinalis, Sterculia urens, S. villosa, Boswellia serrata, Bridelia squamosa, Albizia lebbek, A. odoratissima, A. procera, Hardwickia binata, Bauhinia malabarica, B. purpurea, B. racemosa, Cordia obliqua, Aegle marmelos, Acacia nilotica* ssp. *indica* and *A. leucophloea*, and a variety of smaller trees and shrubs like *Acacia catechu, Gardenia gummifera, G. latifolia, G. resinifera, G. turgida, Xeromphis spinosa, X. uliginosa, Helicteres isora, Grewia tiliifolia, G. hirsuta, G. rothii, G. serrulata, Holarrhena antidysenterica, Wrightia arborea, W. tinctoria, Annona squamosa, Casearia elliptica, Carissa opaca, Alangium lamarkii, Nyctanthes arbor-tristis, Ziziphus mauritiana, Z. xylopyrus, Capparis zeylanica, Flacourtia indica, Mimosa himalayana, Securinega virosa, Kirganelia reticulata, Calotropis procera, Adhatoda vasica* and *Woodfordia fruticosa*. The common Central Indian bamboo, *Dendrocalamus strictus, is found* mostly in pure patches, is of a drier form with thinner and shorter culms than those in the moist deciduous forests.

There are several species of slender climbers on smaller trees and shrubs, sometimes almost camouflaging them or sometimes twining and inter-woven among their branches, only a few are rather woody and attain a more gregarious habit. The common climbing species are *Rhynchosia minima, Atylosia scarabaeoides, Abrus precatorius, Mucuna pruriens, Cocculus hirsutus, Cissampelos pareira, Ipomoea eriocarpa, I. hederifolia, I. nil, I. obscura, Merremia hederacea, M. tridentata, Coccinia indica, Mukia maderaspatana, Diplocyclos palmatus, Momordica dioca, Ampelocissus latifolia, A. tomentosa, Cayratia trifolia, Ventilago denticulata, Ichnocarous frutescens, Hemidesmus indicus, Cryptolepis buchananii, Marsdenia tenacissima, Dregia volubilis, Gymnema sylvestre, Pergularia daemia, Ziziphus oenoplia, Tinospora cordifolia, Dioscorea hispida* var. *daemona* and *D. pentaphylla*. *Cuscuta reflexa* with its yellow wiry twining stems is a common parasitic climber. Epiphytes are poorly represented and are confined to a few partially parasitic clumps of *Dendrophthoe falcata, Scurrula parasitica, Viscum nepalense* and *V. orientale*.

However, there are few patches of these dry deciduous forests which could be said to have reached near climax in their development. Mostly these are degraded to various stages and the more badly affected forests present a picture of a scrub jungle, savannah or even a barren land on which grow only some annual grasses and other herbs for a few months after rains. While travelling in the countryside the usual sight is a vast stretch of barren land with none or may be a few trees struggling to survive the axe of the villagers. A closer look would most likely reveal at least some branches mercilessly lopped away. There are not even saplings to ensure a better future except in the areas protected by law or taken up for development by the forest department. Many of the species mentioned above as constituents of dry deciduous forests, unable to bear the biotic pressure, have more or less disappeared from these areas fundamentally questioning the rich composition of these mixed forests. However, when it comes to real hardiness to survive, two particular tree species need to be mentioned. One is *Butea monosperma,* called the flame of the forests because of its large beautiful scarlet flowers borne in profusion while the trees are leafless in February-April, and dominating the whole scenary. But it is all in the reserved or protected forests where it has a chance to grow to its full stature. More commonly it is found as a woody stump cut down to almost ground level, bearing a few slender branches and a few easily countable number of leaves, but surviving, as though to challenge the human axe. The other species is *Anogeissus pendula* with slender luxuriant branches, dominating or even forming pure patches in the western parts of Central India. Cut down to the ground or even subterranean level and then frequently browsed by goats, it still survives by throwing out prostrate branches forming large cushions. During monsoon and in post-monsoon period, between August to November, a large number of small and large annual or perennial grasses and other herbs give a pleasant green look in the otherwise barren wastelands. Grasses forming large patches belong to several species of *Aristida, Themeda, Apluda, Digitaria, Imperata, Chloris, Cynodon, Dichanthium, Vetiveria, Sporobolus* and *Eragrostis.* Other elements dominating the herbaceous flora belong to a number of families like Leguminosae, Malvaceae, Rubiaceae, Scrophulariaceae, Asteraceae, Boraginaceae, Convolvulaceae, Commelinaceae, Eriocaulaceae and Cyperaceae.

These dry deciduous forests are also sometimes subdivided, though never to complete satisfaction or conviction, on the basis of predominance of a particular species or according to ecological degradation into *dry teak bearing forests; dry peninsular sal forests; dry mixed deciduous forests; dry deciduous scrub; dry savannah forests; dry grasslands; Anogeissus pendula forests; Boswellia serrata forests; Acacia nilotica* ssp. *indica forests; Hardwickia binata forests; Butea monosperma forests; Aegle marmelos forests; dry bambo brakes* and *Riverain forests.*

d. *Tropical thorn forests* :

These are the drier kind of forests found in Central India, dominated by low thorny hard leaved evergreen trees and xerophytes on generally very shallow and poor soil. The trees and bushes are mostly widely scattered forming a broken canopy which is under 10 m. The trees have short boles and low branching crown. The number of species forming these forests are much less than in the moist or dry deciduous tropical forests described above and are usually of a mixed kind. Climbers are scarce, and those found are mostly slender and annual. Epiphytes are represented by only a few species of the partly parasitic members of the family Loranthaceae. Large woody climbers, orchids and ferns are almost absent. In the large patches found barren in the late winters and summers, there is an abundant growth of annual grasses during the rains which persist as long as they could survive the adverse growing conditions and the heavy browsing by goats and cows. These tropical thorn forests occupy a comparatively small area in the plains and the low hills of the north-west border of Morena and in the south-west corner of West Nimar receiving an annual rainfall of 700-1000 mm with a long dry spell.

The common trees in these forests are *Acacia nilotica* ssp. *indica*, *A. leucophloea*, *A. catechu*, *A. farnesiana*, *A. tortia*, *Aegle marmelos*, *Cordia obliqua*, *Albizia lebbeck*, *A. procera*, *A. odoratissima*, *Bombax ceiba*, *Dalbergia sissoo*, *Anogeissus latifolia*, *A. pendula*, *Crateva adansonii* ssp. *odora*, *Hardwickia binata*, *Prosopis cineraria*, *Sterculia urens*, *S. villosa*, *Boswellia serrata*, *Ziziphus mauritiana*, *Balanites aegyptiaca*, *Barringtonia acutangula*, *Gardenia spinosa* and *G. turgida*. The intermixed shrubs are usually *Capparis decidua*, *Flacourtia indica*, *F. jangomas*, *Gymnosporia spinosa*, *Dichrostachys cinerea*, *Grewia rothii*, *G. serrulata*, *G. tenax*, *Mimosa hamata*, *Ziziphus mauritiana* var. *fruticosa* and *Z. nummularia*.

The climbers are few and generally with slender wiry twining branches entangled with shrubs and bushes. Some of the common species are *Cocculus hirsutus*, *Cissampelos pareira*, *Rhynchosia minima*, *Atylosia scarabaeoides*, *Abrus precatorius*, *Ipomoea eriocarpa*, *I. nil*, *I. obscura*, *Coccinia indica*, *Mukia maderaspatana*, *Diplocyclos palmatus*, *Momordica dioica*, *Gymnema sylvestre*, *Cuscuta reflexa* and *Dioscorea hispida* var. *daemona*.

Dendrophthoe falcata, *Viscum nepalense* and *V. orientale*, all partly parasitic profusely branched pernnials with bushy habit are the only epiphytes commonly sighted in these forests.

II. *MONTANE SUBTROPICAL FORESTS* :

It is represented in Central India by only the following type of forest which is confined to some hill tops of Orissa, Madhya Pradesh and to Mount Abu in Rajasthan.

Central Indian Subtropical hill forests :

The sites occupied by these forests being on hill tops are often well exposed and have poor and shallow soil. Besides, most of these places are easily accessible and are under intense biotic pressure. The rainfall is fairly high but the moisture retention capacity of soil is limited. Due to the above mentioned factors, even though these contain many evergreen species, the total appearance of these forests with short-boled branchy trees is sometimes that of a inferior kind of forest. These occur in small patches on the hill tops above 1200 m at places like Pachmarhi and Bailadila in Madhya Pradesh, and its full development is seen only on the slopes and gullies.

Michelia champaca, Mangifera indica, Syzygium cumini, Manilkara hexandra, Symplocos laurina, Salix tetrasperma, Carallia brachiata, Litsea monopetala, Dillenia indica, D. pentagyna, Celtis tetrandra, Toona ciliata, Berberis asiatica, B. lycium, Calamus viminalis, Mallotus philippinensis together with tree ferns like *Cyathea gigantea, C. spinulosa* and *Angiopteris evecta,* and the giant liana *Gnetum scandens* are some of the common elements of these forests.

2. Aquatic Plants

Central India supports a rich aquatic vegetation in its numerous rivers, streams, lakes, drains, ponds, reservoirs, puddles and ditches, or even in the paddy fields. In most of these, however, the water dries up after the rains and the plants growing therein have to pass a part of their lifecycle in moist or even dry conditions. Similarly, plants growing in rather dry conditions may suddenly get temporarily inundated. Besides, there are also border-line species which grow both in wetlands and in water. Thus, the circumscription of aquatic plants continues to be debatable. The following list contains only those common species which generally complete or almost compete their life-cycle in water, and these have been classified into six categories :

a. Free floating hydrophytes :

Azolla pinnata, Eichhornia crassipes, Lemna perpusilla, Nymphoides hydrophylla, N. indica, Pistia stratiotes, Spirodela polyrrhiza, Trapa natans var. *bispinosa* and *Wolffia globosa.*

b. Suspended submerged hydrophytes :

Ceratophyllum demersum, Utricularia aurea and *U. exoleta.*

c. Anchored submerged hydrophytas :

Aponogeton crispum, Blyxa aubertii, B. octandra, Cryptocoryne retrospiralis, Hydrilla verticellata, Myriophyllus oliganthum, M. tuberculatum, Najas spp., *Nechamandra alternifolia, Ottelia alismoides, Podostemon wallichii, Polypleurum stylosum, Potamogeton crispus, P. mucronatus, P. nodosus, P. pectinatus* and *Vallisneria nutans.*

d. Anchored hydrophytes with floating shoots :

Alternanthera philoxeroides, Cyperus platystylis, Hygrorhiza aristata, Ipomoea carnea, Ludwigia adscendens, Neptunia oleracea and *Rorippa nasturtium-aquaticum.*

e. Anchored hydrophytes with floating leaves :

Aponogeton nutans, Caldasia parnassifolia, Limnophyton obtusifolium, Marsilea minuta, Monochoria hastata, M. vaginalis, Nelumbo nucifera, Nymphaea pubescens, N. nouchali, N. rubra, Nymphoides hydrophylla, N. indica, Ottelia alismoides, Potamogeton nodosus, Sagittaria guayanensis ssp. *lappula* and *Tenagocharis latifolia.*

f. Emergent amphibious hydrophytes :

Acorus calamus, Aeschynomene aspera, A. indica, Ammania baccifera, A. multiflora, Brachiaria reptans, Coix aquatica, Crinum defixum,, Cyperus distans, C. nutans var. *eleusinoides, C. pangorei, Echinochloa colona, E. stagnina, Eleocharis acutangula, E. congesta, E. dulcis, E. geniculata, E. palustris, Enhydra fluctuans, Eriocaulon achiton, E. cinereum, E. quinquangulare, E. sollyanum, Fimbristylis schoenoides, F. tetragona, Fuirena ciliaris, Hydrolea zeylanica, Hygrophila auriculata, Hymenachne pseudointerrupta, Isoetes coromandeliana, Limnophila aromatica, L. indica, L. sessiliflora, Lipocarpha chinensis, L. sphacelata, Ludwigia octovalvis, L. perennis, L. prostrata, Ophiurus exaltatus, Oryza sativa, Phragmites karka, Polygonum barbatum, P. dichotomum, P. glabrum, P. hydropiper* ssp. *microcarpum* var. *triquetrum, P. limbatum, Ranunculus sceleratus, Rotala densiflora, R. indica, R. rotundifolia, Scirpus articulatus, S. juncoides, S. lateriflorus, S. maritimus* and *Typha angustata.*

3. Vegetation of Special habitats

While the general account of vegetation has been summerised above, there are several special habitats created by a combination of micro-climatic conditions which support the growth of a few selected species. These are mentioned below :

Along the streams, very close to the flowing water and frequently partly submerged by it, are dense populations of *Syzygium heyneanum* and *S. nervosum*. However, while these species prefer rich clayey soil and shade, *Terminalia cuneata* is one tree species which occurs very commonly along the streams and rivers usually at a little distance from the water, though also capable of surviving on the river-beds and on the drier uplands.

On the river-beds strewn with rocks and pebbles which are more or less exposed during winters and summers but are over-flowed during the rainly season, are found *Tamarix dioica, T. ericoides* and *Rotala aquatica* which do not occur in any other habitat, and *Crinum asiaticum* and *Polygonum* spp. which also occur on the drier uplands.

In the hilly terrain of Central India fully exposed rock-beds and boulders are a common sight and the soil collected in the crannies and crevices supports a very limited number of species. These are *Polycarpaea aurea, P. corymbosa, Anisochilus carnosus, Crotalaria ramosissima, C. orixensis, Indigofera astragalina, I. glabra* and grasses like *Arthraxon prionodes, Chrysopogon verticillatus, Dimeria connivens, D. ornithopoda, Oropetium thomaeum, Perotis indica* and *Pogonatherum crinitum*.

The ridges of the hills are dominated by *Sterculia urens, S. villosa, Lannea coromandelica* and *Boswellia serrata*, conspicuously standing out above the forested slopes.

4. Plantations

During the last several decades Forest Departments have been raising a number of plantations which now form a conspicuous part of the vegetation. The well-known Central Indian teak *Tectona grandis* is the most favourite species in forest clearings, and more than 50 years' old plantations of this species covering large tracts is a common feature. The common bamboo *Dendrocalamus strictus* and various species and hybrids of *Eucalyptus* are usually planted on the forest edges. Along the roads, the common species planted often forming an avenue are *Dalbergia sissoo, D. latifolia, Mangifera indica, Pongamia pinnata, Cassia siamea, Eucalyptus* spp., *Prosopis juliflora, Peltophorum pterocarpum, Terminalia catappa, T. cuneata, Delonix regia, Pithecellobium dulce, Samanea saman, Thespesia populnea* and *Parkinsonia aculeata*. *Santalum album* has been more commonly planted on the hill-slopes in the south-west, though its wood lacks the fragrance for which it is famous. *Anacardium occidentale*, the cashew-nut trees have also been planted in small patches. *Ficus religiosa, Azadirachta indica, Mangifera indica, Tamarindus indica* and *Madhuca longifolia* var. *latifolia* are commonly found planted in the villages.

5. Important crops

While wheat *(Triticum aestivum)*, maize *(Zea mays)* and millets *(Sorghum* spp., *Pennisetum americanum)* are commonly cultivated in the drier north west and central parts, paddy *(Oryza sativa)* is the main crop in the moist south eastern regions. Kodo *(Paspalum scrobiculatum)* and maria *(Eleusine coracana)* are the other graincrops cultivated for consumption by poorer people. Sugarcane *(Saccharum officinale)* is cultivated on a small scale only. *Arachis hypogea, Glycine max, Guizotia abyssinica, Helianthus annuus, Linum usitatissimum, Brassica campestris, B. juncea* and *Sesamum orientale* are cultivated for oil, and *Cajanus cajan, Lathyrus sativus, Lens esculenta* and *Vigna mungo* are commonly cultivated for pulses. *Medicago sativa, Trigonella alexandrium* and *T. pratense* are cultivated for fodder. Besides, a number of vegetables, fruit trees and some spices are also grown. Various species and hybrids of *Gossypium* yielding cotton are grown in the south western region.

BOTANICAL COLLECTIONS

The earliest botanical gatherings in Central India appear to have been made by a French botanist, V. Jacquemont from Sidhi, Rewa, Satna and Panna in 1830, and subsequently in Mandasor, Ratlam, Ujjain, Indore and West Nimar in 1832. Later, N. Vicary (1833) collected in Central India, Bundelkhand, Sagar and Jabalpur; D. Ritchie (*ca* 1838) in Central India; M. P. Edgeworth (1838 & 1847-1848) in Bundelkhand, Dhar, Malwa and Indore; W. Griffith (*ca* 1839) in Jabalpur, Narmada Valley and Malwa Plateau; M. Munroe (*ca* 1839) in Chambal ravines (Morena); D. F. Macleod (1839-1840) in Jabalpur; M. Kittoe (1839-1840) enroute from Northern Circars in Orissa to Nagpur in Maharashtra; R. H. Beddome (1848) in Jabalpur; C.W.W. (1860-1861) in Panna, Rewa and Baghelkhand; D. Brandis (1863, 1888-1889) in Satpura hills; G. King (*ca* 1867) in Bundelkhand, Malwa, Guna and Sagar; T. C. Jerdon (1868) in Central India and Sagar; R. Thompson (1870) in Central Provinces; J. C. Hobson (*ca* 1874) in Asirgarh (Khandwa); O. Kuntze (*ca* 1875-1876) in Jabalpur; A. Barclay (1876) in Guna; C.B. Clarke (1876) in Jashpur, Surguja and Central India; J. J. Wood (1878) in Jashpur and Surguja; Mrs. C. Morris (1881) in Pachmarhi (Hoshangabad); W. Schlich (1883) in Central Provinces; J. F. Duthie (1888-1891) in Bundelkhand, Indore, Nimar, Jabalpur, Sagar, Damoh, Betul and Hoshangabad; C. Maries (1889-1890) in Gwalior; Wingate (?1890's) in Gwalior, Bundelkhand and Sagar; G. Watt (*ca* 1894) in Raipur and Bilaspur; J. Marten (1894) in Jabalpur; A. E. Lowrie (?1896) in Indore; and R. S. Hole (1896-1902) in Central Provinces, Jabalpur and Seoni. It may be mentioned that while some of the above collectors were profesionally experienced botanists who made a comprehensive gathering of all available plants, others made only selective collections of groups like ferns, woody elements or economic plants in keeping with their interest. Still others made only a few stray collections probably for their botanist friends or as a matter of curiosity but deposited these in various herbaria. However, these were the collections available from Central India when J. D. Hooker and his associates were writing the Flora of British India (1872-1897). It is to be noticed that all this exploration work could be done and plants collected from north, north-west, central and central-western parts of Central India where till the end of the nineteenth century the Britishers could establish their influence. Almost no collections could be made in the south-eastern region comprising the present day districts of Raigarh, Bilaspur, Raipur, Durg, Rajnandgaon, Mandla, Balaghat and Bastar where the feudal lords controlled the territories and the Britishers could not enter at that time. Gradually, from about 1900 to 1920 these regions were penetrated by R. S. Hole, Rev. A. Campbell, Rev. L. Cardon, Mrs. A. S. Bell, A. Meebold, I. H. Burkill, D. D. Witt, T. Masters, Allington, W. F. Biscoe, C. G. Rogers, H. H. Haines, R. D. Graham, C. C. Stevens and two Indian enthusiasts, A. B. Pandey and P. Mukherjee. Somehow, perhaps with the advent of newer horizons of botanical research, the plant collection activity almost ceased between 1920 and 1955 during which period only H. F. Mooney made a good gathering in Bailadila hills in Bastar, Jashpur and Surguja, while L. A. Kenoyer, H. Crookshand, C. E. Hewetson, S. D. N. Tewari and S. C. Pandeya contributed to some extent.

The revival of the Botanical Survey of India in 1954 and opening of its Central Circle at Allahabad on the 30th July, 1962 started an era of well planned intense plant collection activiy in Central India. These collections, still continuing, are housed in the Herbarium of the Central Circle, Botanical Survey of India, Allahabad, India (BSA). These amount to about 50,000 specimens of flowering plants and ferns, collected in different seasons from all over the region.

FLORISTIC PUBLICATIONS

The Central Indian plants find their first regular reference in J. D. Hooker's *Flora of British India* (1872-1897) and in an almost simultaneous publication of *Forest Flora of North-West and Central India* by Stewart and Brandis (1874). Duthie's *Flora of the Upper Gangetic Plains and the adjacent Siwalik and sub-Himalayan tracts* (1903-1929) covers parts of Central India lying north and west of the Vindhya Range. Forsyth (1871) gave an interesting layman's account of the forests, fauna and tribal life in *The Highlands of Central India.* Haines (1916) published *Trees, shrubs and economic herbs of Southern Circle, Central Provinces.* These may be taken to be the pioneer publications on the botany of the region, and were followed by a number of other publications like lists of species, often of medicinal or economic plants only, Forest Floras, new distributional records, new taxa, or a mention of floristic composition in ecological accounts. Some of these were from Wood (1902), Hole (1904), Biscoe (1910), Haines (1916), Kenoyer (1924), Pathak (1926), Sagreiya (1938), Sagreiya & Singh (1959), Maheshwari (1958, 1960, 1961, 1962, 1963), Kapoor & Yadav (1962), Sebastine & Balakrishnan (1963), Joseph (1963), Jain (1963, 1964, 1965), Tiwari

(1963, 1968, 1972, 1979), Rao & Sastry (1965), Panigrahi *et al.* (1965, 1966, 1967), Joseph & Vajravelu (1967), Subramanyam & Henry (1967), Saxena *et al.* (1972 & 1976), Sengupta & Ram Lal (1973), Sengupta (1977), Verma (1977, 1981), Sharma & Mamgain (1983) Mukherjee (1986), Chakraverty & Verma (1985), Srivastava (1983, 1986, 1987), Lal *et al.* (1986). A more comprehensive account was published in the Flora of Bhopal by Oomachan (1977), Flora of Pachmarhi and Bori Reserve by Mukherjee (1984) and Flora of Raipur, Rajnandagaon and Durg by Verma *et al.* (1985). The first volume of the Flora of Madhya Pradesh by Verma *et al.* (1995) is cover almost all the Vascular plants of the Central India.

FLORA

The Central Indian region though pretty large in area is physically a more or less uniform terrain except for some variations in the rainfall, and there is no sudden change from its neighbouring areas. The same gradual transition is seen in its vegetation and flora. The flora though not fully worked out as yet is expected to be represented by about 2400 species of flowering plants which means that about 16% of 15,000 angiosperm species found in India would occur in Central India. Out of these, there are about 500 species of trees and shrubs, about 150 species of lianas and climbers, and the remaining are annual or perennial herbs. Epiphytic species are comparatively few, numbering scarcely about one dozen only. Leguminosae (*ca* 270 spp.) is represented by the maximum number of species, closely followed by Poaceae (*ca* 250 spp.), Cyperaceae (*ca* 140 spp.), Asteraceae (*ca* 105 spp.), Euphorbiaceae (*ca* 90 spp.). Acanthaceae (*ca* 85 spp.), Convolvulaceae (*ca* 60 spp.), Rubiaceae (*ca* 52 spp.), Scrophulariaceae (*ca* 45 spp.) and Malvaceae (*ca* 40 spp.). The genus *Crotalaria* with *ca* 26 spp. is perhaps the largest genus. The Dicots are represented by about 1800 species and the Monocots by about 600 species, the ratio between the Monocots and the Dicots is about 1 : 3.

In the absence of a complete recent Flora of India and the lacunae in our knowledge on plant distribution, it would be scientifically unsound to make a firm statement but from the published records and the herbarium specimens that we have, it may be inferred that Central India does not have any typical flora. It appears to be a mixture of species which have migrated from all directions. The dry western and central regions harbour species common in Punjab, Rajasthan and the Gangetic Plains. Its eastern and south-eastern regions have many elements which appear to have migrated from more moist regions of Bihar, West Bengal and Orissa, and also from South India. The Maikal, Satpura and Bastar hills have representatives from Rajmahal hills and Himalayas from the north and Nilghiris from the south. In general the Central India may be called a meeting place of diverse Indian flora, and also a place where migrants from different regions have ended their journey. The records and publications would show very few species as endemic to Central India. These include some new species described from here which may or may not turn out to be distinct in the course of revisionary studies or on further exploration may also be found to occur elsewhere. But there are many species of rare occurrence which have been tabulated below giving their distribution in Central India and outside, and while these may be sieved for conservation, these also indicate the floristic relationship and the migration routes.

DISTRIBUTION OF RARE SPECIES

Name	Distribution in Central India	Outside distribution
1	2	3
Acacia donaldii Haines	Bilaspur, Chhatarpur, Damoh, Durg, Jabalpur, Raipur, Sagar	Bihar
Alstonia venenata R.Br.	Raipur	South Indian hills
Alysicarpus vasavadae (Hemadri) Sanjappa	W. Nimar	Maharashtra
Amorphophallus sylvaticus (Roxb.) Kunth	Raipur	Deccan Peninsula, Sri Lanka
Andropogon grahamii Haines	Amarkantak; endemic	—
Andropogon pumilus Roxb.	Indore	Western India
Argyrolobium flaccidum (Royle) Jaub.	Bhopal, Hoshangabad	North-West India
Arthraxon echinatus (Nees) Hochst.	Rewa	Deccan Peninsula
Aspidopterys cordata (Heyne *ex* Wall.) Juss.	Chhindwara, Seoni	Deccan Peninsula
Aspidopterys glabriuscula (Wall.) Juss.	Bastar	Sikkim, Khasi Hills
Begonia malabarica Lam.	Hoshangabad	Western Ghats, Sri Lanka
Berberis asiatica Roxb. ex DC.	Hoshangabad	Himalayas, Parasnath Hills
Berberis hainesii Ahrendt	Hoshangabad; endemic	
Berberis lycium Royle	Hoshangabad	Western Himalayas
Blepharispermum subsessile DC.	Bastar, Raipur	Western Ghats, Upper Gangetic Plains
Bupleurm plantaginifolium Wight	Hoshangabad	Nilgiri Hills
Calpurnia aurea (Ait.) Benth.	Hoshangabad	South Indian Hills
Calycopteris floribunda Lam.	Bastar	Assam, Bihar, Deccan Peninsula; S.E,. Asia
Ceropegia candelabrum L. (*C. tuberosa* Roxb.)	Raipur	Bihar, Deccan Peninsula
Cleome felina L.f.	Indore	Karnataka
Conyza semipinnatifida DC.	Sidhi	Assam; Myanmar
Crotalaria notonii Wt. & Arn.	Raipur	Niligiri & Pulney Hills, Maharashtra

Name	Distribution in Central India	Outside distribution
1	2	3
Crotalaria ramosissima Roxb.	Sidhi	West Bengal, Bihar, Deccan Paninsula
Crotalaria trifoliastrum Willd.	Hoshangabad	Assam, South India
Crotalaria triquetra Dalz.	Hoshangabad Indore	Assam, South India Concan
Curcuma sulcata Haines	Central Provinces; endemic	
Desmodium ritchie sanjappa	Hoshangabad	Western Ghats
Eulophia mackinonii Duthie	Madhya Pradesh	Uttar Pradesh
Eragrastiella leioptera (Stapf) Bor	Surguja	Assam
Eragrostis pappiana Chiov.	Bilaspur, Raipur	N.W. India; E. Africa
Eragrostis riparia (Willd) Nees	Raipur	South India
Euphorbia caducifolia Haines	Raipur, endemic	
Euphorbia perbracteata Gage	Banda, endemic	
Ficus cupulata Haines	Pachmarhi, endemic	
Fimbristylis intonsa S.T. Blake	Surguja	Sikkim; S.E. Asia
Flemingia grahamiana Wight & Arn.	Raigarh	Nilgiri Hills
Fuirena tuwensis Deshpande & Shah	Shivpuri	Gujarat
Grewia hainesiana Hole	Jabalpur; endemic	
Hibiscus pachmarhiens is Haines	Pachmarhi hills; endemic	
Hypericum gaitii Haines	Bilaspur, Surguja	Bihar
Indigofera angulosa Egew.	Rajnandgaon	Budelkhand, Rajasthan
Ischaemum duthie Stapf Western	Sidhi	Bihar, West Bengal, Himalyas
Iseilema anthephoroides Hack.	Indore	Deccan Peninsula
Lasiococca comberi Haines	Angul; endemic	
Leea compactiflora Kurz	Hoshangabad	Himalayas, Eastern Ghats
Leptodesmia congesta Benth. *ex* Baker	Raigarh	Nilgiri Hills
Melhania hamiltoniana Wall.	Rewa	Deccan Penisula, Myanmar
Maytenus bailadillana (Narayan. & Mooney) Raju & Babu (*Gymnosporia bailadillana* Narayan. & Mooney)	Bastar; endemic	
Maytenus rothiana (Laws.) Lobreau Callen (*Gymnosporia rothiana* Laws.)	Shivpuri	Maharashtra
Mitrephora heyneana	Bastar	South India; Sri Lanka
Neonauclea purpurea (Roxb.)	Bastar	Bihar, Eastern Ghats,

Name	Distribution in Central India	Outside distribution
1	2	3
Merr. (*Nauclea purpurea* Roxb.)	South India	
Neanotis decipiens (Hook. f.) Lewis (*Anotis decipiens* Hook. f.)	Mandla	South India
Nogra dalzelli (Baker) Merr. (*Grona dalzellii* Baker)	Madhya Pradhesh	Concan
Nogra filicaulis (Kurz) Merr. (*Grona filicaulis* Kurz)	Raigarh	Parasnath hills; Myanmar
Ochna integrrima (Lour.) Merr.	Raigarh	South India, Andamans; Myanmar
Osbeckia muralis Naud.	Hoshangabad	Chhota Nagpur, Bengal, Deccan Peninsula
Oropetium villosulum Stapf	Raipur, Bhopal	Maharashtra
Polygonum myriophyllum M. Gross.	Central India, endemic	—
Polypleurum stylosum (Tay. *ex* Tul.) Warming	Raipur	Assam, South India
Premna calycina Haines	Central Provinces	West Bengal, Bihar,
Pulicaria wightiana (DC.) Benth. *ex* C.B. Clarke	Hoshangabad	Orissa South Indian Hills
Rhamnus wightii Wight & Arn.	Hoshangabad	Nilgiris, Concan
Rotala fysonii Blatt. & Hallb.	Raipur	South India Hills
Scleria stocksiana Boeck.	Balaghat	Maharashtra
Scleria tessellata Willd.	Guna, Indore	West India; Tropical Africa
Senecio corymbosus Wall. ex DC.	Bastar	Nilgiri Hills; Sri Lanka
Senecio edgeworthii Hook. f.	Hoshangabad	Canara, Nilgiri Hills
Smithia blanda Wall. ex Wight & Arn.	Hoshangabad	Eastern Himalayas, Nilgiri Hills, Concan
Smithia pycnantha Benth. ex Baker	Hoshangabad	Concan
Sophora glauca Lesch. ex DC.	Raigarh	South Indian Hills
Sophora interrupta Bedd.	Chhindwara, Hoshangabad	Karnataka
Sorghum deccanense Stapf	Indore	Deccan Peninsula
Thalictrum chelidonii DC.	Bastar	Temperate Himalayas
Theriophonum minutum (Willd.) Baill.	Raipur	Bihar, South India
Trachyspernum stictocarpum var. *hebecarpum* (Clarke) Wolf	Hoshangabad	Concan
Tylophora macrantha Hook. f.	Raipur	Nilgiri Hills; Myanmar
Utricularia foveolata Edgew. (*U. scandens* Oliver, non Banj.)	Raipur	Deccan Peninsula

Name	Distribution in Central India	Outside distribution
1	2	3
(*U. baouleensis* A. Chev.)		
Vernonia setigera Arn.	Hoshangabad	Deccan Peninsula; Sri Lanka
Vigna dalzelliana (Ktze.) Verdc. (*Phaseolus pauciflorus* Dalz.)	Hoshangabad	Western Ghats
Viola cineria var. *stocksii* Moullava spicata (Datz.) Nicolsam (Boiss.) W. Beck.	Chambal Valley	Western India, Punjab; Pakistan
Moullava spicata (Dalz.) Nicolson (*Wagatea spicata* Dalz.)	Raigarh	Western ghats, Concan
Wendlandia coriacea DC.	Bastar	Tropical Himalayas
Zanthoxylum armatum DC.	Raigarh	Karnataka, Eastern Ghats

ECONOMIC PLANTS

From time immemorial, plants have been a major source of food, shelter, clothing, fibre, gum, resin, oil, medicine and other miscellaneous purposes. Several species are often used for more than one purpose and some are more useful or popular than the others for the same purpose. With the advent of civilization and availability of alternatives, the uses of some of these plants are now confined to tribal or village populations and the information gathered from them or through their markets is being summarised below alongwith the wellknown species of wider use. These have been categorized, based on their utility, into timber wood, edible plants , plants of miscellaneous uses and medicinal plants.

1. Timber wood :

The more popular species valued for timber of long durability and strength for construction, poles, carts, agricultural implements, furniture, railway sleepers and other such uses are *Acacia nilotica* spp. *indica, Anogeissus latifolia, A. pendula, Azadirachta indica, Dalbergia latifolia, D. paniculata, D. sissoo, Gmelina aborea, Hardwickia binata, Mangifera indica, Ougeinia oojeinensis, Prosopis cineraria, Pterocarpus marsuplum, Shorea robusta, Tectona grandis, Terminalia elliptica* and *Xylia xylocarpa.* Other species falling into this category are *Acacia ferruginea, A. leucophloea, Adina cordifolia, Alangium salvifolium, Albizia lebbeck, Alstonia scholoris, Anthocephalus chinensis, Bombax ceiba, Careya arborea, Cleistanthus collinus, Diospyros melanoxylon Emblica officianalis, Eucalyptus* spp., *Garuga pinnata, Kydia calycina, Lagerstroemia parviflora, Lannea coromandelica, Litsea monopetala, Michelia champaca,* *Miliusa tomentosa, M. velutina, Mitragyna parviflora*, *Drypetes roxburghii, Schleichera oleosa, Schrebera sweiteniodes, Sterculia urens, S. villosa, Stereospermum suaveolens, Syzygium cumini, Trewia nudiflora, Xylia xylocarpa* and *Ziziphus mauritiana.*

2. Edible plants :

These are being listed below according to the plant parts eaten.

(i) *Rhizomes/tubers* (cooked) :

Amorphophallus campanulatus, Dioscorea bulbifera, D. glabra, D. pentaphylla, D. pubera, Eleocharis dulcis, Manihot esculenta, Nelumbo nucifera, Nymphaea nouchali, N. pubescena, N. rubra, Nymphoides indica, Pueraria tuberosa, Sauromatum venosum and *Tacca leontopetaloides.*

(ii) *Leaves and tender shoots* (cooked) :

Amaranthus spp., *Amorphophallus campanulatus, A. sylvaticus, Anethum graveolens, Basella alba, Bauhinia racemosa, B. purpurea, Brassica* spp., *Cassia tora, Cleome gynandra, Cocculus hirsutus, Corchorus* spp., *Dendrocalamus strictus, Glossocardia bosvallia, Gnaphalium indicum, Hibiscus furcatus, H. radiatus, H. sabdariffa, Holostemma annularis, Ipomoea aquatica, I. quamoclit, Lysimachia candida, Martynia annua, Melochia corchorifolia, Melothria heterophylla, Merremia emarginata, Murraya koenigii, Neptunia oleracea, Nymphoides heterophylla, N. indica, Olax scandens, Ottelia alismoides, Oxalis corniculata, Oxystelma secamone, Pergularia daemia, Phoenix acaulis, Phyla nodiflora, Polygonum* spp., *Portulaca oleracea, Rivea hypocrateriformis, Rothia indica, Sonchus* spp., *Tribulus terrestris* and *Trigonella (foenum-graceum).*

(iii) Flowers (cooked) :

Bauhinia purpurea, B. racemosa, Celastrus paniculatus, Hibiscus sabdariffa (calyx), *Holostemma annularis, Madhuca longifolia* var. *latifolia, Moringa oleifera, Nelumbo nucifera* (carpels), *Oxystelma secamone, Pergularia daemia, Semecarpus anacardium, Sesbania grandiflora* and *Woodfordia fruticosa.*

(iv) *Fruits* (raw, cooked or pickled) :

Abelmoschus esculentus, Aegle marmelos, Anacardium occidentale, Annona reticulata, A. squamosa, Antidesma ghaesembilla, Artocarpus integrifolia, Averrhoa carambola, Benincasa hispida, Buchanania lanzan (seeds), *Carica papaya, Carissa* ssp., *Citrus* spp., *Cordia obliqua, Cyamopsis tetragonoloba, Dillenia indica,* D. *pentagyna, Diospyros malabarica, D. melanoxylon, Embelia tsjeriam-cottam, Phyllanthus emblica, Erycibe paniculata, Feronia limonia, Ficus* *hispida* *F. racemosa, F. semicordata, F. virens, Flacourtia indica, Gmelina arborea, Grewia* spp., *Mangifera indica, Manilkara hexandra, Melothria heterophylla, Momordica charantia, M. dioica, Moringa oleifera, Ottelia alismoides, Oxystelma secamone, Parkia biglandulosa, Phoenix acaulis, P. sylvestris* (*toddy*), *Prosopis cineraria, Rothia indica, Sesbania grandiflora, Solanum torvum, Spondias pinnata, Syzygium cumini, S. heyneanum, Tamarindus indica, Trichosanthes cucumerina, Trapa natans* var. *bispinosa, Vicia faba, Vigna unguiculata, Vitis vinifera, Xeromphis uliginosa, Ziziphus mauritiana, Z. nummularia* and *Z. rugosa.*

(v) *Seeds* (cooked or roasted) :

Arachis hypogea, Bauhinia vahlii, Cajanus cajan, Cassia occidentalis, Cicer arientinum Coix aquatica, Eleusine coracana, Glycine max, Hibiscus cannabinus, Indigofera glandulosa, I. trita, Lathyrus sativus, Lens culinaris, Oryza rufipogon, Panicum sumatrense, Pâsplum flavidum, P. scrobiculatum, Pisum sativum, Pithecellobium dulce (raw seed and aril), *Semecarpus anacardium, Sterculia urens, Vigna aconitifolia, V. mungo, V. radiata, V. trilobata* and *V. umbellata.*

3. Plants of miscellaneous use :

(i) *Aquaria plants :*

Hydrilla verticillata and *Vallisneria nutans.*

(ii) *Baskets, hats and mats :*

Arundo donax, Calamus spp., *Cyperus pangorei, Dendrocalamus strictus, Diospyros melanoxylon, Indigofera cassioides, Phoenix acaulis, P. sylvestris, Phragmites karka, Scirpus grossus* and *Typha angustata.*

(iii) Beverages and drinks :

Cassia occidentalis, Madhuca longifolia var. *latifolia, Oryza sativa, Phoenix sylvestris* and *Tamarindus indica.*

(iv) *Bidi rolling :*

Leaves of *Bauhinia vahlii* and *Diospyros melanoxylon.*

(v) *Brooms :*

Culms of *Arundo donax, Thysanolaena maxima, Dendrocalamus strictus,* leaves of *Phoenix acaulis* and branches of *Sida acuta.*

(vi) *Cotton :*

Various species and hybrids of *Gossypium*, and silk cotton from *Bombax ceiba.*

(vii) *Detergent :*

For washing hairs powdered pods of *Acacia sinuata* and soapy liquid obtained after soaking fruits of *Sapindus emarginatus, S. laurifolia* and *S. mukorossi* in water, are used.

(viii) *Dyes :*

Acacia catechu, Butea monosperma, Curcuma aromatica, C. longa, C. zedoaria, Lawsonia inermis, Mallotus philippinensis, Nyctanthes arbor-tristis, Pterocarpus marsupium, Toona ciliata, Woodfordia fruticosa and *Wrightia tinctoria.*

(ix) *Fibres :*

Abelmoschus spp., Abutilon spp., *Agave americana, Bauhinia purpurea, B. vahlii, Butea monosperma, Calotropis gigantea, C. procera, Corchorus* spp., *Crotalara juncea, Eulaliopsis binata, Grewig* spp., *Helicteris isora, Hibiscus cannabinus, H. radiatus, H. sabdariffa, (Marsdenia) tenacissima, Melochia corchorifolia, Millettia extensa, Naravelia zeylanica, Sida* spp., *Soymida febrifuga, Triumfetta rhomboidea. Typha angustata* and *Urena lobata.*

(x) *Fish poison :*

From fruit pulp of *Acacia sinuata, Casearia elliptica, Cleistanthus collinus, Gardenia turgida* and *Xeromphis spinosa*, roots of *Millettia extensa* and bark of *Barringtonia acutangula.*

(xi) *Floss* (for stuffing) :

Bombax ceiba, Calotropis gigantea, C. procera, Cochlospermum religiosum and *Gossypium* spp.

(xii) *Gum and resin :*

Acacia ferruginea, A. nilotica ssp. *indica, A. senegal, Anogeissus latifolia, Boswellia serrata, Chloroxylon swietenia, Cochlospermum religiosum, Cyamopsis tetragonoloba, Gardenia gummifera, Lannea coromandelica, Sterculia urens, S. villosa* and *Woodfordia fruticosa.*

(xiii) *Insect repellent :*

Oil from leaves of *Azadirachta indica* and *Cymbopogon martinii.*

(xiv) *Kattha/Khair :*

From wood of *Acacia catechu.*

(xv) *Khas-khas :*

Roots of Vetiveria zizanoides.

(xvi) *Oil* (for paints, varnishes, lubrication, tanning, soap, massaging, medicine and illumination) :

Argemone ochroleuca, A. mexicana, Brassica spp., *Boswellia serrata, Buchanania lanzan, Casearia graveolens, Celastrus paniculata, Cochlospermum religiosum, Eucalyptus* spp., *Gossypium* spp., *Guizotia abyssinica, Jatropha curcas, Linum usitatissimum, Litsea monopetala, Madhuca longifolia* var. *latifolia, Mallotus philippinensis, Nyctanthes arbor-tristis, Pongamia pinnata, Drypetes roxburghii, Ricinus communis, Schleichera oleosa, Semecarpus anacardium, Shorea robusta, Sterculia urens, Tamarindus indica* and *Ventilago denticulata.*

(xvii) *Paper pulp :*

Boswellia serrata, Dendrocalamus strictus, Eucalyptus spp., *Kydia calycina* and *Pterocarpus marsupium.*

(xviii) *Perfumes :*

Cymbopogon spp., *Jasminum* spp., *Michelia champaca* and *Vetiveria zizanoides.*

(xix) *Poles :*

Bambusa spp., *Cephalostachyum pergracile* and *Dendrocalamus strictus.*

(xx) *Plates and bowls :*

Leaves of *Bauhinia vahlii, Butea monosperma, Madhuca longifolia* var. *latifolia, Musa* spp. and *Shorea robusta.*

(xxi) *Ply-wood* :

From various soft wood species.

(xxii) *Thatching* :

Oryza sativa, Phoenix acaulis, P. sylvestris, Saccharum spontaneum, S. munja and *Typha angustata.*

(xxiii) *Weighing* (Ratti the jewellers weight) :

Seeds of *Abrus precatorius.*

(xxiv) *Wood* (for toys, combs, decorations, match-sticks, packing cases, splinters, pencils and scales) :

Aeschynomene spp., *Ailanthus excelsa, Boswellia serrata, Cassine glauca, Chloroxylon swietenia, Erythrina suberosa, Holarrhena antidysenterica, Holoptelia integrifolia, Kydia calycina, Mallotus philippinensis, Toona ciliata* and *Wrightia tinctoria.*

4. Medicinal plants :

Central India is known to harbour a rich wealth of medicinal plants which continues to be used for amelioration of people's sufferings. Apart from professional Ayurveda practitioners its knowledge is being transmitted from generation to generation, particularly among the village-folks and the tribals. They were consulted during field exploration tours and on the basis of those notes and some standard books on medicinal plants the following list of medicinal plants of Central India has been compiled. Most of these plants are in use by the Indian Pharmaceutical Industries.

Abrus precatorius, Abutilon indicum, Acacia catechu, A. farnesiana, A. nilotica spp. *indica, A. senegal, A. sinuata, Achyranthes aspera, Acorus calamus, Adhatoda vasica, Aegle marmelos, Alangium salvifolium, Albizia lebbeck, Alternanthera sessilis, Alstonia scholaris, Amaranthus caudatus, A. spinosus, Ammania baccifera, Andrographis echioides, A. paniculata, Anona squmosa, Anogeissus latifolia, Anthocephalus chinensis, Argemone mexicana, Argyreia nervosa, A. strigosa, Asparagus racemosus, Atlantia monophylla, Averrhoa carambola, Azadirachta indica, Bacopa monnieri, Balanites aegyptiaca, Baliospermum montanum, Bambusa arundinacea, Barleria cristata, B. prionitis, Barringtonia acutangula, Bauhinia racemosa, B. tomentosa, B. vahlii, B. variegata, Benincasia hispida, Berberis asiatica, B. lycium, Biophytum petersianum, B. sensitivum, Blepharispermum subsessile, Blastania garcinii, Boerhaavia* *diffusa, Bombax ceiba, Boswellia serrata, Butea monosperma, Caesalpinia bonduc, Calotropis gigantea, C. procera, Canscora decussata, Careya arborea, Carica papaya, Cassia absus, C. auriculata, C. fistula, C. obtusifolia, C. occidentalis, C. tora, Cassytha filiformis, Catharanthus pusillus, C. roseus, Celastrus paniculatus, Centella asiatica, Chloroxylon swietenia, Cissampelos pareira var. hirsuta, Cleome simplicifolia, C. viscosa, Clerodendrum indicum, C. phlomidis, C. serratum, Clitoria ternatea, Cocculus hirsutus, Convolvulus arvensis, C. microphyllus, Cordia obliqua, Costus speciosus, Crateva nurvala, Crinum asiaticum, Crotalaria juncea, Curculigo orchioides, Curcuma aromatica, C. zedoaria, Cynodon dactylon, Cyperus rotundus, Dalbergia lanceolaria, D. sissoo, Datura metel, D. stramonium, Desmodium gangeticum, D. gyroides, D. heterocarpon, D. pulchellum, D. triflorum, D. triquetrum, Desmostachya bipinnata, Diospyros peregrina, Diplocyclos palmatus, Dregea volubilis, Eclipta prostrata, Embelia tseriam-cottam, Phyllanthus emblica, Emilia sonchifolia, Enicostema axillare, Erythrina variegata, Eucalyptus* spp., *Eulophia nuda, Euphorbia hirta, E. neriifolia, E. tirucalli, Evolvulus alsinoides, Feronia limonia, Flemingia nana, Girardinia zeylanica, Glycosmis arborea, Gmelina arborea, Gossypium arborum, G. herbaceum, Guizotia abyssinica, Gymnema sylvestre, Helicteres isora, Hemidesmus indica, Hibiscus trionum, Holarrhena antidysenterica, Hydrocotyle sibthorpioides, Hygrophila auriculata, Ichnocarpus frutescens, Ipomoea nil, Lawsonia inermis, Lepidium sativum, Leptadenia reticulata, Leucas capitata, Litsea monopetala, Macrotyloma uniflorum, Madhuca longifolia* var. *latifolia, Mallotus philippinensis, Manilkara hexandra, Marsdenia volubilis, Martynia annua, Melothria heterophylla, Melia azadirachta, Mimosa pudica, Momordica charantia, Mucuna pruriens, Naringi crenulata, Nelumbo nucifera, Nymphaea nouchali, N. pubescens, Ocimum basilicum, O. sanctum, Oldenlandia corymbosa, Operculina turpethum, Oroxylum indicum, Oxalis corniculata, O. corymbosa, O. richardiana, Pavonia odorata, Pentanema indica, Peucedanum nagpurense, Phylhlanthus amarus, Pistia stratiotes, Plantago* sp., *Plumbago zeylancia, Polygala arvensis, Pongamia pinnata, Psoralia corylifolia, Pterocarpus marsupium, Pueraria tuberosa, Rauvolfia serpentina, Rhamnus purpurens, Ruta graveolens, Saccharum spontaneum, Salvia plebeia, Sapindus emarginatus, Scirpus grossus, Semecarpus anacardium, Sesamum orientale, Shorea robusta, Sida acuta, S. alba, S. cordata, S. cordifolia, S. rhombifolia, Smilax zeylanica, Solanum indicum, S. nigrum, S. surattense, Sphaeranthus indicus, Spilanthes acmella, Sterculia urens, Stereospermum suaveolens, Strychnos nux-vomica, S. potatorum, Syzygium cumini, Tamarindus indica, Tectona grandis, Tephrosia purpurea, Terminalia cuneata, T. bellirica, T. chebula, Thalictrum foliolosum, Thespesea lampas, Tinospora cordifolia, Toona ciliata, Trewia nudiflora, Tribulus terrestris, Trichosanthes cucumerina, Trigonella foenum-graecum Tridax procumbens, Uraria alopecuroides, U. picta, Urginea indica, Vanda tessellata, Vernonia cinerea, Vetiveria zizaniodes, Vitex negundo, V. peduncularis, Woodfordia fruticosa, Xeromphis spinosa, Zanthoxylum armatum, Ziziphus mauritiana* and *Z. oenoplia.*

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5.6. ARID ZONE

(B.V. Shetty & V. Singh)

INTRODUCTION

The Thar or the Great Indian Desert occupies the eastern extremity of the north tropical desert belt which extends from the Atlantic coast of Africa through Sahara, the world's largest desert, and arid regions of Arabia, Iran and Pakistan to India. Hooker (1906) included the Punjab (including Haryana), Sind (in Pakistan) and Rajputana west of the Aravalli range and the Jamuna river, Kutch and northern Gujarat in the Indus Plain, one of the botanical regions recognised by him in his *Sketch of the Flora of British India*. In India the western arid zone lies between 21° 30' N and 31° N latitudes and encompasses vast areas of western Rajasthan, western Gujarat and south western Punjab and Haryana together covering an extensive area of over 2,85,600 sq. km of western India. It lies roughly to the west of Rajkot (22° 18'; 70)° 49' Alwar (27° 35'; 76° 36') Ferozepore 30° 57' ; 74° 54') line to the west of Aravalli axis and south-west of the so-called Delhi Lyallpur (31° 25; 73° 04') ridge (Adyalkar, 1964), and includes western Ferozepore (77%), western Bhatinda (88%) and a negligible portion of Sangrur (8%) districts of Punjab, major part of Hissar (90%) and a small portion of Mehendragarh (9%), Gargaon and Rohtak districts of Haryana, Ganganagar, Bikaner, Jaisalmer, Barmer, Jodhpur, Nagaur and Churu districts and western Jhunjhunu (69%), western Sikar (65%), western Pali (48%), major portion of Jalor (88%) and a small portion of Ajmer (9%) districts of Rajasthan, Kutch and western Jamnagar (80%) districts and small portions of Banaskantha (18%), Mehsana (4%), Ahmedabad (6%), Surendranagar (29%), Rajkot (6%) and Junagadh (20%) districts of Gujarat (Krishnan, 1968 a, b). While it extends for about 1100 km in a north-south extension and about 600 km in an east-west stretch, it occupies 1100 km long north-east-south-west strip with a maximum width of 375 km (Adyalkar, *l. c.*).

The arid area in Rajasthan is about 1,96,150 sq km and occupies about 62 per cent of the total area of the state. This arid region is commonly known as the Rajasthan Desert. Area under arid zone in Punjab is 14510 sq km, (5%) in Haryana 12840 sq km (4%) and in Gujarat 62180 sq km (20% (Krishnan, *l. c.*). This western Indian Arid Zone has a well defined boundary in the east marked by the Aravalli ranges tending in north-easterly direction from Champaner in Gujarat in south-west to near Delhi in the north-east.

The desert is characterised by low and erratic rainfall, high solar radiation, extreme variations in diurnal and seasonal temperature with high temperature, low humidity of the atmosphere for the greater part of the year; high evaporation rates, desiccating winds and dust storms during summer; sandy and unretentive character of soil, low water table, general soil and water salinity and poor vegetative cover.

PAST HISTORY

Western Rajasthan (Jaisalmer, Barmer) was occupied largely by a sea during Jurassic, Cretaceous and Eocene and it must have been uplifted into dry land sometimes in the Upper Tertiary (Krishnan, 1952). Even some large lakes and lagoons might have been left over which gradually dried up. Kutch, Kathiawar and Narbada Valley were also said to have been under the sea which extended over western Rajasthan. During *Recent Times,* Kutch and Kathiawar peninsulas were believed to have been islands with seas and lagoons on all sides of Kutch, and with the Gulf of Cambay connected with the Gulf of Kutch by an arm of the sea projecting inlands, thus separating Kathiawar peninsula from the main land.

It is thought that the monsoon conditions were established in India in and after the Miocene when the Himalayas rose high enough to obstruct the south-westerly winds and cause the precipitation of moisture on their southern flanks. There were four glaciations during the Pleistocene (time range about one million years) (De Terra, 1936; Krishnan, *l.c.*) and the interglacial period was pluvial with high rainfall. It is inferred that western Rajasthan continued to be moist till perhaps sub-recent times because of the lowering of temperature due to the Ice Age and the presence of foredeep and is said to have become gradually dry, well after man appeared in Pleistocene and after the last glacial period, possibly in (geologically) *Recent times* (Krishnan, *l. c.*). According to Sankhalia (1952) there is some evidence from N. Gujarat which indicates that the climate there during upper Pleistocene was probably wetter than it is today, or any time since then. "No doubt", he says, "it witnessed a series of oscillations from wet to dry and dry to wet, but on the whole the tendency is towards drier conditions. In Punjab also, there is evidence of transition to drier periods from periods of extreme cold, called the Ice or Glacial Ages" (Sankhalia, *l.c.*).

The report of fossils of *Mesua, Garcinia* and *Calophyllum* of Guttiferae from the Eocene, Fuller's earth deposits in Barmer district of Rajasthan (Lakhanpal and Bose, 1951) and of *Dipterocarpus* from the Pliocene of Kutch (Ghosh and Ghosh, 1959) extends the occurrence of tropical evergreen vegetation during Tertiary to as far west as Rajasthan area, where a poor type of scrub exists today. Species of Guttiferae and Dipterocarpaceae thrive well in moist, warm and equitable climate with a high rainfall and these fossils thus indicate the humid nature of climate then prevailing. The petrified remains of large tree trunks found in the

Akal Fossil Park, a few kilometres away from Jaisalmer, testify the existence of thick vegetation in the Indian desert even earlier, in the Jurassic.

The Aravalli ranges seem to have undergone great changes both in height and extent during the late Himalayan movements. The northern and north-western parts of the once extensive Aravalli range sank, with the result there was a down-warping of the range northwards (Hora, 1952). These changes, according to Hora (*l.c.*), must have profoundly affected the physiography and climatology of Rajputana subsequently. Another characteristic feature of the Himalayas is that the rivers are shifting from the east to west (Chibber, 1949) and there is evidence of the same trend in the Rajasthan areas. The uplift of the Putawar Plateau during late Pleistocene had probably a great effect on the drainage system of the Himalayas and the changes no doubt affected the Rajputana desert adversely (Hora, 1952). There are, thus, geological considerations which seem to have contributed materially to the deterioration of the desert conditions in this area since the close of the last Glacial Period.

The extensive wide channels and beds of rivers in western Rajasthan, though now absolutely dry except immediately after the rains, suggest that this region had, before the aridity set in, a well developed drainage system which carried sufficient silt into the sea. Thereafter, the run off decreased and these streams on rivers now flow subterraneally along these dead channels. It is believed that the Sarasvati (modern Gaggar-cum-Sarasvati) with its tributry Drishadvati (modern Chitang) which was a great river in Vedic times, rivalling the Ganges and the Indus, and flowing through what is now the dry bed of Gaggar, Hakra and East Nara into the Rann of Kutch, dried up during historic times (Krishna, 1952; Sankhalia, 1952). Gaggar and Chitang even now carry some water during their journey through Punjab but by the time they reach the Bikaner territory, their beds are practically dry. According to Krishnan (*l.c.*), "The Indus also had an eastern branch which emptied itself into the Rann, barely a few centuries ago. There might have been other streams, besides these and the Luni, which flowed from western Rajasthan into the Rann during the period when it was enjoying a fairly humid climate". Rode (1964) opines that the prime cause of the desert in this region is due to the impoverishment and consequent deepening of subsoil water-table because of the diversion of the Himalayan waters away from the Gaggar.

Many historians and archaeologists have drawn our attention to the fact that the Rajasthan desert was once the centre of a flourishing civilization. Mohenjo-daro and Harappa are two of the oldest Indian civilisations developed in the area which is in the desert today, and in their buildings burnt clay bricks were used which looking at the present scrubby vegetation is an impossibility, unless the area had a luxuriant tree vegetation in the past. Even as late as the 4th century B. C., at the time of Alexander's invasion, the area was forested and the Mughals are believed to have hunted tigers in these forests (Puri *et al.*, 1989). The desert conditions are believed to have been accentuated by the work of man in cutting down and burning forests for cultivating the area and for use as firewood. According to Raverty (1892) the Indian desert originated in medieval times. Bryson and Baerreis (1967) have expressed the opinion that conditions in western Rajasthan have deteriorated in the recent past in the wake of the destructive activities of man, especially after the fall of the Rangamahal culture in the 7th or 8th century A.D. Vats (1952) and Ghosh (1952), however, are of the view that the Rajputana desert is not of medieval times, since the existence of the desert is attested by the historians of Mohmud Ghazni (*ca* 1000 A.D.) Further back, the Mahabharata (*ca* early centuries A.D.) mentions the disappearance of the river Sarasvati in the midst of the desert (Vats, *l.c.*; Ghosh, *l.c.*). Hence, Ghosh (*l. c.*) is of the opinion that the Rajputana desert is at least two millennia old and its nucleus must have been older still. According to Sankhalia (1952) western Rajasthan was already a desert by at least the third century B.C.

Towards the end of the first millennium A.D., according to Vats (*l.c.*), the population in the western part of Sarasvati Valley became nomadic, probably as a result of complete desiccation of the land.

There are, thus, considerable historical, archaeological and geological evidences to show that the desert conditions have been deteriorating in the past and this process, instead of being checked, has been accentuated by anthropogenic influences in the recent past (Hora, 1952).

BIOTIC FACTORS

Though the original cause of desert can be traced to geological events, largely in the nature of the sheet movements leading to peneplanation, rapid changes in the drainage system, enormous accumulation of loose rocky materials, deepening of water table and consequent famishing of vegetation, its deterioration since *ca* 600 A. D. is attributed largely to the activities of man. The use of trees for firewood and other domestic purposes increased beyond their recuperative power. Heards of goats and sheep moved about by the nomadic tribes used up vegetation wherever it existed or appeared (Hora, 1952).

Agriculture is now the main occupation of the people, particularly in rural areas. Next to land, livestock constitutes the most important asset of the farmer and a large number of goats, sheep, cows and camels are maintained by them. These depend almost entirely on grazing and stall feeding is unknown. There is, thus, over crowding of livestock on grazing land. To make matters worse, rampant destruction of bush and tree growth contiues for obtaining fuel and fencing materials and also for other purposes like making agricultural implements, carts, house construction, etc. The increasing demand for wood has lead to unwise exploitation of vegetation.

Among the insects found in Rajasthan, locust (*Schistocerca gregaria* Forsskal) is the only pest which can contribute to the maintenance or spread of the desert. It is polyphagous, eating most types of vegetation, destroying the annuals and pernnials, devouring both leaves and bark, leaving only woody portions behind. By consuming annuals in the desert, they cause the loosening of soil which results in soil erosion. It is well known that locusts undergo periodic population flux, the plague years or years of high population alternating with periods of extremely low population.

Rodents and to a lesser extent birds also cause considerable damage to the vegetation. Among the rodents the Indian desert gerbil (*Meriones hurrianae* Jerdon) is the most dominant pest of arid zone. They are gregarious in habit and are found in large numbers. In the absence of seeds, which are their preferred diet, they attack seedlings. Stems and rhizomes have been noticed in the stomach contents of gerbils. When they do not get drinking water, as in the extreme barren tracts, they cut the plants and lick the sap which oozes out to quench thir thirst. Their burrow system which is most extensive not only causes soil erosion, but also adversely affects the vegetation as they make the soil very loose and due to over aeration the roots of plants are exposed to hot winds (Prakash, 1959, 1964).

The other animals like Chinkara (*Gazella gazella* Pallas) and Neelgai (*Boselaphus tragocamelus* Pallas) also cause considerable damage to the vegetation.

PHYSIOGRAPHY

The eastern limit of the western Indian arid zone is marked by the north-east tending Aravalli range, once a lofty mountain range when the Himalayas were still in the making. There are no other mountain ranges in western Rajasthan worth the name. Occasionally one comes across hills of relict type, carved out of gently rolling sedimentary rocks or Malani volcanics and their equivalent granitic terrain; in the latter case it often form high hills of most rugged and uneven topography. The crystallince rocks found here are compact quartzose porphyritic schists. Composed of small crystals of pink felspar, and associated with syenite, they resemble Lydian stone, and are to be seen in the shape of scattered hills near Barmer, south of Luni river, and south and south-west of Jodhpur where they assume a pronounced volcanic character. The few hills of the south of the great bend of the Luni rise nearly to 1000 m. In the Jodhpur-Pokhran area there is hardened shale-huge boulders resting upon crystalline rock, and coarse red sandstone. Sandstone of later date is found near Barmer and Jaisalmer upon which rest other sandstones and limestone, abounding in marine Jurassic fossils. Towards the west of Jaisalmer are coltic beds superimposed by nummulitic limestone.

In the desert region of Haryana there are a few isolated hills in Rohtak, Hissar and Gurgaon. In Kutch there are a group of low hills aligned in east-west orientation and occupying anticlinal axes of Jurassic outcrops. The rocks of lower Jurassic are essentially marine with shell and coral limestone, while the upper Jurassic is marked by sandstones, shales and conglomerates. The central highland oriented west-east is less than 40 km broad at its widest and forms the water parting between the Rann of Kutch in the north and the Gulf of Kutch in the south.

Piedmont plains and piedmonts: In Nagaur, Bap, Phalodi, Jodhpur, Jaisalmer, Pali, Jalor and Bikaner areas vast extensive rocky plains with thin veneer of sediments are with several scraps are present. These piedmont plains have been formed by the process of scrap-recession. There are also some other minor rocky plains strewn with stony materials adjacent to the hills and scarps.

The piedmont plains around the hills are sloping, the upper part with 5-10 per cent slope being mostly rocky consisting of boulders and large rock fragments loosely placed against each other. The lower part has 3-5 percent slope and is covered with gritty and gravel sand and small amount of silt. Sand piling here is deep to very deep.

Sand-dunes: A large part of the western arid region is covered with vast stretches of wind blown sand interrupted occasionally by rocky protrudings. A spectacular feature of western arid zone is the occurrence of sand-dunes which vary of height from a few to several metres. Near the Rann of Kutch and in the Barmer area the density of dunes is comparatively more and it gradually decreases in the West-East direction. About 58 per cent of the arid western Rajasthan is covered with sand-dunes of different types, magnitude and orientation and the large-sized dunes are concentrated in the western parts in the districts of Barmer, Jaisalmer and Bikaner. There are two tracts of dunes in western Rajasthan, separated by rocky exposures. The first one passes through Barmer, Ramgarh (in Jaisalmer) and west of Bikaner, while the other one passes through Pachbhadra (in Barmer), Shergarh (in Jodhpur) and Ratangarh (in Churu). These two tracts meet beyond Bikaner and extend further northward (Pandey, 1969). In Kutch, the coasts are fringed with sand-dunes of longitudinal type.

The different types of dunes have been formed by the air currents which sweep across the desert predominantly from the south-west to north-east (SW-NE). Two types of dune complexes have been recognised viz., a) free dunes and b) obstacle dunes and under the former there are four distinct types viz., 1) parabolic, 2) longitudinal, 3) transverse and 4) barchan (Saxena, 1972). The parabolic dunes, formed in the prevailing direction of the wind, are the oldest among all the types of dunes. These dunes are stabilised but the crest and upper slopes are covered with fresh sand. The longitudinal dunes, confined to areas where the winds are strong, lie parallel to the prevailing wind direction (SW-NE) and are mostly distributed in the southern and extreme western parts. The transverse dunes aligned across the wind direction are found more towards the east and north where the wind force is of less intensity. The barchans with the concave side facing the wind occur in the interior where there is a limited supply of loose sand and the velocity of wind is moderate. (Raychaudhri and Sen, 1952; Pandey, *l.c.*).

Most of the dunes are semi-stabilised, some of which are under cultivation and these are of high relief and have developed into whale-back ridges with small calcium carbonate nodules and concretions formed close to the crest and flanks as a thin compact layer. The recent dunes are unstable and are composed of freshly deposited, loose, mobile sand which is freely blown over by the wind. They are of minor relief, compared to the older dunes and are in the evolutionary stage, yet to be stabilised. The percentage of calcium carbonate in them is comparatively low.

The earlier view that the sands comprising these dunes were blown over from the Rann of Kutch by the south-westerly gales is not quite tenable in the light of recent investigations. Their composition seems to indicate that the main source of the sand was probably from the weathering of rocks (Pandey, *l.c.*) and are derived largely from dry stream channels.

Sandy Plains: These are the most predominant features of the desert landscape, the most notable being in the Haryana-Punjab sector, north Gujarat, Bikaner (in part), Jaisalmer and Barmer districts. This area is relatively flatter than the north-western dune infested area, with soils of aeolian origin derived from various parent materials. The broad landform units are old and young alluvial plains. The old alluvial plain is most extensive in central Rajasthan, with a flat topography and with a hummocky surface in some areas due to wind work. The soils are generally calcareous sandy loam with a hard kankar pan at varying depths from 30-150 cms. The younger alluvial plains occur generally in the narrow belts on both sides of the present river channels like the Luni and its tributaries, and the flood plains. The soils are mostly loamy sand with good water potential, having water table at 7-10 mm depth. Coarse material (sand and gravel) is also common (Puri *et al.*, 1989).

Ghaggar alluvial plain : In the northern part of the desert in Ganganagar and Bikaner districts the extensive Ghaggar alluvial plain is situated. It has been built up by streams of the Himalayas and the Aravallis, the streams of the latter, however, are not draining this area at present. The plain is regarded to be the result of post Teritiary alluviation. The alluviation of the region is still in operation (Pandey, *l.c.*). The soil is of fine clay loam to silty clay in texture in the north-east of Ghaggar plain which is at times saline.

Playas or saline depressions : Saline depressions (Playas) of large and small areal extension are found scattered throughout the arid region, the well known ones being Pachbhadra (25° 56' : 72° 08'), Kuchaman (27° 09' : 74° 52') and Didwana (27° 23' : 74° 13/5 35'). In addition, there are many more less known local saline tracts like those at Kaparda, Sujangarh, Tal Chappar, Lunkaransar, Parihara, Sargot, Mithaka-Rann, and Kharia Rann between Jaisalmer and Ramgarh, Pokharan, That, Lawan, Khutani, Khanodwala, Phalodi, Mansar, Kodamdesar, etc. (Adyalkar, 1964; Pandey, *l. c.*).There is also one near the Rann. All these are situated in local depression where the local runoff collects. During summer months they become dry. The salinity diminishes in them gradually away from the salt basin. They consist of clayey soil with a high sodium chloride content in all of them. Pachbhadra and Diwana have in them magnesium sulphate and sodium sulphate respectively as the important constituents (Adyalkar, *l.c.*).

Various theories have been put forward to explain the presence of salt depression in Rajasthan. Previously it was considered that salts are derived from various weathering products. But this theory could not get support as the chlorides which are the main constituent of salts could not be accounted for from rocks. Then the marine inundation theory according to which these salt lakes in Rajasthan are considered to be the relics of an inland sea, and the wind-borne theory, the proponents of which postulated that the salts are transported from the Rann of Kutch and deposited in the salt lakes, were proposed. Godbole (1952) has shown that the different salt lakes show different salt compositions and so they could not have been derived as mere surface deposits due to drying up of the sea. Ghose (1964) has suggested that the salt basins of Pachbhandra, the Rann of Sanwarla and other minor depressions in the northern part of the Central Luni Basin are the isolated remnants of the dead drainage system. Pandey and Chatterji (1970), however, are of the opinion that the playas studied by them are not part of the river bed of the past. Noelting (cf. Sarin, 1952) is of the opinion that the salt of the Sambhar lake is derived from subterranean saline springs.

Coastal marshy zone: The coast lines like those on either side of the Gulf of Kutch and on the western part of Kutch are characterised by saline flats and saline wastes. These marshy zones occupying the intertidal limits are drained only by muddy channels in which sea water flows at low tide to join the main creeks.

Rann of Kutch and the little Rann: The two Ranns, one north of Kutch and the other between Kutch and mainland Gujarat, are saline wastes and have the same origin as the coastal marshes. The Rann of Kutch has an area of about 7000 sq km being 256 km from west to east and 128 km from north to south. The little Rann is much smaller and does not exceed 4000 sq km in area. Both the Ranns are water-logged during monsoons due to ineffective drainage, but are dry during the non-rainy seasons.

Drainage: The Sutlej river in Punjab forms the north-western limit of western arid tract. The river Ghaggar flows through the southern part of Punjab; in Ganganagar (Rajasthan) it is dry except during rains.

The only river of significance in western Rajasthan is the Luni which had its origin before the rise of the Himalayas. It rises in the Aravalli hill range near

Ajmer (26^0 28' : 74^0 39') and after an initial west-south westerly course towards Barmer (25^0 46' : 71^0 23') flows south-westwards until it drains into the north-eastern corner of Kutch. It is an ephemeral river carrying water during the short monsoon period. As far as Balotra (25^0 50' : 72^0) the water is sweet but further down it becomes more and more saline till it turns into brine near the Rann of Kutch. It has a number of tributaries on its left bank but is wind swept and sand ridden on its right bank where it has only one tributary. The principal tributaries of Luni are Lilri (Rajpur Luni), Guhiya, Bandi, Sukri, Jawai, Mitri (Jojri) and Sagai, none of which is perennial. The total length of Luni is nearly 450 km.

The Kanthi river, which is also ephemeral, rises from the northern part of the Aravallis and flowing to the north through Jhunjhunu district dies out in the sand.

The river Banas after originating from the south western part of the Aravallis flows into the little Rann along with its tributaries. It passes through the semi-arid Banaskantha and Mehsana districts of Gujarat. Besides this there are numerous ephemeral streams in Kutch which flow both to the north and south from the central highland and find their way either to the Rann or to the Gulf of Kutch. In western Kathiawar (Saurashtra) also there are a large number of ephemeral streams flowing into the Gulf of Kutch or the little Rann. The river Bhadra with its tributaries draining parts of the south western arid regions of Kathiawar, flows into the Arabian sea.

CLIMATE AND RAINFALL

Pramanik *et al.* (1952 a, b) defined desert or arid region in India as an area having a rainfall of 25 cm (10") or less and a mean annual diurnal temperature of 24^0 F or more, and semi-arid region as an area having a rainfall between 25 and 50 cm (10" and 20") and an annual diurnal range of 18^0 F or more. According to them the Rajasthan desert is the only desert in India; south western portion of Punjab, Kutch and western portion of Kathiawar are, in their opinion, semi-arid. Krishnan's (1968 a, b) delineation of the arid areas in north-west India, based on Thornthwaite's method, however, not only includes western Rajasthan but also south western parts of Punjab and Haryana towards the north of Rajasthan and also western parts of Gujarat towards the south of Rajasthan.

Rainfall

The entire western Indian arid zone forms a typical belt of low rainfall, with the rainfall in western Rajasthan decreasing rapidly from the Aravalli range towards west and west-north-west. Bulk of the annual rainfall is received during the south-west monsoon (June to September), generally associated with depression from the Bay of Bengal or land depressions approaching or entering Rajasthan from east. The Arabian sea currents coming from south-west blow across Gujarat and give some precipitation particularly to the coastal districts of Gujarat, but practically nothing in western Rajasthan. Monsoon generally starts in the arid zone by the beginning of July and the months in which highest rainfall occurs over the region are July and August. In Gujarat and south and central Rajasthan 90-95 per cent of the normal annual rainfall is precipitated during the monsoon period, while the percentage of rainfall for the same period in north Rajasthan and Haryana is 18 to 85 and in Punjab 78 (Krishnan, *l.c.*). The rainfall during the cold weather period, December to February, in association with the western disturbances is 1-5% in south and central Rajasthan and Gujarat and 7-12% in north Rajasthan, Haryana and Punjab (Krishnan, *l.c.*). Table 1 below shows the normal district wise annual rainfall and the percentage contribution of principal seasons in western arid zone of India (Krishnan, *l.c.*).

TABLE I

State	District	Mean annual rainfall (mm)	Percentage of rainfall during S.W. monsoon season (June to September)	Percentage of rainfall during winter season (December to February)
Punjab	Bhatinda	403.2	79	11
	Ferozepur	368.5	78	12
Haryana	Hissar	347.7	81	9
	Rohtak	342.0	84	7
Rajasthan	Jhunjhunu	404.3	86	5
	Sikar	456.4	89	6
	Nagaur	388.6	89	4
	Pali	415.3	93	3
	Jalor	404.4	95	2
	Churu	325.5	86	6
	Jodhpur	318.7	91	3
	Barmer	277.5	91	3
	Ganganagar	253.7	83	9
	Bikaner	263.7	85	5
	Jaisalmer	164.0	91	4
Gujarat	Banaskantha	507.6	95	1
	Mehsana	510.0	96	1
	Surendra-nagar	493.7	95	1
	Jamnagar	471.1	95	1
	Junagadh	499.8	95	1
	Kutch	322.2	94	2

Plate 23. Common land form of unstabilized barren sanddune in the Western Rajasthan

Plate 24. Unstablilized sanddune with vegetation in interdunal gaps

Plate 25. Partially stabilized sanddune colonised by *Calotropis procera, Capparis decidua, Acacia senegal,* etc.

Plate 26. Typical thorny scrub vegetation over partially stabilized sanddune colonised by *Aerva javanica, Calligonum polygonoides* and *Leptadenia pyrotechnica* in the background

Plate 27. *Euphorbia caducifolia* colonising rocky outcrops in the desert.

Plate 28. A view of dry deciduous forest of *Anogeissus, Lannea* and *Boswellia*

Plate 29. Dense dry deciduous forest of Ranthambhor Tiger Reserve (Rajasthan)

Plate 30. A view of dry deciduous forest on Aravalli during monsoon, with patches of *Dendrocalamus strictus*

Plate 31. A view of dry deciduous forest on Aravalli during monsoon

Plate 32. *Tecomella undulata* - a threatened species of arid zone

Plate 33. Deep gorges caused by water erosion along Chambal supporting deciduous flora

Plate 34. Lake in Ranthambhor Tiger Reserve - home of *Crocodilus palustris* (crocodile)

The coefficient of variation of annual rainfall in arid zone is very high and is generally between 50 and 90 for stations with rainfall or less than 10" (305 mm) and between 40 and 60 for stations with more than 10" of rainfall. Generally the coefficient of variability decreases with increase in rainfall (Pramanik, 1952). The failure of monsoon rains in the arid zone is quite frequent causing severe famines. A Marwari proverb tells us to expect one lean year in three and one famine year in eight. In the desert areas (of Rajasthan) one year in five and in semi-arid area one year in eight may be expected to be of large defect (Pramanik, *l.c.*).

Different explanations have been given for the scanty rainfall in the arid zone (Pramanik, 1952; Datta & George, 1964; Bryson & Baerreis, 1967; Krishnan, 1968). It is mainly attributed (1) to the inaccessibility of the area to either of the two branches of the Indian south-west monsoon viz., the Bay of Bengal branch and the Arabian Sea branch, except for a shallow layer. The reason put forward for this is that the areas are within the anticyclonic circulation where there is a dry subsiding air (2) to the presence of large scale dust in the air over the area, the principal effect of which is to deplete the incoming solar radiation by scattering. In the absence of dust there would be less radiational cooling in the atmosphere. This would mean there would be less of subsiding air, as a consequence of which there will be more ascending air and rainfall, because the moisture is already there. The reason why the monsoon water vapour cannot be converted into rain is the lack of lifting agent to cool water vapour to its condensation level.

Temperature

A characteristic feature of the arid zone is the great extremes of temperature with cold winters and very hot summers. In winter the temperature falls at many places below the freezing point and frost occurs. On the other hand, the heat during the summers is very intense and scorching, the desertic tract in western India is the hottest region of India. As a consequence of high temperature, coupled with low rainfall, evaporation far exceeds precipitation with the result there is little moisture to support vegetation.

Temperature starts rising by the middle of March and the hot season prevails during the period April to June. May is generally the hottest month of the year, though very high temperature prevails also in June. The mean maximum temperature in May ranges from 105°-108° F over most parts of Rajasthan with the mean minima at 75°-80° F. On account of the dryness of the atmosphere, clear skies and sandy nature of soil there is a rapid radiation of heat from the earth soon after sunset, with the result the heat of the day rapidly dies down and the temperature at night is considerably lowered. The day temperature shoots up considerably above normal in association with hot waves which generally develop in North India during the summer months. Occasional dust storms bring about a sudden fall in temperature and some of the dust storms of the season culminate in rain, which brings welcome relief from the scorching heat (Pramanik Hariharan, 1952)

The weather cools down with the onset of the monsoon showers. But the northern portion of the desert still continues to be hot, though less than before, and temperatures as high as 115^{0}F have sometimes been experienced even in July. A short second spell of hot season is not uncommon after the withdrawal of monsoon by the second weak of September and this may extend up to the middle of October. The weather then gradually starts cooling and the cold season commences in December (Pramanik & Hariharan, *l.c.*)

The period December to February constitutes the cold season, January being the coldest month of the year. The temperature falls at many places below freezing point and frost occurs.

The exteme variation in temperature gradually converts the rocks, which are subjected expansion and contraction into loose sandy soil which remains uncovered as there is no water or humus to cap it with vegetation initially. Any elevation of land in the desert region is, therefore, shattered and levelled in time. During the dry season the vegetation is subjected to great stress owing to its higher water requirements.

Humidity

Relative humidity is minimum in the summer months of March, April and May and maximum during the monsoon months viz. July, August and September. It is lowest in April and highest in August. During the hot season humidity is in general 35% to 60% in the morning hours and 10% to 30% in the afternoon hours if the values for June are excluded (Pramanik & Hariharan, *l.c.*). In the monsoon season, July to September, there is a marked increase in humidity. But the increase is much less marked in the areas to the west and north-west than in the rest of Rajasthan. Relative humidity during the cold season, December to January, is generally 50% to 60% in the morning hours and 25% to 35% in the afternoon hours (Pramanik & Hariharan, *l.c.*).

Winds

Winds from the south-west or west are more frequent throughout the year in the arid zone, being strongest in June (12.3-31.0 km/hr) and lightest in November (4.0-5.8 Km/hr). They are generally stronger over western desert. In the hot season and during the monsoon, winds are generally between south-west and west. Hot and dust-raising winds are experienced frequently in western Rajasthan during summer. North-westerly and northerly winds are more frequent than those from the conventional directions during the cold weather period and they are generally light and variable. During monsoon, rainfall is often associated with easterly winds. The maximum velocity of wind in the arid tract is of the order of 135 km per hour except in such short-lived and highly localised accidents as tornadoes or severe thunder-squalls (Pramanik & Hariharan, *l.c.*).

These winds complete the work of disintegration and soil erosion. During the hot weather season, with the temperature and evaporation rate high, the strong winds prevalent during this season have a desiccating effect on vegetation. Dry and warm winds effect both the water expenditure from the plant and the physical evaporation from the soil surface.

Dust-storms

Most dust storms occur in north Rajputana than in the south. Denoting south Rajputana by S.R. and north Rajputana by N.R. the number of days of dust storms, based on 30 years' observation is as follows (Banerjee, 1952): Jan. (0), Feb. (S.R. 0; N.R. 1-2), March (S.R. 0.1-1; N.R. 1-4), April (S.R. 0.1-2; N.R. 1-4), May (S.R. 0.1-1; N.R. 1-4), June (S.R. 1-3; N.R. 2-10), July (S.R. 0.1-1; N.R. 1-4); Aug. (S.R. 0.1-1; N.R. 1-2), Sept. (S.R. 0.1-1; N.R. 0.1-1), Oct. (S.R. 0; N.R. 0.1-1); Nov. (0), Dec. (Central part 0.1-1; rest 0).

From the above it will be seen that the highest dust-rainsing winds occur in the hottest months : April, May, June and July (the maximum number of dust storms being in June). After the rains have settled down the sand in the desert there are practically no dust storms; thus October, November, December and January are almost free of dust storms (Banerjee, *l.c.*).

Fog

A few foggy days are reported during the cold season but in generaly they are far too uncommon.

PREVIOUS WORK :

Arid regions of Punjab and Haryana

The flora of the arid regions of Punjab and Haryana, along with the account of physiography, climate, geology soil and the vegetation types are included in the *Flora of the Punjab Plains* by Nair (1978). He has also briefly reviewed the previous work on the flora of the plains of Punjab and Haryana.

Rajasthan desert

Though local floras or lists of plants were available for several regions of India prior to the publication of the *Flora of British India* by Hooker (1872-1897), almost nothing was written for Rajasthan. Hooker & Thomson (1855) in their indroductory essay in *Flora Indica* observed that the vegetation of the plains of Marwar, which are continuous with the great sandy desert tract of Africa, is not known in detail. Even later, in the early part of the 20th century, floras or at least forest floras were published practically for all parts of India, except Rajasthan. This lacuna, however, was filled during the middle part of the century, particularly in the last 40 to 45 years.

King (1869) gave some information on the famine plants of Marwar and later published the *Sketch of the Flora of Rajputana* (King, 1879) which was the first scientific account of the flora of this region. A little later to King, in the years 1869-70, Brandis toured in the forests of Rajasthan and incorporated his observation in his *Forest Flora of North-west and Central India* (Brandis, 1874). This work of Brandis gives the general distribution of the forest species but not the precise localities where they occur. There is an undated, anonymous publication entitled *Introductory note to Jodhpur and Jaisalmer trees and plants*, the author of which is believed to be Miss Macadam and the year of publication is presumed to be 1890. In his book, *Western Rajaputana States*, Adams (1899) listed about 50 species of plants under the chapter "The Forest and Floras". In the chapter on Botany in the *Imperial Gazetteer of India*, Hooker (1907) made some reference to the plants of Rajputana.

The first comprehensive account on the plants of Rajasthan desert was by Blatter and Hallberg who published a series of papers between the years, 1918 and 1921 wherein they enumerated the plants, including several new taxa, from Jodhpur, Jaisalmer and Barmer districts and also described the vegetation and ecological formations there. Biswas (1952), Biswas & Rolla (1953), Sarup (1957 a), Mathuda (1958), Puri & Jain (1960, 1962 a), Joshi (1961), Vyas (1971) and Nathawat (1971) have dealt briefly with the vegetation of Rajasthan. Rolla and Kanodia (1962-1963) gave an account of the vegetation and flora of Jodhpur Division, which includes Jaisalmer, Barmer, Jodhpur and Nagaur districts. Kanodia & Gupta (1969) dealt with the sand dune flora of western Rajasthan. Lists of plants of the different desert regions of western Rajasthan were published by Ramachandra Rao (1941), Sankhala (1951) & Sarup (1951, 1954, 1957 b, 1958 a). Tandon (1958) & Bhimaya *et al.* (1964) studied the vegetation of Ladnun in Nagaur district and Kailana in Jodhpur district respectively. Singh *et al.*, (1976-77) gave an account of the plants of Luni development block in Jodhpur district. Many contributions have been made towards the flora of arid parts of Jhunjhunu district, particularly Pilani, Chirawa, Jhunjhunu, Mandrela and their neighbourhood (Mulay and Ratnam, 1950; Bakshi, 1954; Nair, 1956, 1961; Nair & Natawat, 1956; Nair & Joshi, 1957; Joshi, 1956 a, 1958). Composition of some scrub communities of Churu was studied by Sharma (1962, 1965) and contribution to the botany of Ganganagar district were made by Dhillon & Bajwa (1972) and Dawre *et al.* (1981). Check-list of plants of Pali district has been published by Pandey & Shetty (1984), of Jalor by Vyas *et al.* (1985), of Churu by Pandey *et al.* (1985), of Bikaner by Parmar *et al.* (1985) and of the Desert National Park in W. Rajasthan by Pandey *et al.* (1985).

Pandey *et al.* (1983) and Pandey & Shetty (1985) have provided lists of rare and threatened plants of Rajasthan.

Most of the floristic accounts mentioned above contain references to aquatic vegetation or plants. Sarup (1957 c, 1958c) however, made a special study of hydrophytes.

Sarup (1957 d, 1958 d, e) also studied the halophytes of the Indian Desert. Saxena and Gupta (1973) dealt with the vegetation of Parhbhadra salt basin.

Bhandari has published several papers, mostly relating to new plant records for north-west Indian desert and also on the identity, critical notes and nomenclature of desert plants (Bhandari 1954, 1962, 1963 a, b, 1964 a, b, 1965, 1967, 1971). Bhandari & Singh (1964) reported the occurrence of *Dactyliandra* Hook. f., a cucurbitaceous genus new to Indian Flora from Rajasthan and Kutch. Bhandari & Verdcourt (1972) dealt with the identity and nomenclature of two species of *Rhynchosia* described by Blatter and and Hallberg from western Rajasthan. Majumdar (1971) dealth with the nomenclature of a few plants reported from Rajasthan. New plant records for western Rajasthan have also been published by Nair & Deshpande (1960), Jain & Kotwal (1960), Raizada and Jain (1961), Jain (1963), Hingorani and Gaur (1965), Verma *et al.* (1965), Majumdar *et al.* (1969), Majumdar (1969), Dhillon & Bhandari(1974), Dawre *et al.* (1981), Shetty *et al.* (1982) and Pandey *et al.* (1983). A new species of *Lasiurus* from western Rajasthan was published by Satyanarayan and Shankaranarayan (1964). Another new species viz., *I. rajasthanensis* has been published by Bhandari & Sharma (1977). A taxonomic study of the genus *Indigofera* in Rajasthan was undertaken by Nair & Koshy (1963), of *Eragrostis* by Roy (1976), of *Cassia* by Singh (1976) and of *Ipomoea* by Johri (1984).

The first flora providing keys to the identification along with short descriptions for the species found in western Rajasthan was published by Puri *et al.* (1964). This has been critically reviewed by Gupta & Bhandari (1965). Later, Bhandari (1978) published the *Flora of the Indian Desert* which, however, covers only the districts of Jodhpur, Jaisalmer and Barmer. Very recently Shetty and Singh (1987, 1991 1993) have published three volumes of the *Flora of Rajasthan.*

The study of grasses, especially with particular reference to ecology of grasslands of arid and semi-arid regions and the grazing problems there, for obvious reasons, received considerable attention. Dabadghao, whose name is associated with most of the grassland survey and research in India, and his associates have contributed a number of papers on this aspect of the vegetation of Rajasthan (Dabadghao, 1957 a, b, 1958 a, b, 1960; Dabadghao & Shankarnarayan, 1973). The other papers on the grasslands dealing with the ecology, improvement of grasslands, grassland types, the grazing problems and the impact of grazing on vegetative cover of this region are by Mathuda (1957), Shah (1957), Satyanarayan (1958 a), Prakash & Nanda (1961), Aggarwal (1961), Das *et al.*, (1963, 1965), Prakash & Ahuja (1964), Shankaranarayan & Satyanarayan (1964), Das & Bhimaya (1964), Bhimaya *et al.* (1965, 1969), Gupta & Saxena (1966, 1970, 1971 c, 1972 a, b), Bhimaya (1967), Bhimaya & Ahuja (1967, 1968, 1969), Kaul (1968, 1977), Pandeya (1968, 1977), Nanda & Gupta (1968, 1977), Kaul & Gupta (1968, 1977), Kaul & Chakravarty (1968 a, b, 1977), Chakravarty (1964, 1968), Nanda (1969), Gupta (1971, 1975 a) etc. Gupta (1966 a) gave a general account of the distribution of grasses in various habitats and described the characteristics of some grass species for soil conservation in the arid regions of north-west India. An account of the grasses of the rangelands in arid Rajasthan with an enumeration of grasses found there was given by Gupta & Sharma (1971). A comprehensive account of range ecology and development in the Thar Desert has been given by Gupta (1975 a). Enumeration of grasses for smaller areas have been given by Ramachandran (1950) for Pilani, and Joshi and Sharma (1964, 1966) for certain areas in Jhunjhunu district. Kanondia and Nanda (1968) dealt with the genus *Aristida* in western Rajasthan. The monumental work of Bor (1960) includes information on the taxonomy of grasses of Rajasthan.

The weeds found in the arid zone have been enumerated by Blatter & Hallberg (*l.c.*), Sharma (1959, 1961) and Satyanarayan & Saxena (1966).

Chopra & Handa (1960) and Gupta *et al.* (1966) gave an account of the medicinal plants of the arid zones. King (1869), Gupta & Kanodia (1968) and Bhandari (1974, 1977) dealt with the vegetable products used as food during scarcity and famine periods in the dry regions of India. Vernacular names of the useful plants of north-west Indian arid regions have been given by Gupta and Dutta (1967). Gupta & Saxena (1968 a) and Gupta (1970) undertook a resource survey of two species of *Salvadora* (for non-edible oil) and gummiferous Acacias respectively, in western Rajasthan. Singh & Shetty (1977) dealth with the natural plant resources of western Rajasthan.

The biological spectrum of the Indian Desert flora was studied by Das & Sarup (1951). Barucha (1951, 1975a, 1975), Sarup (1952, 1953, 1955, 1958 b), Puri (1952), Biswas (1952), Ratnam & Joshi (1952), Biswas & Rolla (1953), Vyas (1955), Joshi (1956 b), Sarup & Vyas (1957, 1958), Sarup & Bhandari (1957, 1958), Ratnam & Ramdeo (1958), Satyanarayan (1958 b, 1963, 1964), Sarup & Puri (1960 a), Rolla & Kanodia (1962), Sen (1965, 1966), Shankaranarayan *et al.* (1965), Satyanarayan *et al.* (1966), Satyanarayan & Gaur (1967, 1968), Gaur & Satyanarayan (1967), Gupta & Sexena (1965, 1968 b, 1971 a, b, 1977), Joshi & Bansal (1968), Cherian & Bole (1971), Sexena (1972), Sharma (1972), Gupta & Sharma (1973) and Prakash & Gupta (1976) have dealt with ecological aspects of the desert areas of western India. A study of plant succession and climax vegetation in the dry parts of north-west India was undertaken by Meher-Homji

(1965 b). Gupta & Prakash (1975) have edited a book entitled *Environental Analysis of the Thar Desert.* Gupta (1975b) gave an account of the *'Plant life in the Thar'*. Bharucha (1955 b) reviewed the work on plant ecological research in the arid and semi-arid regions of Afghanistan, India and Pakistan. Sarup (1958 b) and Sarup & Bhandari (1957, 1958) reviewed the work on plant ecology of the Indian desert. Joshi and Gupta (1973) reviewed the work done on the ecology of the arid and semi-arid zones in India, bringing forth the varied aspects of the inter-relationship of vegetation and environment. A bibliography on the ecology (synecology and phytosociology) of arid and semi-arid regions of India was published by Gupta (1966 b). The National Symposium on Desert Ecology held in 1986 at Jaipur (Prakash, 1988) also covered the various aspects of desert ecology, highlighting the impact of man's activities on the desert ecosystem. Puri *et al.* (1989) in their *Forest Ecology* have given a detailed account of the various aspects of the desert vegetation of India.

Roy & Shetty (1980) and Chatterji & Saxena (1988) dealt with the impact of canal irrigation on the flora and ecology of W. Rajasthan.

Agharkar (1952) in his article on *"Plant ecology of the Rajputana desert"* gave a brief account of the vegetation and compared the floral composition of western Rajasthan with that of western (Arabia-African) and eastern (Indo-Malayan) regions, a subject which had earlier been discussed by Blatter & Hallberg (*l.c.*) and Biswas & Rolla (*l.c.*).

A brief account of pattern of plant distribution in Rajasthan was given by Mulay (1960). Barucha & Meher-Homji (1965) conducted investigations on the floristic elements of the semi-arid zones of India. Sharma (1965) dealt with some aspects of the phytogeography of Rajasthan, whereas Meher-Homji (1965 a, 1970), Meher-Homji & Misra (1973) and Meher-Homji & Bharucha (1975) have discussed it in greater detail. Singh (1978) undertook phytogeographical reassessment on the flora of Rajasthan. Bhandari (1988) while dealing with the *"Floral wealth and plant adaptations of the Indian desert"* also gave an account of its phytogeography. Bhandari & Sharma (1977) gave an account of the biogeography of the Indian desert. Majumdar (1975) gave a brief account of the origin, nature and economic aspects of the Rajasthan flora.

The vegetation types of Rajasthan have been described by Champion (1936). Sarup & Puri (1960 b), Mathur (1960) and Champion & Seth (1968), while Saxena (1972) dealth with the vegetation types of western Rajasthan. Gaussen *et al.* (1972) have published the vegetation map of Rajasthan.

Nair (1954), Bhimaya *et al.*, (1964) and Mulay & Joshi (1964) have given suggestion on the choice of species for afforestation of Rajasthan. Provenance trial in relation to tree introduction in arid lands was undertaken by Kaul (1965). Puri & Jain (1962 b) death with the botanical aspects of dry zone afforestation of in India.

Jain (1972, 1977) in his papers on the *"Floral composition of Rajasthan A review"* and Shetty & Pandey (1979) in their paper on *"Studies on the flora of Rajasthan A review"* gave the history of botanical exploration in Rajasthan, a synopsis of the floral composition and vegetation and a comprehensive bibliography.

Arid regions of Gujarat

Palin (1880) published a list of plants of Kutch district. Blatter (1908-1909) pointed out that of the 345 indigenous species (belonging to 74 families) enumerated by him from the Kutch district, 200 have their distribution extending to Sind. He also described in detail the xerophytic adaptations of some of the more common plants. Indraji Thakar (1926) wrote in Gujarati a detailed account of the economically important plants of the area and described 508 species, including some exotics. Kapadia (1954 a) gave a statistical synopsis of the flora of Kutch and also added about a dozen grass species to the flora (Kapadia 1954 b). Other additions were made by Jain (1960), Jain & Kanodia (1960), Jain & Deshpande (1960 a), Deshpande (1961), etc. The other contributions to the flora of Kutch are by Jain & Deshpande (1960 b), Kanodia & Nanda (1966), Jain (1968), Guha Bakshi (1969) and Rolla (1970), The total number of species found in the Kutch district is about 637 (Puri *et al.* 1959).

The flora for the entire state of Gujarat, including the arid regions, has been published by Shah (1978).

General

The climate of dry zones and the influence of climate on the flora and the vegetation of dry zones has been given in considerable detail by Shahbhag (1958), Raheja (1965), and Waheed Khan (1959). Meher-Homji (1977) dealth with the bioclimatic and vegetational aspects of the arid zones of India.

The soils and the vegetation in relation to soils have been studied by Krishnaswamy & Gupta (1952), Sarup & Dutt (1954), Ramdeo (1955), Bharucha (1960), Verma (1964) & Sharma (1967, 1968). Aireal-photo analysis of plant communities in relation to edaphic factors in the arid zone of western Rajasthan was undertaken by Gupta and Abichandani (1968).

VEGETATION

As might be expected from its geographic position and limited rainfall, the flora of western Rajasthan is not rich. The vegetation is sparce and the number of species are limited. The area under forest is negligible, being only 0.69 percent.

There are three ecological zones in W. Rajasthan, viz. 1. to the south and south east of the region near the Aravalli hills, but not strictly in the desert. Near the base of the Aravallis the soil is good and supports what would, for western Rajasthan, be comparatively luxuriant vegetation, were it not ruthlessly destroyed by local people for fuel and fodder. 2. Semi-arid region about 160 km parallel to the first region where plants of the xerophytic type are found. 3. The arid region to the extreme north and west of the region where the vegetation types of W. Rajasthan as "formations" which are exclusively controlled by adaphic factors. The five habitats distinguished by them are: 1. Aquatic, 2. Sand, 3. Gravel, 4. Rock and 5. Ruderal. Biswas & Rolla (1953), taking into consideration the edaphic factors against the general poor rainfall, classified the desert vegetation as 1. Sand community (Psammophytic), 2. Gravel community and 3. Rock community. Based on physiographic factors, Mulay & Joshi (1964) recognised four main ecosystems in Rajasthan namely, 1. Rocky areas, 2. Aquatic and marshy areas, 3. Saline areas and 4. Sandy plains and dune areas. Similar classification has been adopted by Saxena (1972) who showed that there are seven ecosystems in W. Rajasthan viz., 1. Hills and rock outcrops, 2. Piedmont slopes, 3. Alluvial plains, 4. Saline flats and depressions, 5. Graded river beds, 6. Sand dunes and 7. Aquatic areas. These have further been sub-divided by him, depending upon the features of the environment and the vegetation. In a later publication (Saxena, 1977), he recognised six formations in the Indian desert namely 1. The mixed xeromorphic thorn desert, 2. The mixed xeromorphic woodland, 3. the mixed xeromorphic riverine thorn forest, 4. the lithophytic scrub desert, 5. the psammophytic scrub desert and 6. the halophytic scrub desert. Mathur (1960) enumerated seven types of vegetation from Rajasthan of which one type, namely tropical thorn forest is from W. Rajasthan. Based on the classification of Champion & Seth (1968) in their *Revised Survey of Forest Types of India*, the following types of vegetation can be recognised from W. Rajasthan (under the sub-group, 6B, - Northern tropical thorn forests) : 1. Desert thorn forest (6 B/C 1), 2. *Ziziphus* scrub(6 B/DS 1), 3. Tropical *Euphorbia* scrub (6 B/D S 2), 4. *Euphorbia* scrub (6/E 1), 5. *Acacia senegal* forest (6/E 2), 6. *Salvadora* scrub (6/E 4), 7. *Cassia auriculata* scrub (6/E 4/DS 1) and 8. Desert dune scrub (6/IS 1).

Based on the edaphic factors, the vegetation of the western Rajasthan desert may conveniently be treated under the following heads :

1. Sand-dunes and interdunal areas

2. Sandy and hummocky plains

3. Gravelly/rocky plains

4. Isolated hills and rock outcrops

5. Saline habitats

6. River beds

7. Marshy/aquatic habitats

8. Weeds of cultivated and fallow fields

1. **Sand-dunes and interdunal areas :** The most spectacular amongst the land-forms in the Indian desert are the sand-dunes and about 58% of western Rajasthan is covered with dunes of different types, magnitude and orientation. They may be stabilised, partially stabilised or unstabilsed and barren. Two types of dune complexes have been recognised here viz., free dunes and obstacle dunes, and under the former there are four distinct types viz., 1. coalesced parabolic, 2. longitudinal, 3. transverse and 4. barchan (Saxena, 1972).

The common shrubs or small trees found on stablished and partially stabilsed dunes are *Calligonum polygonoides Calotropis procera* subsp. *hamiltonii Capparis decidua Clerodendrum phlomidis*., *Haloxylon salicornicum* and *Lycium barbatum*. On some of the dunes trees like *Acacia senegal*., *Prosopis cineraria* and *Salvadora oleoides* are also common. The other common inhabitants of sand-dunes include *Aerva javanica, Citrullus colocynthis, Crotalaria burhia, Dipterygium glaucum, Farsetia hamiltonii, Indigofera argenta, I. cordifolia, I. linifolia, Leptadenia pyrotechnica, Melhania denhamii, Sericostoma pauciflorum, Tephrosia falciformis, Tribulus pentandrus* var. *macropterus*, etc. The root parasite, *Cistanche tubulosa* is also fairly common. The common grasses and sedges which play an important role in binding the sand are *Aristida adscenscionis, A. funiculata, A. hirtigluma, Cenchrus biflorus, C. ciliaris, C. prieurii, C. setigerus, Cymbopogon jwarancusa, C. schoenanthus, Dactyloctenium aegyptiacum, D. scindicum, Desmostachya bipinnata, Eleusine compressa, Eragrostis ciliaris, E. diarrhena, E. tenella, E. tremula, Lasiurus sindicus, Latipes senegalensis, Panicum antidotale, P. turgidum, Sporobolus helvolus, Cyperus arenarius* Retz. and *C. conglomeratus*.

The base of the dunes and the interdunal gaps support more luxuriant vegetation due to greater availability of moisture. The common trees and shrubs encountered here, are *Acacia jacquemontii, A. senegal, Prosopis cineraria, Salvadora oleoides, Tecomella undulata, Capparis decidua, Aerva javanica, Calatropis procera*. subsp. *hamiltonii, Calligonum polygonoides, Ziziphus nummularia*, etc. with *Citrullus colocynthis* as the common creeper. In addtion, almost all the plants found on the sand-dunes grow more profusely in the interdunal areas. It is also of interest to note that *Prosopis juliflora*, a native of Mexico, is found naturalised in this habitat, particularly in interdunal areas at several places.

At the foot of the isolated hills and rock outcrops, the windward sides which obstruct the movement of sand, obstacle dunes are often formed. The stabilisation here is quicker due to the large amount of water down the hills. On these dunes a mixture of elements of the sand-dunes and the rock outcrops are found. *Acacia senegal* and *Salvadora oleoides* are usually the dominant are species. The other common plants associated with them are *Anogeissus pendula.*, *Balanites aegyptiaca*, *Capparis decidua*, *Commiphora wightii*, *Grewia tenax*, *Maytenus emarginatus*, *Aerva javanica*, *Calligonmum polygonoides*, *Leptadenia pyrotechnica*, *Ziziphus nummularia*, *Crotalaria burhia*, etc. Among climbers, *Cocculus pendulus* is common, whereas *Ephedra ciliata*, the only gymnosperm found in the Rajasthan desert, is occasionally met with.

The unstabilised dunes are least covered with vegetation. The following are some of the pioneer species to colonise these dunes: *Cyperus arenarius*, *Cenchrus biflorus*, *Crotalaria burhia*, *Aerva javanica*, *Calotropis procera* subsp. *hamiltonii*, *Leptadenia pyrotechnica* and *Citrullus colocynthis*.

2. **Sandy and hummocky plains :** These constitute the major part of the desert landscape, the most notable being the Haryana-Punjab sector, Bikaner (in part), Jaisalmer and Barmer districts of Rajasthan and north Gujarat. The broad landform units are old and young alluvial plains. The old alluvial plain is most extensive in central Rajasthan, with flat topography, and with a hummocky surface in some areas due to wind action.

The common trees and shrubs found here are Acacia senegal, *Calligonum polygonoides*, *Calotropis procera* subsp. *hamiltonii*, *Capparis decidua*, *Prosopis cineraria*, *Salvadora oleoides*, *S. persica*, *Tecomella undulata* and *Ziziphus nummularia*. As one goes towards the western border *Salvadora oleoides* becomes more and more common. Undershrubs and herbs commonly met with are *Aerva javanica*, *Arnebia hispidissima*, *Crotalaria burhia*, *Farsetia hamiltonii*, *Heliotropium strigosum*, *Indigofera cordifolia*, *Leptadenia pyrotechnica*, *Polygala erioptera*, *Tephrosia purpurea* etc. The most common creeper is *Citrullus colocynthis*, the other creepers found being *Citrullus lanatus*, *Cucumis melo* var. *culta*, *C. prophetarum* etc. Climbers are represented by *Coccinia grandis*, *Momordica dioica*, *Melothria maderaspatana* and *Pergularia daemia*. *Ephedra ciliata* is also rarely met with. Grasses frequently found are *Aristida adscensionis*, *A. hirtigluma*, *Cenchrus biflorus*, *C. ciliaris*, *C. setigerus*, *Dactyloctenium scindicum*, *Eleusine commpressa*, *Lasiurus sindicus* and *Panicum antidotale* Among sedges, the most common ones are *Cyperus arenarius* and *C. conglomeratus*.

3. **Gravelly/rocky plains :** The sorting action of the wind by which sand particles are lifted and deposited on the dunes results in the formation of gravelly plains. The surface of the soil here is strewn with gravel and stones. In Nagaur, Bap, Phalodi, Jodhpur, Jaisalmer, Pali, Jalor and Bikaner areas such gravelly plains are extensively present. Rocky plains strewn with stones are also found adjacent to the hills. But for the biotic pressure these lands would have supported some stands of hardy species; but today they are almost devoid of any vegetation cover. In such areas trees and shrubs like *Prosopis cineraria*, *Salvadora oleoides*,

Capparis decidua, Maytenus emarginatus, Calotropis procera subsp. *hamiltonii* and *Ziziphus nummularia* are found scattered. The other plants met with are *Anticharis senegalensis, Blepharis linariaefolia, Boerhaavia diffusa, Cleome brachycarpa, C. viscosa, C. scaposa, Corchorus depressus, Dipteracanthus petulus* var. *alba, Fagonia schweinfurthii, Heliotropium strigosum, Leptadenia pyrotechnica, Limeum indicum, Monsonia senegalensis, Odontanthera varians, Salvia aegyptiaca, Seddera latifolia, Tephrosia purpurea* etc. Certain plants of gravel are prostrate and star-like with branches adpressed to the ground e.g. *Euphorbia clarkeana, E. granulata, Indigofera cordifolia, I. hochstetteri, Mollugo cerviana, M. nudicaulis* and *Tribulus terrestris.* The parasite, *Striga angustifolia* mostly attacks grasses in gravelly habitats. At certain places, the gravel plains support characteristic grass-legume associations. The common grasses are *Enneapogon brachystachyus, E. elegans, Melanocenchris abyssinica, M. jacquemontii, Oropetium thomaeum, Tragus roxburghii* etc.

4. Isolated hills and Rock outcrops : Many isolated hills of low elevation, rocky ridges and rock outcrops of various origin are situated in the region to the west of Aravallis, the important rocky areas in western Rajasthan being 1. Jaisalmer plateau and outliers composed of limestone of Jurrasic age overlying sandstone and hardly exceeding 30 metres, 2. Barmer hills, chiefly of volcanic origin consisting of Malani Rhyolites and reaching considerable height, 3. Jalor hills of granite and Rhyolite and 4. Kailana-Jodhpur-Mandore plateau composed of Vindhyan sandstone, resting uncomfortably on the older Malani lavas and rising abrubtly from the plains, attaining considerable height. The rock outcrops in western Rajasthan however account only for about 13200 sq km. There are a few isolated hills in Rohtak, Hissar and Gurgaon, situated in the desert region of Haryana. Kutch is an undulating rocky area with many small hills. The vegetation here is very sparce and scanty.

The most characteristic rock plant or lithophyte is the cactiform *Euphorbia caducifolia* which forms thick shrubbaries supporting climbers like *Sarcostemma viminale.* Br. In addition, trees and shrubs like *Acacia senegal, Anogeissus pendula, Capparis decidua, Commiphora wightii, Grewia tenax, Maytenus emarginatus* are also encountered. The climbers present include *Abrus precatorius Commicarpus verticillatus, Cardiospermum helicacabum, Ipomoea sindica, Melothria maderaspatana, Rhynchosia minima* and *Rivea hypocrateriformis.* Undershrubs and herbs are represented by *Achyranthes aspera, Anticharis senegalensis, Barleria acanthoides, B. prionitis, Blepharis linariaefolia, Boerhaavia diffusa, Cleome brachycarpa, Corbichonia decumbens, Corchorus depressus, Dipteracanthus petulus* var. *alba, Fagonia schweinfurthi, Heliotropium bacciferum, Indigofera cordifolia, Lepidagathis trinervis, Lindenbergia indica, Pavonia zeylanica, Rostellularia vahlii, Schweinfurthia papilionaceae, Seddera latifolia, Sida cordata, Tephrosia purpurea, Tridax procumbens* etc. along with grasses like *Aristida adscensionis, A. hirtigluma, A. pogonoptila, Cymbopogon martini,* *Enneapogon brachystachyus, E. elegans, Melanocenchris jacquemontii, Oropetium thomaeum, Stipagrostis hirtigluma, Tragus roxburghii* etc.

The vegetation is comparatively more dense at the foot of the hills and nearby areas with *Acacia senegal* being the dominant tree species in such habitats.

5. Saline habitats : The salinity in the Rajasthan desert is widespread and extensive. The saline depressions (Playas) or lakes are scattered throughout Rajasthan, the well known ones being Pachpadra, Kuchaman and Didwana. The northern tip of the Rann of Kutch butts into Barmer and Jalore districts.

Mudflats make up most of the coastal areas near the Gulf of Kutch and a part of Kutch district the Great Rann and the Little Rann. These areas with halomorphic soils, dark grey to black in colour are inundated during the monsoon season. During summer a few millimetre thick white crust of salt is deposited, manifesting polygonal cracks.

The principal species in this type of habitat are *Chenopodium album, Cressa cretica, Haloxylon salicornicum, Limeum indicum, Peganum harmala* var. *stenophyllum, Peplidium maritimum, Portulaca oleracea, Pulicaria crispa, Salsola baryosma, Sesuvium sesuvioides, Solanum virginianum, Suaeda fruticosa, Trianthema portulacastrum, T. triquetra* and *Zygophyllum simplex*. The notable grasses and sedges here are *Aleuropus lagopoides, Dactyloctenium aegyptium, Eleusine compressa, Eragrostis ciliaris, E. diarrhena, E. minor, Sporobolus coromandelianus, S. marginatus, Cyperus arenarius* and *C. rotundus*

At the periphery of the halophytic zone, stunted but gregarious growth of *Tamarix indica* and *T. dioica*, along with *Calotropis procera* subsp. *hamiltonii, Capparis decidua, Acacia nilotica* subsp. *indica, Salvadora oleoides, S. persica* and *Prosopis juliflora* are met with.

The Rann of Kutch is a vast expanse of mud flats inundated by sea during the monsoon and rich in soluble salts. On mud flats *Arthocnemon indicum, Peplidium maritimum, Salicornia brachiaria, Salvadora persica* (bushes), *Sesuvium portulacastrum, Suaeda fruticosa, S. maritima* and *S. nudiflora* are present, some of them scattered or in small or large patches. A little interior where the soil is less sandy and saline, species like *Capparis decidua, Lycium barbatum, Salvadora persica, Alhagi maurorum, Atriplex stocksii, Cassia italica, Corchorus depressus, Cressa cretica, Indigofera oblongifolia, Juncus maritimus, Malachra capitata* and *Trianthema triquetra*, along with sedges and grasses like *Cyperus bulbosus, Fimbristylis cymosa, Scirpus tuberosus, Aleuropus lagopoides, Cenchrus biflorus, Chloris villosa, Diplachne fusca, Sporobolus maderaspatenus* and *Urochondra setulosa* are found occurring in small or large, pure or mixed colonies (Shah, 1978).

6. **River beds** : The river Luni, which is the only river of significance in western Rajasthan, and its tributaries like Mitri and Sukari carry water for a short duration during the monsoon period. For the rest of the period they remain dry. On the dry river beds of coarse gravelly sand *Tamarix ericoides* is very common and at times forms a homogeneous community. The other common plants found are *Amaranthus hybridus* subsp. *cruentus* var. *paniculatus*, *Ammania baccifera*, *Argemone mexicana*, *Echinops echinatus*, *Eclipta prostrata*, *Launaea procumbens*, *Phyla nodiflora*, *Polygonum glabrum*, *Portulaca oleracea*, *Potentilla supina*, *Pulicaria crispa* etc. The notable grasses and sedges include *Dactyloctenium aegyptium*, *Desmostachya bipinnata*, *Eragrostis ciliaris*, *E. minor*, *Polypogon monspeliensis*, *Cyperus rotundus*, *Scirpus roylei* and *S. supinus*. The common trees and shrubs found along the margins of river beds are *Cordia gharaf*, *Prosopis juliflora*, *Salvadora oleoides*, *S. persica*, *Tamarix indica* etc.

7. **Marshy/aquatic habitats** : In tanks and water reservoirs in western Rajasthan which are generally surrounded by hillocks, rain water collects. Dipressional areas formed on low-land also get filled with water during the rainy season. In the moist areas near ponds, tanks, lakes, streams and dam sites, where the soil is rather clayey, there is luxuriant growth of plants like *Alternanthera sessilis*, *Ammania baccifera*, *A. desertorum*, *Bacopa monnieri*, *Bergia ammaniodes*, *Caesulia axillaris*, *Coldenia procumbens*, *Dentella repens*, *Eclipta prostrata*, *Enicostema axillare*, *Glinus lotoides*, *Gnephalium polycaulon*, *G. luteo-ablum*, *Grangea maderaspatna*, *Heliotropium ovalifolium*, *H. supinum*, *Peplidium maritimum*, *Phyla nodiflora*, *Polygonum plebejum*, *Potentilla supina*, *Pulicaria crispa*, *Typha angustata*, *Vahlia digyna*, *Veronica anagallis-aquatica* etc. Among the common sedges and grasses mention may be made of *Cyperus iria*, *C. rotundus*, *Fimbristylis dichotoma*, *Scirpus roylei*, *S. supinus*, *S. tuberosus*, *Dichanthium annulatum*, *D. pertusum*, *Eragrostis diarrhena*, *Echinocloa colona*, *E. crus-galli*, *Polypogon monspeliensis*, *Saccharum spontaneum*, *Sehima nervosum* and *Vetiveria zizanioides*.

Tanks and reservoirs retaining water throughout the year support aquatic plants like *Ceratophyllum demersum*, *Hydrilla verticillata*, *Ipomoea aquatica*, *Lemna perpusilla*, *Najas graminea*, *Nelumbo nucifera*, *Nymphaea pubescens*, *N. nouchali*, *Potomogeton nodosus*, *P. pectinatus*, *Spirodila polyrhiza*, *Trapa bispinosa*, *Vallisneria spiralis* var. *densesserulata*, *Wolffia arrhiza* etc. In certain ponds and lakes *Eichhornia crassipes* is also encountered.

a. Weeds of cultivated and fallow fields

The large number of weeds found in the cultivated and fallow fields and wastelands include *Abutilon indicum*, *Arnebia hispidissima*, *Alhagi maurorum*, *Anagallis arvensis*, *Aeschynomene indica*, *Asphodelus tenuifolius*, *Boerhaavia diffusa*, *Cassia italica* subsp. *micrantha*, *Celosia argentea*, *Corchorus aestuans*

C. olitorius, *C. tridens*, *Datura fastuosa*, *Digera muricata*, *Echinops echinatus*, *Euphorbia dracunculoides*, *E. hirta*, *Fumaria indica*, *Gisekia pharnaceoides.*, *Heliotropium strigosum*, *Indigofera cordifolia*, *I. linifolia*, *I. linnaei*, *Leucas cephalotes*, *Melilotus alba*, *M. indica*, *Mollugo cerviana*, *Phyllanthus maderaspatensis*, *Polycarpaea corymbosa*, *Pulicaria angustifolia*, *Rumex dentatus* subsp. *klotzschianus*, *Trianthema portulacastrum*, *Trigonella corniculata*, T. *occulta*, *Verbascum chinense*, *Withania somnifera*, *Xanthium strumarium*, etc. The common sedges and grasses found are *Cyperus laevigatus*, *C. rotundus*, *Aristida* spp., *Cenchrus* spp., *Cynodon dactylon*, *Eragrostis* spp., *Polypogon monspeliensis* etc.

FLORAL COMPOSITION

The total Angiosperm flora of W. Rajasthan, including both indigenous and naturalised plants, comprises of about 775 species and 48 varities, belonging to 384 generra under 90 families. The following table (Table 2) gives number of families, genera and species under Dicotyledons,. Monocotyledons and Gymnosperms.

TABLE 2

STATISTICAL SYNOPSIS OF THE FLORA

	Families		Genera		Species	
	No.	%	No.	%	No.	%
Dicotyledons	76	83.52	301	78.20	588	75.87
Monocotyledons	14	15.38	83	21.55	186	24.00
Gymnosperms	1	1.10	1	0.25	1	0.13
	91	100.00	385	100.00	775	100.00

The families with 16 or more species are as follows :

1.	Poaceae (Gramineae)	125 spp.	(56 genera)
2.	Fabaceae (Leguminosae)	80 spp.	(30 genera)
3.	Asteraceae (Compositae)	49 spp.	(35 genera)

4.	Convolvulaceae	38 spp.	(9 genera)
5.	Cyperaceae	32 spp.	(6 genera)
6.	Malvaceae	29 spp.	(9 genera)
7.	Acanthaceae	26 spp.	(14 genera)
8.	Euphorbiaceae	24 spp.	(7 genera)
9.	Boraginaceae	22 spp.	(9 genera)
10.	Cucurbitaceae	21 spp.	(11 genera)
11.	Amaranthaceae	19 spp.	(9 genera)
12.	Scrophulariaceae	16 spp.	(13 genera)
13.	Solanaceae	16 spp.	(6 genera)
14.	Tiliaceae	16 spp.	(3 genera)

The following families have 8 or more genera

1.	Poaceae (Gramineae)	56 genera	(125 spp.)
2.	Asteraceae (Compositae)	35 genera	(49 spp.)
3.	Fabaceae (Leguminosae)	30 genera	(80 spp.)
4.	Acanthaceae	14 genera	(26 spp.)
5.	Scrophulariaceae	13 genera	(16 spp.)
6.	Cururbitaceae	11 genera	(21 spp.)
7.	Asclepiadaceae	10 genera	(11 spp.)
8.	Convolvulaceae	9 genera	(38 spp.)
9.	Malvaceae	9 genera	(29 spp.)
10.	Boraginaceae	9 genera	(22 spp.)
11.	Amaranthaceae	9 genera	(19 spp.)
12.	Caryophyllaceae	8 genera	(8 spp.)

The genera with 6 or more species are as follows :

Ipomoea L. (17 spp.), *Cyperus* L. (17 spp.), *Indigofera* L. (14 spp.), *Heliotropium* L. (14 spp.), *Tephrosia* Pers. (12 spp.), *Euphorbia* L. (12 spp.), *Eragrostis* P. Beauv. (12 spp.), *Aristida* L. (11 spp.), *Convolvulus* L. (9 spp.), *Corchorus* L. (8 spp.), *Alysicarpus* Neck. ex Desv. (8 spp.), *Amaranthus* L. (8 spp.), *Sida* L. (7 spp.), *Cassia* L. (7 spp.), *Fimbristylis* Vahl (7 spp.), *Abutilon* Miller (6 spp.), *Hibiscus* L. (6 spp.), *Ziziphus* Miller, (6 spp.), *Solanum* L. (6 spp.), *Chloris* Sw. (6 spp.), *Digitaria* Haller (6 spp.) and *Sporobolus* R. Br. (6 spp.).

Except for Poaceae and Cyperacae with 125 and 32 species respectively, the Monocotyledons are poorly represented. The remaining 29 species belong to 12 different families. The ratio of the total number of genera to species is 1: 2.01 which is rather low in comparison to the corresponding ratio for the whole of India which is estimated to be about 1: 7, but it is more or less comparable to the ratio for north Gujarat (1: 1.83, Saxton, 1922). There is a general resemblance between the flora of W. Rajasthan and that of N. Gujarat as far as the dominant families are concerned, the first and second positions being occupied by Poaceae and Fabaceae (Leguminosae) respectively. Cyperaceae, however, is more dominant in N. Gujarat when compared to W. Rajasthan.

ENDEMIC TAXA

The Great Indian Desert lies in the zone of poor endemism, as the area is not 'isolated' The endemic taxa reported from the Rajasthan desert are :

Farsetia macrantha Blatter & Hallberg

Cleome gynandra L. var. *nana* (Blatter & Hallberg) Bhandari

Abutilon bidentatum Hochst. ex A. Rich. var. *major* (Blatter & Hallberg) Bhandari

A. fruticosum Guill. & Perr. var. *chrysocarpa* Blatter & Hallberg

Pavonia arabica Hochst & Steudel ex Boiss. var. *glutinosa* Blatter & Hallberg

P. arabica Hochst. & Steudel ex Boiss. var. *massuriensis* Bhandari

Ziziphus truncata Blatter & Hallberg

Alysicarpus monilifer (L.) DC. var. *venosa* Blatter & Hallberg

Anogeissus sericea Brandis var. *nummularia* King ex Duthie (Endemic to W. Rajasthan, Panjab & Gujarat)

Pulicaria rajputanae Blatter & Hallberg

Convolvulus auricomus (A. Rich.) handari var. *ferruginosus* Bhandari

C. blatteri Bhandari

Ipomea cairica (L.) Sweet var. *semine-glabra* (Blatter & Hallberg) Bhandari

Anticharis glandulosa Asch. var. *caerulea* Blatter & Hallberg ex Santapau

Barleria prionoites L. var. *dicantha* Blatter & Hallberg

Aristida royleana Trin. & Rupr.

Cenchrus prieurii (Kunth) Maire var. *scabra* Bhandari

C. rajasthanesis Kanodia & Nanda

Chloris quinquesetica Bhide

Digitaria pennata (Hochst.) T. Cooke var. *shettyana* Pandey *et al.*

Lasturus ecaudatus Saty. & Shank.

L. sindicus Henr.

PHYTOGEOGRAPHY

The Sudano-Zambezian Region in the African Subkingdom under the Paleotropical Kingdom of Takhtajan (1988) includes the huge area from the Atlantic coasts of southern Mauritania, Senegal, and northeastern Guinea to the Sudan Republic (including a greater part of it), northeastern and eastern tropical Africa, the island of Socotra, tropical parts of the Arbabian Peninsula, and tropical deserts of Iran, Pakistan and northewstern India. The Sind Province, one of the Provinces under the Omano-Sindian Subregion of Sudano-Zambezian Region comprises the Province of Sind in Pakistan, the plains of Punjab in Pakistan and India, the Thar Desert, Haryana, western Rajasthan and northern Gujarat (Takhtajan, *l.c.*).

The pioneering work of Hooker and Thomson (1855) dividing India into floristic provinces was continued further by Clarke (1898) who included Rajputana in his subsubarea, "India Deserta" which coincides roughly with the "Indus Plain Region" of Hooker (1906), Calder (1937) and Chatterjee (1939). Agharkar (1952) regarded the flora of Rajputana desert as a mixture of western (Arabia-African), eastern (Indo-Malayan) and general (Indian and widely distributed) elements. He also observed that they are found in varying proportions in different parts, the western elements being more common in the west.

Blatter & Hallberg (1918-21) recorded the following 13 geographical elements in the flora of the Indian desert, under three well marked elements viz., 1) Western element, 2) Eastern element and 3) General element.

I) Western element :
1. North African Indian desert element
2. Tropical and north African Indian desert element
3. Tropical African element
4. Oriental element
5. Mediterranean element

II) Eastern element :
6. Indo-Malayan element

III) General element :
7. Endemic element
8. Indian element
9. Element of the tropics
10. Element of the tropics of the Old World
11. Element of warm countries
12. Element of tropical and subtropical regions
13. Cosmopolitan element.

The area included under north African-Indian desert element (Sahara, Arabia (except the south), Mesopotamia, Persia and northwest India) by Blatter *et al.* (1929) and Good (1947) corresponds to the "Saharo-Sindian" element of Eig (1931, 1939). The tropical and north African-Indian desert element also known as North African steppe element is designated as "Sudano-Deccanian" element by Eig (*l.c.*). Meher-Homji (1965a, 1970) and Meher-Homji and Misra (1973) have arguments against the use of the term "Sudano-Deccanian" element suggesting that it would be more appropriate to call it "Sudano-Rajasthanian" on bio-climatic grounds.

Blatter & Hallberg (*l.c.*) showed the ratio of the eastern Indo-Malayan element (27 species) to the western element (180 species) for the Indian desert to be 1: 7. These ratios indicate that western Rajasthan is perhaps the meeting ground of the two elements. On the basis of this finding they confirmed Drude's (1890, 1913) line between the Indo-Malayan flora and the Perso-Arabian flora (western element) from the Gulf of Cambay northwards along the Aravallis. This demarcation was later supported by Biswas and Rolla (1953). In eastern Rajasthan and Delhi the western element though predominating (Maheshwari 1963; Ratnam 1951, Nair & Nathawat 1957; Nair & Kanodia 1959; Vyas 1962), the ratio of eastern to western element is lesser than in western Rajasthan (about 1: 3 in eastern Rajasthan and Delhi as against 1:7 in western Rajasthan). Referring to Drude's line of demarcation, Nair and Kanodia (*l.c.*) and Vyas (1962, 1964, 1967) argued that the demarcation point between the Indo-Malayan and Perso-Arabia flora should be where these mingle in equal proportions and therefore, they proposed a shift in the line of demarcation further eastwards, even beyond the limits of Rajasthan where the western element is no longer dominant. Studies undertaken by Singh (1978) also support this view.

Legris & Meher-Homji (1968, 1975), Meher-Homji (1970) and Meher-Homji & Bharucha (1975) evaluated the floristic elements according to vegetation types ('series' of vegetation) and recognised two series of vegetation from the desert region viz., a) *Calligonum polygonoides* series in the Thar and b) *Salvadora oleoides-Prosopis cineraria* series in western Rajasthan and Kutch. They found that the western elements (Indus Plain, Saharo-Sindian, Sudano-Rajasthanian, Tropical Indo-African and Mediterranean) are well represented in these two series. The combined contribution of the three elements, Indus Plain, Saharo-Sindian and Sharao-Rajasthanian is 42% (17 species) in the *Calligonum* series and 41% (53 species) in *Salvadora-Prosopis* series. Then their strength decreases in two directions viz., eastwards and southwards. Mediterranean elements (with 3 species in both the series) are poorly represented. The pantropical element and the "element of the warm countries" are on the whole well distributed. The Indo-Malayan element is little represented-5% (2 species) in the *Calligonum* series and 8% (10 species) in *Salvadora-Prosopis* series (Meher-Homji & Misra, 1973). The 'Indian element' also according to Meher-Homji and Misra (*l.c.*) is poorly represented in the above series and the 'temperate element' is practically non-existent.

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5.7. NORTHERN WESTERN GHATS AND NORTHERN WEST COAST

(S. Karthikeyan)

The west coast runs for about 1600 km and borders the Arabian sea. It is limited by Cambay in the North and by Kanyakumari in the South. The coastal region situated between Goa and Tapi basin being the North-west coast is considered here. It is about 800 km long and 10-25 km wide. It is also known as 'Konkan' The N.W. coast in the north ends in two peninsulas, viz., Kutch and Kathiawar. The coastline towards the south may be classified as Konkan coast, Karnataka coast and Kerala coast; the whole of Konkan coast is dealt with here.

Some important landmarks on this coast are Goa, Vengurla, Malwan, Ratnagiri, Alibag, Bombay, Thana, Silvassa, Daman, Navasari, Surat, Cambay, etc.

The N.W. coast is fringed with sand dunes. The plains extending from east to west are fertile and thickly populated. South of the Bombay city, the rocky coast has a series of small bays and coves. Pure coral reefs and rocks full of corals and shells occur along the coast of Bombay.

The north-western ghats-which start below Tapti (Tapi) river mouth and run up to Goa, about 750 km in length form a narrow strip facing the Arabian sea lying almost parallel to the coast. They are popularly known as 'Sahyadris' in Maharashtra and lie between 15° 21' N and 73° 50' to 75° 50' E. The altitudes range between 300 1500 m above M.S.L. excluding high crests. Along the Sahyadris, isolated coinical, flat-topped hills occur with steep sides marked with distinct striations; in contrast, the ghats south of Amboli and Goa present rather gradual slopes, without striations.

Some of the major peaks in Sahyadris are Harishchandragad (1424 m), Mahabaleshwar peak (1438 m) Salher (1567 m) and Kalsubai (1646 m) (Chatterjee, 1965).

Rivers

The northern part of the west coast i.e. Gujarat is drained by Malvi, Narmada, Sabarmati and Tapti rivers; in the middle i.e. in Maharashtra, it is drained by the Vaitarna river, which rises close to the source of Godavari and flows westwards. North of the Vaitarna river the shores are marshy especially near

Dahanu. Another important river is Ulhas, which rises from the north of bhorghat, flows and enters into the Bassein creek near Kalyan. The midle part of the coast is also drained by Bhima, Godavari and Krishna which though flow eastward, the general drainage is westward towards the Arabian sea.

Climate

The N.W. ghats receive heavy rainfall - the S.W. monsoon starts in early June and trails off during September. The top regions in N.W. ghats such as Mahabaleshwar and Amboli get rainfall of 6200 mm and 7477 mm respectively are to the windward side of the Sahyadris. The mean annual rainfall varies from 2359 mm to 7450 mm. The humidity during monsoon months ranges between 70% 90% and during dry periods it is 10 30%. The mean annual temperature varies from 20° C to 24° C. The mean daily temperature in the coldest months - December and January ranges between 18° C to 24° C, the absolute minumum temperature being in the range of 6° to 14.8° C in different places of Sahyadris.

The climate of N.W. coast is maritime, humid almost throghout the year. Rainfall is regular and usually heavy the average being 2610 mm per annum and well distributed during the S.W. monsoon season. Cold season ranges between December and February. Summer is from March to June. Day and night temperature do not vary much. The hottest month is May; the daily mean maximum temperature is 32.9° C. From the beginning of November the temperature goes down. The coldest month is January, the mean daily maximum temperature being 27.7° C; mean daily minimum is 16.8° C.

Soils

The main groups of soils found along the north-western ghats are high and low level laterites, red loam, medium black soils, red gravelly soils and mixed red and black soils. Usually medium black soils are found on flat hill tops while the valleys have deep, red, gravelly soils with good humus content. Most of the soils in N.W. coast are leached lateritic and reddish (Mahabale, 1987). They are originally derived from Deccan traps. Along the river banks and near estuaries the soils are alluvial and fertile. Near the sea coast and on top of hills, the soils are poor.

Floristic Account

Past work

The flora of N.W. coast and N.W. ghats have been treated by Cooke (1901 1908) and Talbot (1909 1911). The floristic findings of the previous works of

Graham (1839), Dalzell and Gibson (1961), Nairne (1894), J. D. Hooker (1872 1897) etc. on this region have been incorporated in Cooke's Flora. For an exhaustive list of floristic works of this region one may refer to Blatter (1911), Santapau (1952 & 1953, 1958), Narayanaswami (1961 & 1965), Karthikeyan (1981) and Nayar (1984 1986).

Some notable and selected works which throw light on the rich floristic content of this region are those of Vartak (1966) on the flora of Gomantak, Rolla Rao (1985 & 1986) on Goa, Daman, Diu and Nagar Haveli, Almeida & Mistry (1993 1986) on flora of Ratnagiri district, Almeida (1990) on flora of Savantwadi, Kulkarni (1988) on from of Sidhudurg, Kotharis Moorthy (1993) on flora of Raigad (formerly Kulaba) district, Billore (1972) on flora of Thane, Shah & Badrinath (1985) on Dahanu forest division, Santapau & Randeria (1955) on Krishnagiri National Park (later Sanjay Gandhi National Park), Borivili, Santapau & Shah (1963, 1969)and Shah (1962 a, 1962 b, 1970) on Salsette and other islands of Bombay, Bole & Almedia (1980-1989), Deshpande (1987), Deshpande *et al.*(1993) on Mahabaleshwar, Hemadri (1970) on flora of Junnar, Janardhanan (1966) on flora of Bhimashankar, Lakshminarasimhan & Sharma (1991) on flora of Nasik district, Pradhan (1992) on flora of Ahmednagar district, Santapau (1951) on flora of Sinhagad, Santapau (1953) on flora of Khandala, Santapau (1958) on flora of Purandhar, Vartak (1962) on flora of Katraj ghat, reddy (1969 & 1970) on floristics of Ambavane & Sakarpather, Santapau (1954 1955) and Shah & Yadav (1979) on flora of Dangs forest, Shah (1978) on the flora of Gujarat. Dixit (1984) gives an account of pteridophytes available in this region.

Chatterjee (1962), Gadgil & Vartak (1977), Mahabale (1979), Meher - Homji (1978), Nair & Daniel (1986), Rolla Rao (1978) and Subramanyam & Nayar (1974) have discussed the vegetation, phytogeography, floristic patterns, floristic diversity, delineation and other interesting features in detail. Nair & Daniel *(op. cit.)* summarised the floristic diversity of Western Ghats as a whole and its conservation.

Dev Rais (Sacred Groves)

Conservation of biodiversity is not an alien concept to our country as many people seem to think. It is ingrained in our life system and religion since times immemorial. The animals and plants have been deified in our religious literature and worshipping places. We have been taught to look upon them as manifestation of God. However, the greed for wealth has turned the worshippers as butchers and consequently we have been losing both our flora and fauna. *Dev-rais* or sacred groves are relics of such conserved natural forests. Gadgil & Vartak (1976, 1981), Vartak (1983), Vartak & Gadgil (1981 a & b) and Sharma & Kulkarni (1980) have drawn the attention to some of them still being preserved in N.W. ghats.

Endemic, Rare & Threatened Plants

The treatise on endemism of Indian flowering plants by Chatterjee (1940) opened a new vista in Indian botany. There are too many references dealing with the endemic plants of N.W. ghats and N.W. coast and their status as delineated by Lucas & Synge (1978) ; however, mention should be made of Ahmedullah & Nayar (1987), Karthikeyan (1983), Nair & Daniel (1986), Nayar (1980), Rao (1972, 1979), Sharma & Kulkarni (1980), Singh & Sundara Raghavan (1986), Sundara Raghavan (1982), Sundara Raghavan & Singh (1983, 1984) and Vartak (1983).

Shah *et al.* (1983) listed medicinal plants. Arora (1983) and Arora & Nayar (1983) have brought out some interesting details about genetic resources, distribution of wild relatives and related rare species of economic plants of Western ghats. Nair & Deniel (1986) give statistical details about the availability of Algae, Fungi, Bryophytes and Lichens in Western Ghats. Dikshit (1991) prepared a case study of environment, ecology and its relationship and effects on people. His work area was Mahabaleshwar, an impotant hot spot in N.W. Ghats from where many new species have been described.

Subba Rao & Kumari (1981) have listed plants common to Western & Eastern ghats that help in phytogeographic studies.

Floristic Analysis

It is estimated that about 300 flowering plants species occur in Sahyadris, belonging to 231 families. In north-west coast about 1550 species occur which comprise 702 genera and representing 147 families. The large families are Poaceae, Fabaceae, Cyperaceae, Euphorbiaceae and Asteraceae.

Vegetation Types

The different types of vegetation occuring in N.W. Coast may be classified as esturarine vegetation consisting of mangrove species along the narrow muddy banks of rivers adjoining the sea, strand vegetation along coastal belt, plateau vegetation at lower elevations or plains. The vegetation, beyond this, gradually merge with ghats.

The vegetation types of Sahyadris may be classified into scrub, dry deciduous, moist deciduous and montane subtropical ever green forests.

Dixit (1932) reported the sea-grasses *Halophila decipiens* and *H. ovalis* from N.W. coast. *Ruppia rostellata* has also been found in many places.

On the sandy sea shores *Aleuropus lagopoides, Cressa cretica, Cyperus bulbosus, Hyphaene dichotoma, Pandanus tectorius, Pedalium murex, Spinifex littoralis, Tribulus terrestris,* etc. are found.

All along the coast line of N.W. coast there are tidal swamps and mud flats mostly covered by mangroves. Champion & Seth (1968) classified this as 'mangrove scrubs and mangrove forests' Strand forests occur at some places where the soil is sandy. A few pockets of evergreen forests are found in Sindhudurg but they are not continuous.

Rich mangrove vegetation may be observed along the banks of river Chapora at Colvale, river Zuari at Borium, river Goa at Amona and river Tiracol at Canad in Goa ; at creeks of Devgad, Achre, Deobag and Kalawli in Malwan, Kochre in Kudal, all in Sindhudurg district ; at Thane creek ; Alibag, Dasgaon in mahad, Dharamtan creek from Ghosale to Murud, Elephanta Island, Rajapuri Mhasle creek in Janjira - Murud, Revas, Rev danda, Uran etc. in Raigad district; in Bandra, Ghodbunder and Bhyander creeks in Greater Bombay and along Gujarat Coast.

Avicennia marina, A. officinalis, Rhizophora mucronata and *Sonneratia alba* are some the dominant species. Other associate species include *Acanthus illcifolius, Aegiceras corniculatum, Avicennia alba, Bruguiera cylindrica, B. gymnorrhiza, B. parviflora, Cerbera manghas, Ceriops tagal, Excoecaria agallocha, Kandelia candel, Lumnitzera racemosa, Rhizophora apiculata, Sonneratia caseolaris,* etc.

Non-mangrove halophytes found here are *Atriplex stocksii, Bulboscoenus maritimus, Caesalpinia crista, Cyperus compactus, Juncus maritima, Salicornia brachiata, Salvadora oleoides, S. persica, Suaeda fruticosa, S. maritima, S. monoica, S. nudiflora, Tamarix troupii,* etc. Pure communities of *Urochondra setulosa* is observed along tidal creeks and on shallow back water in Gujarat coast. *Acrostichum aureum* has been found in open situations near Goa coast.

Strand vegetation

Behind the tidal swamps, the sand binders and strand vegetation is found, sometimes it is in patches only. Trees and shrubs such as *Calophyllum inophyllum, Clerodendrum inerme, Colubrina asiatica, Pandanus tectorius, Pongamia pinnata, Premna corymbosa, Thespesia populnea,* etc. occcur here. The most commonly found climbers are *Canavalia virosa, Derris trifoliata, Ipomoea pes-caprae* etc. Notable herbs are *Cyperus squarrosus, Launaca procumbens, Nenotis rheedii, Pedalium murex, Perotis indica, Spinifex squarrosus, Tricholepis glaberrima, Vernonia cinerea, Zoysia matrella,* etc.

Groves of *Cocos nucifera* fringe behind the coast line. *Hyphaene dichotoma* is found in patches at places like Alibag, Revdanda and Vasai. *Phoenix sylvestris* and *Areca catechu* are found in Thane, Uran, etc.

Plateau Vegetation at lower elevations or plains

Undulating rocky plateaus with sparse vegetation is found in various places. *Acacia chundra, Buchanania lanzan, Carissa congesta, Flacourtia indica, Grewia abutiliifolia, Holarrhena pubescens, Ixora brachiata, Microcos paniculata, Woodfordia fruticosa*, etc. occur here.

Borassus flabellifer grows in groups on low hills and plais. They are occasionally intermixed with *Crotalaria lutescens, Elephantopus scaber, Flemingia strobilifera, Ixora coccinea, Naregamia alata, Ochna obtusata, Polygala elongata, Sida rhomboidea*, etc. The common climbers in these situations are *Abrus precatorius, Ampelocissus latifolia, Aspidopterys cordata, Bridelia stipularis, Cissampelos pariera, Derris scandens, Dioscorea bulbifera, Gloriosa superba, Gymnema sylvestre, Hemidesmus indicus, Ichonocarpus frutescens, Wattakaka volubilis*, etc.

Along the river banks on stony, sandy or alluvial soils, riparian flora is found. The common species of this type are *Barringtonia acutangula, B. racemosa, Homonoia riparia, Rotala serpyllifolia, R. aquatica, Syzygium heyneanum, Tamarix dioica, T. ericoides, Vetiveria zizanioides*, etc.

Hydrophytes

Hydrophytes occur along streams, ponds, lakes and other water sources. About 279 species have been recorded for Maharashtra and both N.W. coastal and ghat regions have been included in this study (Karthikeyan *et al.* 1982). The common species include *Aeschynomene aspera, Ammania baccifera, Bergia ammannioides, Coix lacryma-jobi, Cryptocoryne retrospiralis, Eriocaulon odoratum, Ludwigia adscendens, Monochoria vaginalis, Neptunia oleracea, Nymphaea pubescens, Oryza rufipogon, Rotala densiflora, Scirpus grossus, Trapa natans* var. *bispinosa, Utricularia aura, Vallisneria spiralis*, etc.

Grasslands

A belt of grasslands has been observed extending from Raita near Kalyan, Bhivandi to Palghar, Dahanu, Umbergaon and continue beyond Vapi in Southern Gujarat. Poaceae is the dominant family of flowering plants found in N.W. coast. The species number around 186 under 74 genera. The common grasses are *Arthraxon hispidus, Arundinella setosa, Arundo donax, Bothriochloa pertusa, Brachiaria ramosa, Capillipedium huegelii, Chloris barbata, Cynodon dactylon, Dichanthium annulatum, Digitaria ciliaris, Echinochloa colonum, Eleusine indica, Eragrostis unioloides, Heteropogan contortus, Iseilema laxum, Jansenella griffithiana, Saccharum spontaneum, Sporobolus diander, Themeda cymbaria*, etc.

Weeds

In the cultivated fields, a large number of weeds are found. Some of the common weeds are *Ageratum conyzoides, Coldenia procumbens, Crotalaria verrucosa, Dentella repens, Desmodium heterocarpon, Drosera burmanni, Goniogyna hirta, Ludwigia perennis, Vernonia cinerea,* etc.

Scrub forests

This type occurs along foot hills and lower elevations where the soil is usually lateritic and gravelly. *Maytenus senegalensis* is a very prominent and pioneer species of this area. *Acacia chundra, A. nilotica, Aerva sanguinolenta, Barleria prionitis, Capparis divaricata, Corchorus trilocularis, Dichrostachys cinerea, Dicliptera zeylanica, Eranthemum roseum, Hemigraphis latebrosa, Justicia diffusa, Rungia repens, Flacourtia indica,* etc. also occur.

Some of the climbers and seandent shmubs are : *Ancistrocladus heyneanus, Annicnatea grahamii, Butea superba, Connarus wightii, Dalbergia volubilis, Elaeagnus conferta, Embelia viridiflora, Grewia umbellifera, Luvunga eleutherandra, Naravelia zeylanica, Paramignya monophylla, Toddalia asiatica, Uvaria narum, Ventilago bombaiensis, V. Maderaspatana,* etc.

Epiphytes are represented by *Aerides dalzelliana, Aeschynanthus perrotletii, Bulbophyllum fimbriatum, Cymbidium aloifolium, Dendrobium barbatulum, Hoya wightii, Piper hookeri, P. trichostachyon, Porpax jedoniana,* etc.

Parasites such as *Dendropthoe trigona, Helicanthus elastica, Helixanthera wallichiana, Maenosolen capitellatus, Scurrula philippensis, Taxillus cuneatus, Viscum angulatum, V. monoicum,* etc. are found here.

Some members of the rich herbaceaus flora are *Adelocanyum coelestinum, Adenostemma lavenia, Anisomeles heyneana, Anisema murrayi, Cajanus lineatus, Capillipedium huegelii, Cardamine trichocarpa, Conyza leueantha, Costus speciosus, Crotalaria albida, C. nana, Cynodon dactylon, Delphinium malabaricum, Dicanthium annulatum, Echinochloa colonum, Eranthemum roseum, Exacum bicolon, Flemingia congesta, Fleurya interrupta, Gynura cusimbua, Impatiens kleinii, Leucas ciliata, Neanotis calycina, Pecteilis susannae, Salmonia ciliata, Thalictrum dalzellii, Urena lobata,* etc. *Enseta superbum* forms the screen vegelation.

Dry deciduous forests

A little higher above, the vegetation changes into dry deciduous, and trees start appearing, *Tectona grandis* is predominant. Other trees are *Acacia chundra, Albizia odoratissima, Anogeissus latifolia, Bauhinia racemosa, Bombax ceiba,* *Bridelia squamosa, Cassia fistula, Dalbergia latifolia, Gmelina arborea, Haldina cordifolia, Holarrhena pubescens, Holoptelea integrifolia, Lagerstroemia parviflora, Lannea coromandelica, Mitragyna pavifolia, Terminalia chebula, T. crenulata, T. paniculata, Wrightia tinctoria, Ziziphus mauritiana,* etc.

The common shrubs and climbers of these forest are : *Abrus precatorius, Aspidopterys cordata, Carissa congesta, Celastrus paniculata, Derris scandens, Dioscorea bulbifera, Helicteres isora, Ichnocarpus frutescens, Maytenus rothiana, Mimosa hamata, Wattakaka volubilis, Woodfordia fruticosa, Ziziphus oenoplia,* etc.

The prominent herbs and undershrubs include, *Alpuda mutica, Begonia crenata, Cymbopogon martinii, Dichanthium annulatum, Digitaria ciliaris, Elephantopus scaber, Eragrostis unioloides, Flemingia strobilifera, Heteropogan contortus, Ixora coccinea, Naregamia alata, Sehima nervosum, Themeda triandra,* etc.

Tropical moist deciduous forests

Higher elevations and better soil with improved climatic conditions present tropical moist deciduous forests. They are usually found along hill slopes. The soil is quite rich. The top storey consists of *Albizia chinensis, Canthium dicoccum, Catunaregam spinosa, Dillenia pentagyna, Ficus racemosa, Glochidion hohenackeri, Hymenodictyon obovatum, Macaranga peltata, Mallotus philippinensis, Meyna laxiflora, Olea dioica, Symplocos racemosa, Syzygium caryophyllatum, S. cumini, Tetrameles nudiflora, Trewia nudiflora, Xantolis tomentosa,* etc.

Distinct communities of *Ligustrum perrottetti* and *Wendlandia thyrsoidea* have been found to occur in many places.

Common shrubs of this type of forests are *Callicarpa tomentosa, Canthium rheedii, Clerodendrum viscosum, Grewia abutiliifolia, Leea asiatica, Rhus mysorensis, Thelepaepale ixiocephala,* etc.

Climbers often met with are *Spatholobus parviflora, Cayratia auriculata, Clematis gouriana, Combretum albidum, Diploclisia glaucescens, Entada rheedii, Gnetum ula, Jasminum malabaricum, Mezoneuron cucullatum, Moullava spicata, Mucuna monosperma, Premna coriacea, Stephania japonica, Tetrastigma canarense, Ziziphus rugosa,* etc.

The common herbs and undershrubs are *Adenostemma lavenia, Alysicarpus bupleurifolius, Carvia callos, Crotalaria retusa, Demodium laxiflorum, Ecobolium ligustrinum, Gnidia glauca, Leea asiatica, Leucas stelligera, Lobelia nicotianaefolia, Mackenziea integrifolia, Rauvolfia densiflora,* etc.

Some common epiphytes found here are *Aerides crispum, Drynaria quercifolia, Eria microchilos, Impatiens acaulis, Oberonia recurva, Utricularia striatula, Vanda tessellata*, etc.

The parasites, saprophytes and insectivorous plants that are met with here include *Aeginetia indica, Balanophora fungosa* ssp. *indica, Dendrophthoe falcata, Drosera indica, Tolypanthus lagenifer, Utricularia caerulea, U. graminifolia, U. reticulata, U. striatula, U. uliginosa, Viscum articulatum, etc.*

Montane subtropical evergreen forests

The evergreen forests that occur in the north-western ghats of Maharashtra are not typical evergreen forests (Qureshi, 1965). As the trees tend to be dwarf, without any tiers or canopies of tropical elements they are classified as montane subtropical evergreen forests.

Some trees found in these forests are *Actinodaphne angustifolia, Alseodaphne semecarpifolia, Beilschmiedia dalzellii, Cinnamomum verum, Cryptocarya bourdillonii, Elaeocarpus serratus, Ficus callosa, Garcinia indica, Holigarna grahamii, Knema attenuata, Lagerstromenia microcarpa, Litsea stocksii, Mammea suriga, Memecylon umbellatum, Mesua ferrea, Neolitsea cassia, Perseq macrantha, Polyalthia fragrans, Prunus ceylanica, Symplocos racemosa, Syzygium hemisphericum, S. laetum, Vitex altissima*, etc.

Small trees or shrubs are represented by *Actephila indica, Blachia andamanica* ssp. *denudata, Dichapetalum gelonioides, Erodia luna-ankerda, Euonymus indicus, Ixora nigricans, Meiogyne pannosa, Memecylon talbotianum, Pavetta siphonantha, P. tomentosa, Pittosporum wightii, Psychotria dalzellii, P. truncate, Sageraea laurifolia, Saraca asoca*, etc.

Some of the climbers and scandent shrubs are : *Ancistrocladus heyneanus, Amicratea grahami, Butea superba, Connarus wightii, Dalbergia volubilis, Elaeagnus conferta, Embelia viridiflora, Grewia umbellifera, Luvunga eleutherandra, Naravelia zeylanica, Paramignya monophylla, Toddalia asiatica, Uvaria narum, Ventilago bombaiensis, V. maderaspatana*, etc.

Epiphytes are respresented by *Aerides sp. Aeschynanthus perrottetti, Bulbophyllum fimbriatum, Cymbidium aloifolium, Dendrobium barbatulum, Hoya wightii, Piper hookeri, P. trichostachyon, Porpax jerdoniana*, etc.

Parasites such as *Dendrophthoe trigona, Helicanthus elastica, Helixanthera wallichiana, Macrosolen capitellatus, Scurrula philippensis, Taxilus cuneatus, Viscum angulatum, V. monoicum* etc. are found here.

Some members of the rich herbaceous flora are *Adelocaryum coelestiinum, Adenostemma lavenia, Anisomeles heyneana, Arisaema murrayi, Cajanus lineatus, Capillipedium huegelii, Cardamine trichocarpa, Conyza leucantha, Costus speciosus, Crotalaria albida, C. nana, Cynodon dactylon, Delphinium malabaricum, Dichanthium annulatum, Echinochloa colonum, Eranthemum roseum, Exacum bicolor, Flemingia congesta, Fleurya interrupta, Gynura cusimbua, Impatiens kleinii, Leucas ciliata, Neanotis calycina, Pecteilis susannae, Salomonia ciliata, Thalictrum dalzellii, Urena lobata*, etc. *Ensete superbum* forms the scree vegetation.

Ferns & Fern Allies

Lycopodium hamiltonii is found to grow on tree along with *Selaginella delicatula, S. panchganiana*, etc. The most common ferns are *Adiantum philippense, Asplenium indicum, Athyrium hohenackerianum, Cheilanthes albomarginatus, C. farinosa, Leucostegia immersa, L. pulchra, Microsorium membranaceum, Pteris biaurita, P. quadriaurita, P. vittata, Tectaria macrodonta*, etc.

Endemic, rare and threatened plants

Chatterjee (1940, 1962) suggested that about 2045 species of Dicotyledons and 500 species of Monocotyledons are endemic to peninsular India. Subramanyam & Nayar (1974) have listed 20 genera and 89 species from Western ghats. Ahmedullah & Nayar (1987) estimated 1932 endemic species and infraspecific taxa. Many of them occur in N.W. ghats. The endemism and endemic plants of this region have been discussed by various authors, the notable being Chatterjee (1940, 1962), C. K. Rao (1972, 1979), Subramanyam & Nayar (1974), Rolla Rao (1970), Karthikeyan (1983), Sundara Raghavan & Singh (1983, 1984), Singh & Sundara Raghavan (1986), Nair & Daniel (1986) and Ahmedullah & Nayar (1987).

The endemic genera found in N.W. Ghats are *Bhidea, Bonnayodes, Erinocarpus, Frerea, Helicanthes, Pinda, Pseudodichanthium, Seshagiria* and *Supushpa* ; *Glyphochloa* and *Pogonachne* are the endemic genera found in coastal regions.

Endemic species in the coast are far less in number in comparison with those of ghats. Some endemic species of N.W. coast are : *Argyreia boseana, Crotalaria filipes, Crotalaria lutescens, Desmodium ritchiei, Glyphochloa acuminata, G. goensis, Ipomoea salesettensis, Lepidagathis bandraensis, Operculina tansaensis, Pogonachne racemosa, Psilostachys sericea, Synnema anomalum, Torenia indica* etc.

Some of the endemic species in the north-western Ghats are *Arthraxon jubatus, Barleria gibsonioides, Canscora khandalensis, Dichanthium armatum, Eriocaulon elenorae, Flemingia rollae, Glyphochola santapaui, Habenaria panchganiensis, Isachne borii, Jatropha nana, Knema attenuata, Lavandula gibsonii, Moullava spicata, Nepeta bombaiensis, Oianthus deccanensis, Pseudodichanthium serrafalcoides, Rotala ritchiei, Supushpa scrobiculata, Tripolopogon ramosissimus, Utricularia lazulina, Vigna khandalensis,* etc.

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5a. SOUTHERN WESTERN GHATS - SOUTH OF GOA

(E. Vajravelu & K. Vivekananthan)

1. INTRODUCTION

Western Ghats are the most important biogeographical zones in peninsular India. Due to their latitudinal ranges, varied topography and bioclimate they become the richest areas in India, next to Himalayas. Their past geographical history adds new dimension to their richness. Nayar (1977) pointed that "at present as the Himalaya preside over the biogeography of India, the Western Ghats to a large extend preside over the ecology and biogeography of Peninsular India"

2. GEOGRAPHICAL LOCATION AND PHYSIOGRAPHY

The Western Ghats are also known as Sahyadri, a chain of mountains along the western border of the Deccan, overlooking the Arabian Sea on the west and are running more or less parallel to the coast in Peninsular India. They extend from the mouth of Tapti (Tapi) River Valley (21^0 N) in Gujarat to Kanniyakumari (Cape Comorin) (8^0 N) in Tamil Nadu the southern most tip of Indian Peninsula. The Ghats are about 1600 km long in the north south direction and 5-10 km broad, on an average. The whole region lies between $8^0 20'$-$20^0 4'$ north latitudes and 73^0-77^0 east longitudes and is an almost a narrow strip of land, with an average altitude ranging from 300-1500 m, excluding the isolated peaks. From north to south the Ghat passes through the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu and forming the back-bone of economy of these states.

Topographically, the Western Ghats are characterised by both conical and flat-topped hills interspersed with valleys and spurs. The more or less continuous hill ranges have a major discontinuity at Palghat known as the Palghat (Palakkad) Gap, separating the Nilgiris ranges from the Anaimalais. The Ghats descend steeply in the west, whereas they merge gradually through a series of hills with the Deccan plateau in the east. Whereas the northern, southern and western boundaries of the Western Ghats are geographically distinct, the eastern limit is confused with the eastern plateaux and hills of Deccan (Meher-Homji, 1978).

Geologically the Ghats fall into two sectors; the Ghats north of Krishna basin with fragile rocks of the Deccan Trap are formed of basalt rock. Isolated, conical, flat-topped hills occur herewith, steep sides marked with striations and they seldom rise above 1500 m in altitude. South of Krishna basin being the region of Pre-Cambrian archaen, crystaline hard rocks formed of granites, schists, gneisses, quarzites etc. The rounded hills here rise to great heights (Anaimudi, 2695 m and Doddabetta 2637 m). Chatterjee (1965) states that the Sahydris composed of at least two different types of rocks of varying hardness on the basis of which the range can be divided into two sections. About 640 km of the northern Sahyadri is built of horizontal sheet of lava. The next 640 km from the 16^0 N latitude to the Nilgiri mountains the granitoid gneiss takes the place of basalt and the countryside has a different aspect. Mahabale (1979) points out about the two components viz. 1. the Sahyadris beginning from Dangs to Goa and Muliangiri in Mysore and 2. the mountain ridge from Malaprapha and Kali rivers in Karnataka right down to Palnis. The first part is volcanic in origin and the second part is mainly made up of archaens. The soil types charcteristic to the region are laterites, red loam, medium black hill soils, red gravelly, alluvial including coastal alluvium and mixed red and black soils. Seth and Yadav (1960) who analysed the soil types of Western Ghats have given various combinations of the basic formations depending upon location and vegetation cover.

South of Goa in Karnataka, the Western Ghats rise sharply to form an unbroken though uneven rempart averaging an altitude of 900 m. Deep valleys plunging to less than 200 m and precipitious or rounded peaks rising to over 1500 m make up this rugged country (Saldanha, 1984 a). Kudremukh, the highest peak, is 1892 m high and the Ghats are so close to the sea near Karwar, that they seem to dip in to the sea. As a contrast to the western windward face of the range, the eastern leeward face has rolling hills and shallow valleys with mean elevation of about 800 m. The Sahyadri in this section runs southwards very close to the coast and at several places touches the sea shore and finally joins the Nilgiri mountains. Eventhough Bababundangiri and Biligirirangan hills are phytogeographically linked to the W. Ghats they have been not included here because of there distinct floristic links. The Ghats are between 700 and 1000 m rising suddenly at Kodachadri to 1343 m and fall to about 600 m at Agumbe. From Kudremukh up to Palghat Gap, the edge of the plateau is very often higher than 1000 m and the peaks are more numerous and higher too, Pushpagiri (1713 m) in the north Kodagu, Tadiandamol damol (1745 m), Banasuram (2060 m), Vavul Mala (2339 m) at the edge of Wynaad plateau. The Nilgiris or the Blue mountains are some of the most picturesque, habitable compact plateau of about 2, 590 sq. km. It is the meeting ground of three mountain systems of Peninsular India, the Sahayadiri joining it opposite of Mukurti peak, the Southern Ghats across the Palghat Gap in the south, and the Eastern Ghats in the north-eastern corner (Chatterjee, 1965). The abrupt rise of Nilgiris from the surrounding area is very striking. The two highest peaks in the Nilgiris are Doddabetta-the second highest peak in south India (2637 m) and Mukurti (2554 m). There are several peaks like Nilgiri peaks, Pichal Betta, Devar Betta, Naraidu Betta, Kundikadu Betta, Kalari Betta, etc., which are over 2500 m above m.s.l. Udhgamandalam (Ootacamund), the Queen of hill stations in south India is situated on a broad undulating valley at the foot of Doddabetta. The verdent Silent Valley is situated at the south western corner of Nilgiris (on the lower side of Nilgiri plateau) being roughly a rectangular table-land closed on all sides. The highest peaks on the northen and north-eastern boundary are Anginda (2383 m) and Sispara (2206 m) and on the west Poochipara (1376 m) and Valiamulla Mala (1237 m). Due to the presence of high ridges all around, the whole plateau is shielded.

The Palghat Gap, about 24 km wide, creating an east-west corridor, marks a prominent break in the continuity of the range along the western border of the Deccan plateau. Beyond the Palghat Gap the Sahayadri again continues southwards. It has different names in different parts but it is collectively known as the Southern Ghats. Anaimudi, the highest peak (2695 m) in peninsular India is a nodal point in Southern Western Ghats from which three ranges radiate in three different directions, viz, the Anaimalais in the north; the Palnis in the north-east; and the Cardamom Hills or the Elamalais in the south. This block is a composite range made up of Nelliampathi Plateau (drained by the Chalakudi river) to the West, the Anaimalai Plateau (largely converted into teak and tea plantations and distinctly elevated to the east) in the centre and the Palni horst overlooking the plains of Tamil Nadu from a hight of almost 2000 m. Kodaikanal, an important hill-station, is located in the Palni hills. Palni hills are considered by a few geologists and geomorphologists as not part of the W. Ghats. Meher-Homji (1978) clearly indicated the strong phytogeographic affinity of the Palnis with the W. Ghats and no link with Eastern Ghats. To the south of this west coast oriented block, the Ghats display further changes. Here, they from an elevated plateau slanting towards the west the Periyar plateau. The eastern part of the plateau forms the Elamalai which has a number of cardamom plantations and hence is locally known as the cardamom hills. The central range attains its peak at Devar Malai (1922 m) and terminates in the east by a sheer cliff about 1000 m high. From this, Varushnad massif is detached and continued by the Andipati which toghether with the Palni hills embraces the Kambam valley, south of Devar Malai at about 9^0 N. The Ghats are once again interrupted by the narrow Shencottah Pass. From here they continue as a narrow ridge with steep slopes to the west as well as to the east. The inaccessibility of the southern portion of the southern Ghats has made it very sparsely populated. Agastyamalai and its environs including Mundanthurai, Kalakkadu, Mahendragiri, Muthukuzhivayal and Neyyar which are situated at the southern end of the Western Ghats, form the most diverse and least known ecosystems in Peninsular India (Henry *et al.*, 1984). The conical Agastyamalai peak locally known as "Pothikaimudi" and Agasthiyarkudam (1968 m) is the towering highest peak at the tail-end of the Western Ghats. Spate (1957) who illustrated the topography of these hill notes it as a remarkable group of mountains more complex than the Nilgiri and Anaimudi of Peninsular India.

The important rivers of Peninsular India, *viz.* Godavari, Krishna and Cauvery except the Narmada and the Tapti, flow eastwards into the Bay of Bengal, though they have their sources on the crest of Sahyadri which is only 50 to 80 km away from the Arabian sea coast. Tungabhadra, the most important tributary of the river Krishna, formed by the union of the Tunga and Bhadra, both rising near Gangamula peak (1199 m) about 25 km south-west of Shringeri. The Cauvery has its source on the Brahmagiri hill in the Kodagu District of Karnataka. Of the west flowing rivers, the Sharavathi deserves mention. It has been dammed in the hills to create a vast lake and beautiful waterfalls the famous Jog falls near Gersoppa on the west of the crest. Nilgiris are drained by several small perennial streams which join to form the following major river systems, *viz.* the Pykara, the Pillithada Halla, the Kundah up to Parali, where Bhavani joins, the Coonoor river, the Sigur river and the Kedar Halla. The Bhavani river springs from the Kundah mountains near Kudikadu betta in the Nilgiris. Kunthipuzha, being a perennial river and a tributary of Bharathapuzha, originating at an altitude of 1861 m near Kotnipura peak in the north, floos down the entire length of the Silent Valley. The Periyar river rises near Devar Malai (1922 m) and flows westwards into the Arabian Sea. The Vaigai also floos for about 90 km within the hills. Courtallum (Kuttralam) the famous waterfalls and sanctorum traversed by three small rivers and the river Chittar is the major one which has got its source in the hills. At the fag end, the Tambraparni is the most important perennial river and it rises near Agastyamalai and forms a series of waterfalls before descending to the plains at Papanasam. The falls at Banatheerthun and five others at Papanasam are particularly notable. Neyyar, Karamanayar and Kodayar are the other river systems here.

3. CLIMATE AND RAINFALL

The climate of Western Ghats is mainly influenced by the south-west monsoon, even though Western Ghats situated in the Karnataka, Tamil Nadu and Kerala, receive north-west monsoon during October-January. The annual rainfall varies from 2350 mm in the north to 7450 mm in the south. The western slopes of the Ghats, exposed to the frontal attack of south-west monsoon, receive the maximum rainfall. In certain peaks like Agumbe (Karnataka), Kundah range, Nilgiris (Tamil Nadu) and Anaimudi (Kerala) the annual rainfall often exceeds 5000 mm; but the rainfall figures of 2000 to 4000 mm in one single month July or August are not rare. Areas like Silent Valley which are shielded all round have developed a special micro climate. The mean annual temperature is around 24^0 C whereas towards south, on an average the mean annual temperture is only 20^0 C.

4. PHYTOGEOGRAPHICAL REGIONS

Hooker & Thomson (1855) and later Hooker (1907) recognised nine botanical provinces in the erstwhile British India based on flora. The mountain ranges of Western Ghats fall under Hooker's botanical region "Malabar". Clarke (1898) proposed eleven phytogeographical provinces by the distribution of Cyperaceae members and called this region as "Malabarica". Based on the relative humidity and dryness, Prain (1903-8) recognised six regions and according to him, "India Aquosa" comprises the wet forest tracts along the Western Ghats from Gujarat to Travancore which receive the full force of south-west monsoon and correspond to the "Malabar" province of Hooker and Clarke. Calder (1938) based on the outline of vegetation, followed the Malabar province. Good (1947) and Turril (1953) have also mentioned the approximate outlines of these provinces. Chatterjee (1939) after a study of the endemic species of dicotyledons recognised ten botanical regions and placed Western Ghats under Malabar and excluded Sri Lanka (Ceylon). Razi (1955) recognised twenty one botanical provinces in India, based on migration of plants. His "Malabar" region, includes Sri Lanka also. Puri (1960) dealt with ten botanical regions, in which the west coast of the Malabar includes the Western Ghats. Laccadive and Minicoy group of Islands on the west coasts have been treated as an additional separate botanical region. Chatterjee (1962) and Maheswari *et al.*, (1965) also followed the approximate outline of these provinces. Blasco (1979) renamed the eight divisions of Chatterjee (1939) as the eco-floristic zones emphasising the characteristic endemic flora of every division including the Malabar. Most of the phytogeographers agree in placing the Western Ghats in the "Malabar" of Hooker, Clarke and Chatterjee. The Western Ghat region is further phytogeographically divided by Subramanyam & Nayar (1974) as follows: 1. the Western Ghats from the river Tapti to Goa 2. the Western Ghats from the river Kalinadi to Coorg 3. the Nilgiris and 4. the Anaimalais, the Palnis and Cardamom hills. Ahmedullah & Nayar (1987) on the basis of the distribution of endemic species of peninsular India considered the following regions as centres of endemism. 1. Northern Western Ghats (R. Tapti to Goa) 2. Central Western Ghats (R. Kalinadi to Coorg) 3. Southern Western Ghats (Travancore, Malabar, Nilgiri, Anaimalai, Palni, Tirunelveli hills complex). Gadgil and Mehar-Homji (1982) derived the biogeographic zones mainly from the distribution of the vegetation types. They document the status of the 40 vegetation types of India in which 8 vegetation types occur in Southern Western Ghats. Pascal (1988) in his studies of wet evergreen forests of the Western Ghats of India, divided Western Ghats into three major regions 1. Surat to Goa 2. Goa to Nilgiri mountains and 3. south of Palghat gap. Meher-Homji (1991) analysing from ecological angle, pointed out that endemics are very often rare plants of no particular significance in constituting the vegetational landscapes. He derived twenty nine vegetation types, grouped into eleven phytoclimatic zones for Peninsular India, in which Western Ghats fall under three phytoclimatic zones having nine types of vegetation.

5. SALIENT FEATURES OF THE VEGETATION

Most of the familiar types of South Indian forests are represented here along with the forests that are peculiar to the hill tops of peninsular India. In richness, variety and diversity of vegetation pattern, this tract surpasses any other tract in

India. The Salient features of the vegetation of the Western Ghats has been discussed by Nair & Daniel (1986) and Subramanyam & Nayar (1974) while from Karnataka northwards has been analysed by Rao (1978).

Champion and Seth, (1968) placed the forests of the Southern Western Ghats under the four main types, each with several subdivisions and edaphic or seral variations as follows:

I. MOIST TROPICAL FORESTS

1. Tropical Wet Evergreen Forests:

   i) Southern tropical wet evergreen forest a) Southern hilltop tropical evergreen forest b) West coast tropical evergreen forest.

2. Tropical Semievergreen Forests:

   ii) Southern tropical semievergreen forests a) West coast semievergreen forest, b) Tirunelveli semievergreen forest, c) West coast secondary evergreen *Dipterocarpus* forest.

3. Tropical Moist Deciduous Forests:

   iii) South Indian Moist deciduous forests a) Very moist teak forest, b) Moist teak forest, c) Slightly moist teak forest, d) Southern moist mixed deciduous forest, e) Southern secondary moist mixed deciduous forest.

4. Littoral and Swamp Forests:

   iv) Tropical fresh water swamp forests a) *Myristica* swamp forests, b) submontane hill valley swamp forest. c) Tropical riparian fringing forest.

II. DRY TROPICAL FORESTS

1. Tropical Dry Deciduous Forests:

   i) Southern tropical dry deciduous forests : a) Dry teak forest, b) Southern dry mixed deciduous forest

2. Tropical Thorn Forests:

   ii) Southern tropical thorn forests : a) Southern thorn forests, b) Southern thorn scrub.

III. MONTANE SUBTROPICAL FORESTS

1. Soubtropical Broad-leaved hill forests:

i) Southern subtropical broad leaved hill forests a) Southern (Nilgiri) subtropical hill forest, b) South Indian subtropical hill savannah (Woodland) c) Reed brakes *(Ochlandra)*.

IV. MONTANE TEMPERATE FORESTS

1. Montane Wet Temperate Forests:

a) Southern montane wet temperate forest, b) Southern montane wet scrub, c) Southern montane wet grassland.

The detailed maps of vegetation and environmental condition of Peninsular India (1961 to 1978) in twelve sheets, (prepared at the French Institute, Pondicherry) were published by the Indian Council of Agricultural Research, giving another approach to the classification of the forest types. Gadgil & Meher-Homji (1982) documented the status of the forty vegetation types of India and prepared vegetation maps with biogeographic regions. These vegetation maps have been adopted from the vegetation maps of the French Institute, Pondicherry. Their classifications are mainly based on thorny (arid to semi-arid), deciduous, (teak and sal), semi-evergreen (montane) and evergreen (wet and dry) characters with vegetation types, mainly based on important dominant tree species. These vegetation maps reflect the vegetation dynamics of Southern Western Ghats and the following are the important vegetation types with geographical range, altitude and major nature reserve, currently existing, with key areas, for long term preservation in this area.

I (a) Wet evergreen forests of West Coast-Western Ghats. *Cullenia-Mesua-Palaquium.*

Western side of Western Ghats in Kerala and some moist pockets in Tamil Nadu up to 1000 m. Kalakkadu, Neyyar, Periyar, Silent Valley, Agasthyamalai, Sabarigiri, Nilgiri western slopes.

(b) *Dipterocarpus-Mesua-Palaquium.* Along the west Coast and Western Ghats from 12° N to 14° 40' N up to 1500 m. Makut and Agumbe.

(c) *Persea-Holigarna-Diospyros.* Shimoga, Uttara Kannada, Belgaum and Goa up to 1500 m.

(d) Montane Shola *(Elaeocarpus serratus, Gordonia obtusa, Meliosma arnottiana, M. simplicifolia* ssp. *pungens, Schefflera stellata).* Above 1500 m. High hills of Nilgiri, Palni, Anaimalai. Upper Bhavani Plateau, Eravikulam plateau near Kodaikanal.

(e) *Memecylon-Syzygium-Actinodaphne.* Uttara Kannada, Belgaum 700-1500 m.

II. 1) Wet evergreen-Teak ecotone. *Tectona-Lagerstroemia-Dillenia Terminalia paniculata.* Western side of Western Ghats in Kerala and eastern fringe of Western Ghats in Karnataka up to 1000 m. Uttara Kannada.

2) Teak Zone. *Anogeissus-Terminalia-Tectona.* Kanniyakumari to North, up to 1000 m. Bandipur, Mudumalai, Nagarahole.

Das Gupta (1976) marked nine main types of forests, for South India. Of these, seven main types viz. tropical wet evergreen forests, tropical semievergreen forests, tropical moist deciduous forests, littoral and swamp forests, tropical dry deciduous forests, subtropical broad leaved hill forests and montane wet temperate forests occur in southern western ghats.

The classification for Karnataka forests based on the vegetation map of Legris and Pascal (1982) has been summarised by Saldanha (1984a) as follows:

Group I. Evergreen to semi evergreen climax forests and degradations:

A. Evergreen and potentially related semi evergreen forests: 1) Low elevation forests (0-850 m), 2) Medium elevation forests (650-1400 m), 3) High elevation forests (1400-1800 m).

B. Secondary or degraded stages evergreen climax forests: 1) Evergreen to semi-evergreen forests, 2) Secondary moist deciduous forests, 3) Formations other than forests.

Group II. Deciduous climax forests and degradation:

A. Moist deciduous forests: 1) Dense forests, 2) Woodlands, 3) Tree savannah, 4) Scrub to dense thickets, 5) Discontinuous thickets or scattered shrubs.

B. Dry deciduous forests: 1) Dense forests, 2) Woodlands, 3) Tree savannah, 4) Scrub to dense thickets, 5) Discontinuous thickets or scattered shrubs. All these types occur in the Ghat portion of Karnataka. Considering the topography, bioclimate and soil Saldanha (1984a) classified the vegetation of Ghat portion of Karnataka under the following three main categories 1) West coast tropical vegetation, 2) Upland deciduous vegetation and 3) southern tropical montane vegetation.

Chandrasekaran (1962, 1973) classified the southern western Ghats of Kerala forests, mainly based on the frame work of Champion's, with minor alterations in certain cases. The classification suggested are as follows:

1) TROPICAL WET EVERGREEN FORESTS :

Climax forest types: 1) Low level evergreen forests, 2) High level evergreen forests, 3) "Low" tropical Ghat evergreen forests.

Secondary Forest types: 1. Semi evergreen (secondary) forests, 2) Secondary evergreen forests, 3) Moist deciduous (secondary) forests, 4) Open deciduous forests, 5) Wet bamboo (reed) brakes, 6) Moist bambo *(Bambusa)* brakes and 7) Low level grassland.

Edaphic Forest types: a) *Myristica* swamps, b) Tropical valley freshwater swamps, c) Tropical riverine forests, d) Cane brakes, e) *Xylia* mixed forests, f) Laterite scrub.

II. TROPICAL MOIST DECIDUOUS FORESTS :

Climax Forest Type: 1) Wynaad Plateau deciduous forests and 2) Moist mixed deciduous forests.

Secondary Forest Types: 1) Moist savannah and 2) Secondary forest with bamboo.

Edaphic Forest Types: Post climax evergreen forests.

III. TROPICAL DRY DECIDUOUS FORESTS:

Climax Forest Types: 1) Tropical dry deciduous forests and 2) Mixed dry deciduous forests with Sandal.

Secondary Forest Types: 1) Dry savannah.

IV. MONTANE SUBTROPICAL FORESTS:

Climax Forest Type: Subtropical wet hill forests.

V. MONTANE TEMPERATE FORESTS:

Climax Forest Type: Wet temperate forests.

Secondary Forest Type: High level (montane) grassland.

Nair & Vivekananthan (1983) described the vegetation of Southern Western Ghats of Tamil Nadu following Champion & Seth (1968) as follows: 1) Dry deciduous forests (Southern dry mixed deciduous forests), 2) South Indian moist deciduous forest, 3) Semi-evergreen forests (Tirunelveli semi-evergreen forests), 4) Wet evergreen forests (Southern hill top tropical forests and West Coast tropical evergreen forests), 5) Sholas (Southern montane wet temperate forest) and 6) Grasslands i) Low level and ii) High level (Southern montane wet grasslands).

The salient features of the vegetation of Southern Western Ghats are dealt herewith into three major regions 1) Goa to Nilgiri 2) Nilgiri and Silent Valley and 3) Southern Ghats, (South of Palghat gap) the Anaimalai, Palni and

Cardamom hills. In addition, these ghats are an assortment of various floristically diverse segments showing different aligments of forest types. Hence each major area has been dealt here seperately.

1) THE WESTERN GHATS FROM GOA TO NILGIRI

This region occupies the states of Karnataka and Northern Kerala. The vegetation of Karnataka has been dealt with by Ahuja, 1962 (Belgaum); Arora, 1960, 1961, 1963 a, 1963 b, 1964a, 1964 b, 1965 a, 1965 b, 1966 a, 1966 b (Kodagu, Uttara and Dakshina Kannada); Eners 1907 (Manjarabad Hassan); Jain, 1944-45, 1960 (Hassan, Karnataka); Kadambi, 1941, 1960 (Agumbe-Shimoga, Karnataka); Keshava Murthy and Yoganarasimhan, 1990 (Kodagu District.); Krishnaswami, 1941, 1942 a, 1942 b, 1945, 1950 (Agumbe-Shimoga, Hassan); Naithani, 1966 (1967) (Bandipur); Puri *et al.*, 1960, Raghavan, 1981 (1983) (Agumbe-Shimoga); Razi 1950, 1955 (Mysore); Rao & Razi, 1981 (1983) (Agumbe-Shimoga); Razi 1950, 1955 (Mysore); Rao & Razi, 1981 (Mysore District.); Saldanha, 1984 a & 1984b (Karnataka); Saldanha & Nicolson, 1976 (Hassan District.); Trimurti, 1955 (Kodagu) and Yoganarasimhan *et al.*, 1981 (Chickmagalur District.).

THORN AND SCRUB TO THICKET

The scrub type of vegetation is seen along the eastern slopes and foothills from 200-500 m altitudes, in rain shadow region. The vegetation chiefly consists of thorny species with a few stunted trees. The dominant species of these forests are *Acacia catechu, A. chundra, A. planifrons, Albizia* spp., *Argyreia cuneata, Balanities roxburghii, Canthium parviflorum, Capparis sepiaria, Carissa congesta, Cassia auriculata, Cipadessa baccifera, Dichrostachys cinerea, Dodonaea viscosa, Erythroxylum monogynum, Euphorbia antiquorum, Flacourtia indica, Gardenia* spp., *Maytenus* spp., *Ixora arborea, Lantana camara, Pavetta indica, Plecospermum spinosum, Pterolobium hexapetalum, Rhus mysorensis, Securinega leucopyrus, Soymida febrifuga, Zizyphus* spp. and *Xeromphis spinosa*. Climbers are represented by *Abrus precatorius, Bridelia scandens, Cissus quadrangularis, Cissampelos pariera, Cyclea peltata, Hemidesmus indicus, Ichnocarpus frutescens, Jasminum* spp. and *Tylophora* spp. The undergrowth consists of grass species of *Apluda, Aristida, Eragrostis, Oplismenus* and *Heteropogon contortus, Setaria pumila* and other herbaceous species mostly belonging to genera like *Alysicarpus, Andrographis, Barleria, Blepharis, Crotalaria, Fimbristylis, Indigofera, Lepidagathis, Polycarpaea, Rungia* etc. In most dry areas, *Caralluma umbellata, Euphorbia antiquorum, Plectranthus caninus* and *Sarcostemma acidum* are common. The scrub forests of Uttara Kannada are of two types. The black soil scrub has the following species: *Bridelia scandens, Diospyros melanoxylon, Flacourtia indica, Ixora arborea, Maytenus emarginata* and *Lagerstroemia parviflora* etc. are occasionally found. In contrast to the above, laterite scrub is

Plate 35. Mountains clad with evergreen forest at Kodaikanal, Tamil Nadu

Plate 36. Shola and grassland vegetation at Kulamavu, Kerala

Plate 37. Evergreen forest in Sivagiri hills, Tamil Nadu

Plate 38. Rocky slopes colonised by the endemic palm *Bentinckia condapanna* in Agasthyamalai hills (1300 m)

Plate 39. *Euphorbia santapaui* - an endemic species in Agasthyamalai hills (1200 m)

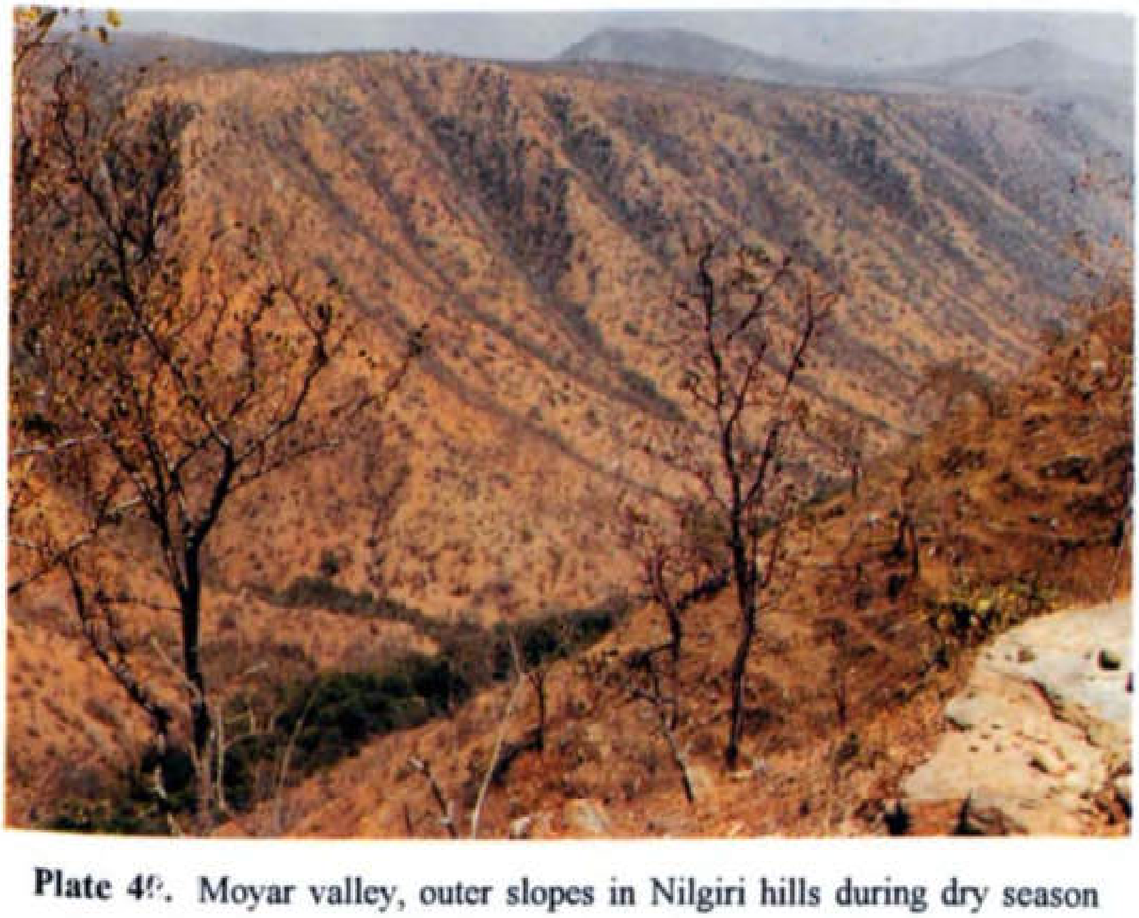

Plate 40. Moyar valley, outer slopes in Nilgiri hills during dry season

Plate 41. Moyar valley (850 m), Nilgiri hills during rainy season

Plate 42. Teak plantation on the Nilgiri hills (850 m)

Plate 43. Dry deciduous forest on the Nilgiri hills

Plate 44. Wild elephants at Mudumalai wildlife sancturay, Nilgiri hills

Plate 45. *Acrocarpus fraxinifolius* Wight & Arn. in Kerala

Plate 46. Idukki reservoir (Painavu), Kerala

Plate 47. *Rhododendron arboreum* subsp. *nilagiricum* (Zenk.) Tagg.- characteristic of high altitude of South-western Ghats above 1700 m in Nilgiri, Palni and Anamalai ranges

Plate 48. *Humboldtia decurrens* Bedd. ex Oliver - an endemic tree in South- western Ghats

Plate 49. *Impatiens floribunda* Wight - an endemic balsam of Peninsular India

Plate 50. *Gastrochilus calceolaris* (Buch. - Ham. ex J. E. Smith) D. Don in Kerala

Plate 51. *Phyllanthus indofischeri* Bennet - endemic to Peninsular India

Plate 52. *Cyathea crinita* (Hook. f.) Copel. in Kerala

characterised by the presence of *Canthium dicoccum* var. *umbellatum*, *Gardenia* spp., *Osyris arborea* etc. *Careya arborea* and *Terminalia chebula* are the common trees. *Santalum album* is occasionally found. In Shimoga and Chickmagalur *Gardenia-Syzygium-Ixora; Syzygium-Canthium-Ixora: Maytenus (Gymnosporia)-Carissa-Catunaregam (Randia)* and *Acacia-Capparis-Euphorbia* communities are found in the evergreen and deciduous scrubs (Puri *et al.*, 1960). In Shimoga District., towards Shimoga the vegetation turns to scrub with *Azima tetracantha, Capparis sepiaria, Cassia absus, C. auriculata, C. congesta, Cocculus hirsutus, Cissampelos pareira* and *Plecospermum spinosum* being dominant. (Raghavan, 1981, 1983). The scrub type in and around areas of Hunisekatte, Kallahalla of Nagarhole in Kodagu District, consists of *Andrographis serpyllifolia, Asparagus racemosus, Barleria buxifolia, Blepharis asperrima, Catunaregam spinosa, Flacourtia indica, Gardenia turgida, Hemidesmus indicus, Leonotis nepetifolia, Opuntia stricta, Plecospermum spinosum, Rungia pectinata, Stachytarpheta jamaicensis* and *Toddalia asiatica* (Keshava Murthy and Yoganarasimhan, 1990)

In some areas, trees like *Anogeissus latifolia, Bauhinia racemosa, Buchanania lanzan, Careya arborea, Cassia fistula, Chlroxylon swietenia, Cochlospermum religiosum, Diospyros melanoxylon, Pterocarpus marsupium, Radermachera xylocarpa, Santalum album* and *Semecarpus anacardium* are seem to prefer these open jungles with scrubby associates. However, the demand for fuel and fodder reduces most areas to scrub and thicket formations. (Nair and Daniel, 1986; Saldanha, 1984 a; Subramanyam and Nayar, 1974).

DRY AND MOIST DECIDUOUS FORESTS

The dry deciduous forests occur on the eastern part of the Ghats and around hills of lower elevation between 300 to 900 m, in several protected areas, which receive moderate rainfall. The canopy is open and the trees leafless during the summer months. Flowering and fruiting are generally, far advanced before the first flush of new leaves. *Anogeissus latifolia* is the most dominant tree in these forests. *Albizia lebbeck, Boswellia serrata, Bridelia retusa, Cochlospermum religiosum, Dillenia pentagyna, Diospyros montana, Ehretia laevis, Emblica officinalis, Gardenia latifolia, Givotia rottleriformis, Grewia orbiculata, G. tiliaefolia, Gyrocarpus asiaticus, Mitragyna parvifolia, Pterocarpus marsupium, Shorea roxburghii, Sterculia urens, Strychnos potatorum, Terminalia* spp., and *Zizyphus xylopyrus* are some of the common typical trees. *Balanites aegyptiaca, Gmelina asiatica, Naringi crenulata* etc. are the armed trees or shrubs well adopted to the marginal forests. *Cansjera rheedii, Cardiospermum helicacabum, Dalbergia volublis, Decalepis hamiltonii, Ipomoea* spp., *Opilia amentica, Secamone emetica etc.* are the common climbers. *Cadada fruticosa, Tarenna asiatica, Ximenia americana* and *Zizyphus oenoplia* are the noteworthy erect or scandent shrubs. The undergrowth consists of *Carvia callosa, Desmodium* spp., *Flemingia strobilifera, Sida rhombifolia* and *Urena lobata.* Besides grass species of *Apluda,* *Eragrostis, Oplismenus, Themeda* and several bulbous plants like *Crinum asiaticum, Habenaria roxburghii, Scilla hyacinthina* and *Urginea indica* are part of the ground floor. *Lantana camara* is found as a naturalised weed. *Cycas circinalis* is a frequent gymnosperm in isolated ravines. Bamboos like *Bambusa arundinacea* and *Dendrocalamus strictus* are commonly met with in these forests. *Phoenix sylvestris* grows in close strands especially in the shallow open valleys between dry hills.

On the lower side of the Ghats and at the foothills, the moist deciduous type occurs having a brief leaf fall, a non stratified understorey of shrubs and climbers as well as a number of epiphytic orchids. It occurs between 500 and 1200 m depending upon the rainfall. In undisturbed areas where the soil is good *Carallia brachiata, Holigarna ferruginea, Hopea parviflora, H. ponga, Syzygium caryophyllatum* and *Vateria indica* constitute a luxuriant tree cover. In degraded areas *Ailanthes malabarica, Alstonia scholaris, Bombax ceiba, Ervatamia heyneana, Lannea coromandelica* are frequent. Common among the canopy trees are *Anthocephalus chinensis, Lophopetalum wightianum* and *Vitex altissima. Garcinia indica* and *Strychnos nux-vomica* are frequent in the understorey. *Xylia xylocarpa* is abundant where laterisation has taken place, *Cordia macleodii* and *Erinocarpus nimmonii* are restricted to the northern moist deciduous forest while *Radermachera xylocarpa* and *Schleichera oleosa* are abundant in the forest around Nagarhole. *Calycopteris floribunda, Hugonia mystax, Salacia fruticosa* etc. are the frequent climbers. *Ixora coccinea, Gomphia serrata, Memecylon malabaricum* and *Uvaria nanum* are the conspicuous common shrubs. The undergrowth of forest has several species of *Ixora* and *Psychotria* and as well as *Mussaenda belilla. Chromolaena odorata* is abundant along forests edges. *Aerides crispum, Dendrobium barbatulum, D. nutans, Pholidota pallida* and *Rhynchostylis retusa* are the epiphytic orchids in profusion. This type gradually merges with the evergreen type through the semievergreen type. Many dry deciduous trees of lower elevations and evergreen trees of higher elevations intrude into this zone. Due to the high yield of valuable timber, these forests have been extensively exploited and consequently greatly disturbed.

Semievergreen forests occur as transitional zones between the evergreen and moist deciduous vegetation. *Antidesma menasu, Apodytes dimidiata, Aporusa lindleyana, Lagerstroemia microcarpa* and *Mallotus tetracoccus* are frequent. *Fragraea ceylanica, Schefflera venulosa* and *S. wallichiana* are the common woody stragglers. *Aeschynanthis perrottetii* and *Remusatia vivipara* are festooned on the trees (Saldanha (1984a & b); Subramanyam and Nayar (1974); Yoganarasimhan *et al.* (1981).

EVERGREEN FORESTS

West Coast Tropical Evergreen forests occur in the lower slopes and valleys of the Ghats. Giant trees with buttressed bases and trunks that are unbranched over

30 m with closed canopy and several strata are characteristic of these forests. There are variations in the composition of the canopy trees not only from north to south but also depending upon soil, slope and altitude. *The Dipterocarpus-Kingiodendron-Vateria* and the *Dipterocarpus-Mesua-Palaquium* associations occur between 70-600 m. Other dominants appear at altitudes of 600-1200 m. The *Memecylon Actinodaphne Syzygium* series has been found in Uttara Kannada and in the western part of Belgaum district. Towards to south in Chickmagalur, Hassan and Kodagu districts, the *Myristica Bischofia Canarium* association is more frequent (Saldanha, 1984 b). Pascal (1988) reported 1. *Persea macrantha-Diospyros* spp.-*Holigarna* spp. (North or river Sharavati to Karnataka northern border from coastal zone to the western edge of the plateau at elevation below 700-800 m), 2. *Dipterocarpus indicus Diospyros candolleana-Diospyros oocarpa* (Shimoga District extending up to Sharavati river up to 850 m (southern part) foot and slopes of Agumbe Ghats 550 to 600 m), 3. *Dipterocarpus indicus - Humboldtia brunonis - Poeciloneuron indicum* (Shimoga District between 700 and 850 m crest of the Ghat on the western slopes), 4. *Dipterocarpus indicus-Persea macrantha* (Shimoga District eastern slopes), 5. *Dipterocarpus indicus-Kingiodendron pinnatum-Humboldtia brunonis* (to the middle of Uttar Kannada downwards in Mercara and Shimoga), 6. *Poeciloneuron indicum-Palaquium ellipticum-Hopea ponga* (Chikmagalur, Hassan, Kodagu Districts - western slopes and 7. *Diospyros* spp. *Dysoxylum malabaricum Persea macrantha* (Shimoga & Uttara Kannada western slopes) these types as probable in the Wet Evergreen forests of the Karnataka portion of the Western Ghats. The most common association is *Dipterocarpus Kingiodendron Vateria* (Saldahna, 1984 a); while *Dipterocarpus indicus Kingiodendron pinnatum Humboldtia brunonis* (Pascal, 1988) covers larger area in the lower elevations.

Other common tall trees are *Artocarpus hirsutus, Holigarna grahamii* and *Lophopetalum wightianum.* The lower strata consists of *Cinnamomum malabaricum, Elaeocarpus serratus, Harpullia arborea, Persea macrantha* and *Scleropyrum pentandrum. Arenga wightii* is the common palm. In the shrub-stratum *Ixora nigricans, I. polyantha, Mycetia acuminata* and *Rhynchotechum permolle* are common. *Ancistrocladus heyneanus* is another common scandend shrub. In the undergrowth *Alpinia malaccensis, Amomum cannicarpum* and *Zingiber montanum* etc. are encountered. *Bauhinia phoenicea, Beaumontia jerdoniana, Chonemorpha fragrans, Entada riheedii Gnetum ula* and *Moullava spicata* are some of the striking woody climbers. *Pothos scandens, Rhaphidophona pertusa* and species of *Peperomia* and *Piper* cling to the trees. *Sarcanthus pauciflorus, Thunia venosa* and many epiphytic orchids add richness to the flora. *Microsorum punctatum. M. memberanaceum, Pleopeltis nuda* and *Pyrrosia ceilanica* are some of the rhizomatous epiphytic ferns. With increase in altitude, the composition of the evergreen forests gradually changes and new dominants appear. *Bischofia javanica, Canarium strictum, Mesua ferrea, Myristica dactyloides, Palaquium ellipticum* and *Poeciloneuron indicum* are some of the canopy trees. The understorey also may have different plants like *Cinnamomum macrocarpum, Litsea floribunda, Symplocos cochinchinensis, Syzygium laetum* etc. (Saldahna, 1984 a).

In Uttara Kannada the evergreen forests are found in central Southern and Western parts of the district in places like Kog, Katgal, Yellapur with the following five communities. *Cinnamomum Olea Diospyros; Diospyros Cinnamomum - Myristica; Hopea - Myristica - Cinnamomum; Myristica - Hopea - Diospyros* and *Myristica Diospyros Polyalthia.* Amongst the evergreen communities *Cinnamomum Myristica Diospyros* type, which has wide range of distribution constitutes the best climax community. The top storey trees in these forests are: *Artocarpus hirsutus, Alseodaphne semicarpifolia, Cinnamomum zeylanicum, Diospyros buxifolia, Elaeocarpus tuberculatus, Holigarna grahamii, Hopea wightiana, Litsea stocksii, Lophopetalum wightianum* and *Polyalthia fragrans.* The second and third storeys consist of *Alseodaphne semecarpifolia* var. *angustifolia, Aporusa lindleyana, Chionanthus mala-elengi, Cinnamomum zeylanicum, Chassalia curvifolia, Diospyros* spp., *Holigarna arnottiana, Ixora brachiata, Olea dioica* and *Psychotria* spp. The tree trunks and branches are perched by a rich growth of orchid species belonging to *Aerides, Bulbophyllum* and *Pholidota imbricata* (Arora, 1960, 1963). Both the sides of the Sharavathi river (between Jog falls and Gersoppa) in Uttara Kannada District is having a dense evergreen vegetation. In high altitudes (300-600 m), the top canopy is occupied by trees like *Artocarpus gomezianus* ssp. *zeylanicus, A. hirsutus, Calophyllum apetalum, Dipterocarpus indicus, Lophopetalum wightianum, Isonandra perrottetiana* and *Vateria indica.* At lower elevations, the top strata is occupied by trees like *Holigarna arnottiana, H. grahamii, Hopea parviflora, H. ponga, Polyalthia fragrans* and *Vepris bilocularis.* The other common trees found in this area are *Actinodaphne malabarica, Cleidion javanicum, Cinnamomum malabatrum, Cryptocarya bourdillonii, Diospyros candolleana, D. paniculata, Ficus asperrima, F. callora, F. glomerata, F. tjakela, Garcinia gummi-gutta, G. indica, G. morella, Knema attenuata, Madhuca nerrifolia, Myristica dactyloides, M. malabarica, Olea dioica, Pterospermum reticulatum, Sapindus laurifolius, Syzygium codyensis, S. courtallense, S. cumini, S. lanceolatum, S. montanum, S. laetum, S. zeylanicum and Trichilia connaroides.* The undergrowth consist of *Antidesma menasu, Aporusa lindleyana, Atlantia racemosa, Canthium dicoccum, C. rheedii, Diospyros saldanhae, Dichapetalum gelenoides, Grewia microcos, Ixora brachiata, I. polyantha, Memecylon talbotianum, M. terminale, Symplocos racemosa* etc. Climbers are represented by *Abrus pulchellus, Calycopteris floribunda, Caesalpinia cucullata, Capparis zeylanica, Cissus discolor, Cyclea peltata, Elaeagnus conferta, Entada rheedii Gnetum ula, Ichnocarpus frutescens, Jasminum flexile, J. malabaricum, J. rottleriana, Moullava spicata, Paramygnia monophyela, Sarcostigma klenii* and *Tetrastigma muricatum.* The common epiphytic orchids are *Dendrobium crepidatum, Pholidata pallida, Porpax reticulata* and *Rhynchostylis retusa. Arenga wightii* is a common palm distributed at higher as well as lower elevations.

The common rattans are represented by *Calamus lacciferus, C. thwaitesii* etc. A small belt of *Pinanga dicksonii* followed by a dense vegetation is found at Kalhalkane, associated with *Myristica fatua* var. *magnifica* in swampy area characterised by knee roots.

The evergreen belt in Agumbe-Hulical ranges in Shimoga District extend all along the Ghat region facing Dakshina Kannada. The altitudinal and horizontal distribution of the forests vary depending on elevation. The forests from foot of Ghat (100 m to crest 400 m) have trees like *Acrocarpus fraxinifolius, Aglaia talbotii, Artocarpus gomezianus* ssp. *zeylanicus, Beilschmiedia gemmiflora, Homalium zeylanicum, Myristica dactyloides, Pterospermum diversifolium, Polyalthia fragrans, Garcinia indica, Strychnos nux-vomica* and *Xanthophyllum flavescens* are found at the foot of Ghats. Species of *Calamus* which form impenetrable breaks higher up are displaced by bamboo at lower down. In the Ghats crest region from 400 to 750 m climax type of evergreen forests occur with trees like *Calophyllum apetalum, Canarium strictum, Cryptocarya bourdillonii, Diospyros sylvatica, Lophopetalum wightianum, Dipterocarpus indicus, Elaeocarpus tuberculatus, Garcinia talbotii, Mesua ferrea, Persea macrantha* and *Poeciloneuron indicum.* The undergrowth is chiefly composed of *Aglaia anamallayana, Chassallia curviflora* var. *ophioxyloides, Dichapetalum gelonioides, Diospyros nigrescens, Euonymus indicus, Gomphandra tetrandra, Lasianthus acuminatus* and species of *Casearia, Ixora, Psychotria, Salacia* etc. A narrow belt of *Poeciloneuron-Mesua* community along with *Aglaia barberi, Meiogyne pannosa* and species *of Psychotria* occurs along the Ghats crest region. Closely follows the *Poeciloneuron - Dipterocarpus* community extending 3-4 km towards the interior with *Dipterocarpus* towering over *Poeciloneuron.* Here *Mangifera indica, Diospyros sylvatica, Palaquium ellipticum, Elaeocarpus tuberculatus* and *Strombosia ceylanica* also attain great heights with prominent buttresses. *Humboldtia brunonis is* a common undergrowth 5-8 km away and *Hopea parviflora* is dominant along with *Cassine glauca, Canarium strictum,* species of *Diospyros* and *Ficus.* In disturbed areas *Lagerstroemia* community is conspicuous. An edaphic varient of these forests is the that community in swampy areas characterised by knee roots. (Kadambi 1960; Raghavan, 1981, 1983.

In Chikmaglur District the evergreen forests are common around the hills and valleys of Bhagavathi, Bhyrapura, Charmadi Ghats, Kemmangundi and Samse where the altitude ranges from 500 to 1500 m. These forests are on the windward side of the Western Ghats. The top layer consists of trees like *Artocarpus hirsutus, Chukrasia tabularis, Elaeocarpus tuberculatus, Gordonia obtusa, Hopea parviflora, Mesua ferrea, Mimusops elengi* and *Vateria indica.* The eco-dominant layer composes of the following species: *Bischofia javanica, Garcinia morella, Humboldtia brunonis, Kmena attenuata, Meliosma simplicifolia, Myristica dactyloides, Persea macrantha, Sapindus laurifolia* and *Archidendron monadelphum.* In the undergrowth *Apama siliquosa, Asystasia chelonoides, Begonia malabarica, Curcuma aromatica, C. zedoaria, Elatostema lineolatum,* *Girardinia diversifolia, Ophiorrhiza mungos, Peliosanthes teta, Pellionia heyneana* and *Rauvolfia serpentia* are common. Climbers and lianas like *Adenia hondala, Aristolochia tagala, Cissampelos pareira, Cissus quadrangularis, Dioscorea bulbifera, Dumasia villosa, Erycibe paniculata, Gnetum ula, Stephania japonica* and *Thunbergia alata* are frequent. In addition species of *Ceropegia, Piper* and *Tylophora* are also noteworthy. The trees are usually covered with epiphytic orchids, aroids and ferns. *Acampe praemorsa, Aerides crispum, Bulbophyllum proudlockii, Dendrobium* spp., *Liparis viridiflora, Oberonia* spp., *Polystachya flavescens, Porpax reticulata, Sirhookera lanceolata* and *Trias stocksii* deserve special mention as epiphytic orchids. The Shola type of vegetation are seen along elevations of 1200 m and above, mainly around Gangamula, Kemmanagundi, Kudremukh and patches of Charmadi Ghats. All the sholas are enclosed by a narrow but a dense belt of *Nilgirianthus heyneanus*. The most conspicuous trees and shrubs of sholas are *Acronychia peduculata, Diospyros saldanhae, Euonymus angulatus, Eurya nitida, Gordonia obtusa, Litsea glabrata, Michelia nilgirica, Pittosporum neigherrensis, Schefflera rostrata, S. venulosa* and *Symplocos cochinchinensis* ssp. *laurina. Elaegnus kologa* is also frequently met as a straggling shrub. (Yoganarasimhan *et al.*, 1981).

In Kodagu District Keshava Murthy and Yoganarasimhan (1990) reported the common occurrence of tall trees such as *Acrocarpus fraxinifolius, Anthocephalus chinensis, Carallia brachiata, Chrysophyllum lanceolatum, Dysoxylum binectariferum, Diospyros sylvatica, Dipterocarpus indicus, Elaeocarpus tuberculatus, Palaquium ellipticum* and *Tetrameles nudiflora* in the top layer of evergreen forests. *Aporusa lindleyana, Artocarpus heterophyllus, Baccaurea courtallensis, Bischofia javanica, Garcinia gummi-gutta, G. xanthochymus, Harpullia arborea, Holigarna nigra* and *Syzygium zeylanicum* are found in the eco-dominant layer. The common lianes and climbers encountered here are *Artabotrys zeylanicus, Bauhinia phoenicea, Capparis cleghornii, Celastrus paniculatus, Entada rheedii* and *Sarcostigma kleinii*. Apart from epiphytic orchids, *Belosynopsis vivipara, Medinilla beddomei, Pothos scandens* and *Peperomia spp.* are the other epiphytic plants. The Ground layer consists of *Asystasia crispata, Jerdonia indica, Ophiorriza hirsutula, Rhynochoglossum notonianum etc.* Shola type of vegetation with genera of tropical and subtemperate regions are seen in higher elevations. The presence of *Cullenia exarillata* in Kodagu District indicates the similarity to the wetter forests of Kerala.

The Northern Kerala Ghat forests have been dealt with by Ansari, 1985 (Kasargod District Thesis unpub.), Chandrasekaran, 1962 (Kerala), Ellis *et al.*, 1968 (Sulthanbathery and Chedaleth), Matthew 1988, (Malapuram District - Thesis unpub.) and Ramachandran & V.J. Nair, 1988 (Kannur District). Pascal (1988) demarked the northern portion of Kerala Ghats with large area under *Dipterocarpus indicus Kingiodendron pinnatum Humboldtia brunonis* type (well conserved from the Periya R.F., Wynaad) and *Cullenia exarillata Mesua ferrea Palaquium ellipticum* type in medium elevations of wynaad plateau in the evergreen zone of forests, apart from the deciduous forests. Ansari (1985) deals with the West Coast Tropical wet-evergreen forests, West Coast Tropical semievergreen forests, Southern Tropical Secondary moist mixed deciduous forests, Laterite scrub forests and riparian vegetation in the mountainous region of Kasargod. The West Coast tropical wetevergreen forests occur on the slopes of hills which are below 1000 m. The trees in the top canopy are formed by *Aglaia elaeagnoidea, Artocarpus hirsutus, Diospyros candolleana, Holigarna arnottiana, Hopea parviflora, Mesua ferrea, Terminalia paniculata, Tetrameles nudiflora* and *Vateria indica.* Trees like *Baccaurea courtallensis* with cauliflorous red flowrs lend a very attractive appearance to these forests. Large area adjacent to the Parappa forest are planted with *Tectona grandis* and *Hopea parviflora* for timbers. Laterite scrub forests are met in Mulleria and Karimbam with common stunted trees of deciduous habit. *Bridelia retusa, Butea monosperma, Cassia fistula, Diospyros candolleana, Holarrhena pubescens, Santalum album, Strychnos nux-vomica, Tectona grandis, Terminalia bellirica* and *T. paniculata* are the common trees here. The shrubs growing in these forests comprise of *Calliocopteris floribunda,* and *Ixora coccinia.*

Ramachandran & V.J. Nair (1988) have dealt with the mountainous zone vegetation of Kannur under the following heads. 1. the moist deciduous type, 2. the semievergreen type, 3. the evergreen type, 4. the sholas and 5. the grasslands, In the moist deciduous forests *Albizia odoratissima, Anogeissus latifolia, Dalbergia latifolia, Haldina cordifolia, Lagerstroemia microcarpa, Mitragyna parviflora, Pterocarpus marsupium, Tectona grandis, Terminalia* spp. etc. constitute the upper canopy. In the semi-evergreen forests the dominant species in the top storey are *Artocarpus hirsutus, Dimocarpus longan, Elaeocarpus tuberculatus, Hopea parviflora, H. ponga, Otonephelium stipulaceum, Vateria indica* and *Xylia xylocarpa.* The evergreen forests are characterised by a high proportion of *Mesua ferrea-Palaquium ellipticum* and *Cullenia exarillata.*The other tall trees are *Bischofia javanica, Drypetes macrophylla, Elaeocarpus tuberculatus, Garcinia gummi-gutta, G. morella, Gordonia obtusa, Knema attenuata, Myristica dactyloides, Reinwardtiodendron anamallayayanum* etc. The second and understorey comprises of *Agrostistachys borneesis, Allophylus distachys, Antidesma menasu, Colebrookea oppositifolia, Ixora elongata, Memecylon hyneanum, Madhuca neriifolia, Mallotus ferrugineus, Olea dioica, Psychotria nudiflora, P. nigra* and *Xanthophyllum flavescens.* A few palms like *Arenga wightii, Caryota urens* and *Pinanga dicksonii* are also conspicus. The important plants in the ground storey are *Begonia malabarica, Clausena heptaphylla, Girardinia diversifolia, Ophiorrhiza* spp., *Scutellaria violacea* and *Thottea siliquosa.* Of the rhizomatous monocots which are conspicuous, *Curcuma* spp., *Boesenbergia pulcherrima, Costus speciosus, Globba ophioglossa, Schumannianthus* and *Zingiber* spp. are noteworthy. Some of the numerous lianas and climbers inter-twinning the trees are *Allophylus concanicus* var. *lanceolatus, Artabotrys zeylanicus, Cissus* spp., *Derris brevipes, Entada rheedii Erythropalm populifolium, Moullava spicata, Mucuna hirsuta, Paramigyna armata, Salacia* *beddomei, Sarcostigma kleinii* and *Toddalia asiatica*. Among orchids, *Dendrobium* spp. predominate. *Acampe ochracea, Bulbophyllum tremulum, Cottonia peduncularis, Oberonia* spp., *Kingidium decumbens, Pholidota pallida, Polystachya flacescens* and *Sirhookera lanceolata* constitute the epiphytic orchids.

The tree fern *Cyathea gigantea* and another large fern *Angiopteris erecta* are the most conspicuous ferns. The Shola type of forest composed of stunted evergreen trees, is characteristically seen along elevations above 840 m around places like Chandanathode, Periyar and Tirunalli. The grasslands usually occur at the top of the hills. *Phoenix loureirii* grows in a scattered manner in the grasslands. The important species of grasses are *Arundinella setosa, Chrysopogon hackelli, Eulalia trispicata, Jansenella griffithiana* and *Themeda* spp. The following specis are commonly interpersed with grasses: *Curcuma neilgherrensis, Euphorbia rothiana, Exacum bicolor, Habenaria longicorniculata, Hypericum rothiana, Hypericym mysorense, Justicia nilgherrensis, Knoxia mollis, Laggera alata, Leucas vestita, Murdannia lanuginosa, Peristylus spiralis* and *Swertia lawii*. Chandrasekaran (1962) dealt with the forest occurring in Malappuram, Wynaad and Kannur districts. Wet Temperate forests occur in the slopes of Nilgiri above Nilambur. The typical sholas in this region are not very considerable but they consist of all or a few of the shola forest elements of Nilgiris. In the Nilambur hills, the forests above 1350 to 1800 m altitude the subtropical Wet Hill forests occur and consist of trees like *Cinnamomum* spp. *Cullenia exarillata, Elaeocarpus* spp. and *Mesua ferrea*. A small bamboo *Teinostachyum wightii* is common at this altitude. In this zone, grasslands are also met with as low level or high level (montane) grasslands, depending upon the altitude. The High Level Evergreen forests occur in Nilambur valley and Wynaad Ghats between 500 to 1250 m. These forests are characterised by a high proportion of *Calophyllum elatum, Cullenia exarillata, Mesua ferrea* and *Palaquim ellipticum*. Bamboo appears mainly as *Ochlandra* brakes along the larger streams but occasionally spreads out on the slopes. The undergrowth is mainly of Rubiaceae members and species of *Strobilanthes* spp. (*s.l.*), *Arenga wightii* and *Pinanga dicksonii* are the common palms. In the low level evergreen forests found in the foothills between 300 m to 500 m in Wynaad Ghats *Hopea parviflora* and *Vateria indica* are abundant while *Calophyllum polyanthum* and *Palaquium ellipticum* occur in low proportion. *Acrocarpus fraxinifolius, Artocarpus hirsuta, Dipterocarpus indicus, Dysoxylum malabaricum, Filicium decipiens, Kingiodendron pinnatum, Schleichera oleosa, Pterospermum rubiginosum* etc. are the other trees. In the semievergreen (secondary) forests of Nilambur, *Canarium strictum, Eugenia* spp., *Hopea parviflora, Sterospermum colais, Tragia polycarpa, Terminalia paniculata, Vateria indica* and *Xylia xylocarpa* are encountered. *Bambusa arundinaceae* occurs in patches. The Moist deciduous (Secondary) forests occur in places like Parappa, Kannoth and Nilambur. The most characteristic species of this type is *Terminalia paniculata* associated with *Adinia cordifolia, Dalbergia latifolia, Lagerstroemia lanceolata, Sterospermum colais, Terminala elliptica* and a few evergreen species. *Bambusa arundinacea* is a typical component of the understorey in many places. *Desmodium* spp., *Glycosmis pentaphylla, Helicteres isora, Leea indica, Limonia acidissima, Mallotus phillippensis* etc. are the common undergrowth. *Bambusa arundinacea* and *Oxytenantheria ritcheyi* are found in Nilambur and Kannoth forests and in Wynaad Plateau. Deciduous forests occur in Chedaleth, Sulthanbathery and Begur from 800-1300 m, where the following species are common: *Adina cordifolia, Anogeissus latifolia, Bombax ceiba, Dalbergia latifolia, Grewia tiliaefolia, Lagerstroemia lanceolata, Pterocarpus marsupium, Tectona grandis* and *Terminalia elliptica* are the notable trees here. *Shorea roxburghii grows* more or less gregariously along the drier eastern boundary with *Anogeissus latifolia*. The under storey consists of *Allophylus cobbe, Cordia dichotoma, Helicteres isora* and *Wrightia tinctoria*.

2. NILGIRI AND SILENT VALLEY

The vegetation of the Nilgiris attracted the attention of Agarwal *et al.*, 1961; Allardyce 1836 ; Asmlam, 1959 ; Beddome, 1876, 1880 ; Bidie, 1880 ; Bor, 1938, 1941, Rege *et al.*, 1959, 1967 ; Jayadev, 1957 ; Noble, 1967 ; Ranganathan, 1938, 1941, 1959 ; Sebastine, 1960 ; Shankaranarayan, 1958, 1959 ; Sharma *et al.*, 1977, 1978 ; Shetty & Vivekananthan, (1983) ; Theagarajan (unpub.) and Vajravelu & Chandrasekaran (1983) along with many other workers. The significnant geographical location, wide range of topographic features having the altitude varying from 300 to 2,637 m, the unique proximity of triseas to these hills, the marked difference in rainfall ranging from 700 mm to 7,629 mm, the high intensity of solar radiation with significant diurnal range of temperature are mainly responsible for the richness, uniqueness, and unusual diversity in the vegetation pattern of the Nilgiries. Almost all the important forest types of South India are represented here. Tropical thorn forests, Tropical dry-deciduous forests, Tropical moist-deciduous forests, Tropical semi-evergreen forests, Tropical wet evergreen forests, subtroical broad-leaved forests, Southern montane wet temperate forests popularly known as " Sholas " interspersed with Southern montane wet grasslands (Savannah), Subtropical hill savannah and Fresh Water swamps which are peculiar to the hills are encountered in these hills. These include their seral and edaphic modifications having variations in floristic composition. Four distinct regions for the Nilgiris can be recognized viz. i) the Nilgiri plateau, ii) the Nilgiri-Wynaad, iii) the Sigur plateau and iv) the outer slopes facing the plains on the east and west. (Jayadev, 1957 ; Sharma *et al.*, 1977).

i) Nilgiri plateau

Southern montane wet temperate forests (locally known as Sholas) interspersed with large tracts of Southern montane wet grasslands (Shrub Savannah) are the main type occurring above 1,600 m altitude mostly in and around Kundah, Naduvattam, Nilgiri Peak, Parson Valley, Porthmund, Pykara, Staircase Shola and Governors Shola. The Sholas are compact, sharply well defined small woods confined to sheltered valleys, glens, hollows and depressions where there is adequate moisture and good drainage. They are distributed all over the range but their composition, the size and height of the trees vary according to altitude and the velocity of wind. In places like Bangitappal, Sispara and in Western Catchment area where the altitude is more than 1,900 m the Sholas are few and smaller with poor stunted trees of one to three metres high. But the Sholas change considerbably with the decrease in altitude, there being a gradual increase in the growth of trees until finally they merge with the well defined Southern subtropical hills forests. The tree species of the Sholas are all of predominantly of tropiclal stock and evergreen represented mostly by members of natural orders Celastraceae, Elaeocarpaceae, Icacinaceae, Lauraceae, Myrtaceae and Symplocaceae. The undergrowth consists of a large number of species of Acanthaceae (*Strobilanthes* spp. *(s.l.)*) and Rubiaceae. The ground flora consists of great wealth of ferns, mosses and fungi. The epiphytic flora which is abundant, consists of orchids, ferns, Lichens and Byrophytes. There is no difference in canopy layers. However, the total absence of tropical families like Anacardiaceae, Annonaceae, Bixaceae, Datiscaceae, Dipterocarpaceae, Ebenaceae, Sterculiaceae etc. which are characteristic of tropical rain forests of the adjacnent regions is striking. The principal tree species which characterise the Shola type of vegetation are *Cryptocarya lawsonii, Daphniphyllum neilgherrense, Elaeocarpus serratus, Euonymous crenulatus, Gordonia obtusa, Ilex denticulata, Litsea floribunda, L. oleoides, L. wightiana, Meliosma pinnata* ssp. *barbulata, Michelia nilagirica. Microtropis microcarpa, M. ramiflora, Phoebe wightii, Schefflera rostrata, Symplocos foliosa, Syzygium calophyllifolium, S. densiflorum, S. tamilnadensis* and *Vaccinium leschenaultii. Melicope indica, Memexylon flavescens, Symplocos macrophylla* ssp. *microphylla* and *Viburnum hebanthum* are the endemic elements occuring here.

Along the margins of sholas *Eurya nitida, Gaultheria fragrantissima, Rapanea wightiana, Rhododendron arboreum* ssp. *nilagiricum, Rhodomyrtus tomentosa, Symplocos cochinchinensis* ssp. *laurina, Ternstroemia gymnanthera* and *Turpinia nepalensis* are common. The undergrowth consists of *Calanthe triplicata, Elatostema lineolatum* var. *falcigera, Lasianthus* spp., *Lycianthes laevis* ssp. *kaitisis, Myriactis wightii, Pavetta breviflora* var. *glaberrima, Pilea melastomoides, Pogostemon wightii, Psychotria bisulcata, P. nilgiriensis, Saprosma foetens, Strobilanthes* spp. *(s.l.)* and many ferns like, *Adiantum cuneipinnulum, Asplenium lunulatum, A. tenuiifolium, A. zenkerianum,, Dryopteris filixmax, Polystichum aculeatum, P. auriculatum, Pteris cretica* and *P. quadriarita. Cyathea nilgirensis* is a noteworthy fern found particularly along streams inside the sholas. Epiphytic orchids such as *Aerides ringens, Coelogyne odoratissima, Oberonia* spp. and *Schoenorchis filiformis* are frequently met with. Climbers are represnented by *Piper mullesua, P. schmidtii, Rosa leschenaultiana, Senecio corymbosus, S. intermedius, Toddalia asiatica* var. *floribunda* etc.

The Southern montane wet grasslands (shrub Savannah or high altitude grasslands) are extensive and include a complex of grasses, herbs, undershrubs and few shrubs and trees. *Chrysopogon zeylanicus Arundinella* spp. type of savannah is well represented on the Wenlock downs and Mukurti region (Blasco, 1971). *Andropogon polyptychus Eulalia phaeothrix* type of grassland occurs above 1,800 m elevation. *Andropogon lividus, Arundinella purpurea, A. setosa, Bothrichloa insculpta, Eragrostis nigra, Ischaemum indicum* and *Tripogon bromoides* are the other main species. A large number of ligneous and herbaceous plants like *Anaphalis neelgerryana, Heracleum hookerianum, Leucas rosmarinifolia, Pleocaulus sessilis* and *Senecio polycephalus* occur here. *Anemone rivularis, Fragaria nilgerrensis, Habenaria* spp., *Impatiens* spp. etc. also occur in large proportion in this area. In limited areas *Cymbopogon Eulalia* subtype and *Themeda triandra* dominant type of grasslands are found. High rainfall savannah are encountered in the southern and western part of Nilgiris in places like Western Catchment area, Upper Bhavani which are extremely windy and rainy during the S.W. monsoon. The altitude here is about 2,400 m and the mean annual rainfall exceeds 5,000 mm (in places like upper Bhavani and Arikayampuzha). Rainfall g 2,000 to 4,000 mm in one single month July or August are not rare here. In these places the "monsoon flora" is very interesting with a number of ephemerals and a great profusion of *Impatiens* spp. The vegetation is characterised by a herbaceous cover and more or less discontinuous because of rocky outcrops. *Themeda triandra* and *Isachne* spp., are well adopted in the region. *Anaphalis neelgerryana, A. wightiana, Andrographis lawsonii, Leucas suffruticosa, Phlebophyllum lawsonii* and *Teucrium wightii* are other small shrubs and herbs. The woody *Rhododendron arboreum* ssp. *nilagiricum, Ligustrum perrottetii* and *Syzygium calophyllifolium* are also met here with in a stunted form.

Among the common herbs and ligneous species growing amidst grasses mention may be made of *Asyneuma fulgens, Bupleurum distichophyllum, Clinopodium umbrosum, Dipsacus leschenaultii, Drosera peltata, Gentiana pedicellata* var. *wightii, Geranium nepalense, Heracleum ringens, Justicia* spp., *Osbeckia leschenaultiana, Pimpinella leschenaultii, Polygala sibirica, Prunella vulgaris* var. *hispida, Ranunculus reniformis, Senecio lavandulaefolius, Spiranthes lancea, Swertia corymbosa, Valeriana leschenaultii* and *Wahlenbergia marginata. Anaphalis notoniana, Hedyotis hirsutissima, Helichrysum wightii, Heracleum hookerianum, Senecio lessingianus, S. polycephalus* and *Teucrium wightii* are the noteworthy endemic species amidst grasses.

The presence of temperate species like *Alchemilla, Anemone, Gaultheria, Geranium, Lysimachia, Mahonia, Rhododendron, Thalictrum* and *Vaccinium* on these high altitude grasslands and margins of Sholas is interesting and has roused the interest of many phytogeographers and various theories (Hooker, 1906 ; Blasco 1971b ; Meher-Homji, 1965, 1967; Theagarajan (unpub.) have been proposed.

Swamps and marshes in grasslands filled with peat deposits are noteworthy feature in Kundah Range. Hooker (1904) pointed out that the presence of peat bogs in depressions of Nilgiri hills western slopes at about 2,000 m is a rare occurrnece. The curious plant *Pleiocraterium verticillara* (Rubiaceae) is characteristic of these bogs. The surface of these bogs is covered with herbaceous species of *Carex, Eriocaulon, Juncus, Isachne, Utricularia* and *Xyris*. The grass *Eriochrysis rangacharii* is a soil indicator and it indicates the peaty undrained, soils of Nilgiris (Chinnamani, 1983). In the marshy places *Drosera burmannii, Eriocaulon nilagirense, E. robustum, Fimbristylis kingii, Juncus inflexus, J. prismatocarpus, Laurembergia hirsuta, Lysimachia procumbens, Myriphyllum oliganthyum, Plantago erosa* and *Rotala rotundifolia* are encountered. *Osmunda regalis* is found frequently growing amidst rocks near streams in grassland.

Southern subtropical hill forests are found where the altitude is less than 1,600 m and on the slopes between 1,000 and 1,600 m and in Kundah range at places like Avalanche, Carrington, Thai Shola and on the eastern side of Doddabetta hills, neighbourhoods of Coonoor, in the valleys of Amarampalam, Ouchterlony, Naduvattam, T.R. Bazaar, Pakasura hills and certain areas in Nilgiri eastern slopes. Some of the common trees noted in the regions are *Celtis tetrandra, Cinnamomum* spp., *Elaeocarpus* spp., *Garcinia gummi-gutta, Litsea wightiana, Neolitsea cassia, Olea glandulifera, Persea macrantha, Prunus ceylanica, Syzygium* spp., *Vernonia monosis* and *Viburnum coriaceum*. The undergrowth consists of *Calamus* spp., *Chassalia curviflora* var. *ophioxyloides, Lepianthes umbellata, Polygala arillata, Sarcandra chloranthoides, Strobilanthes* spp. *(s.l.)* etc. Adjacnent to these forests, South Indian subtropical Hill Savannah (low level grasslands) are found. *Phoenix loureirii* is found in abundnance in these grasslands. The other plants encountered are *Breynia retusa, Clerodendrum serratum, Glochidion velutinum, Osyris quadripartita* and *Wendlandia thyrsoidea*.

The evergreen scrub vegetation occurs in extensive areas in certain tracts particularly in Coonoor range, west of Pykara, around Naduvattam and Udhagamandalam. These may be either distributed sporadically or may occur in smaller or larger patches. This serial stage is found in cleared shola and subtropical hill forest sites (Southern montane wet scrub). The components in this type of scrub are *Berberis tinctoria, Dodonaea viscosa, Gaultheria fragrantissima, Hypericum mysurense, Mahonia leschenaultii, Osyris quadripartita, Rhodomyrtus tomentosa, Rubus* spp., *Strobilanthes* spp. *(s.l.)*, *Wendlandia thyrsoidea* etc. Stray species of *Rhododendron arboreum* ssp. *nilagiricum* and haggard individuals of *Syzygium densiflorum, Vaccinium neilgherrense* etc. are also met with. Various kinds of formations from pure *Hypericum mysurense* or *Pteridium aquilinum* to more mixed formations with a few plants of Shola species are found. The extensive plantations of coffee, eucalyptus, tea and wattle have affected the natural vegetation of Nilgiris to a great extent. Moreover, the varied topography and climate have stimulated many generations of farmers, gardners and foresters to introduce and establish useful and decorative plants from other parts of the world. Plants like *Ageratina adenophora, Ageratum houstonianum, Erigeron karvinskianus, Helichrysum bracteatum, Sarothamnus scoparius, Solanum sisybrifolium* and *Ulex europeus* have become naturalised and form dominant floral elements.

ii) Nilgiri-Wynaad plateau

The Mudumalai, Cherambady ranges and some area in the north-western corner of the Sigur range comprise the Nilgiri-Wynaad plateau. The average altitude of this plateau is about 1,000 m (varies between 350 to 1,250 m) and the rainfall varies from 1,000 to 4,500 mm. Mainly depending on the amount of annual rainfall, various subtypes of the moist deciduous and dry deciduous teak forests occur in different parts of this tract. Patches of evergreen and semi-evergreen forests occur in Cherambady range and Benne block where the annual rainfall is high. The forests vary from dry deciduous scrub on the eastern end to dry deciduous and then moist deciduous with an increasing admixture of evergreen elements as they progress further towards Benne. The Mudumalai wild life sanctuary (335 sq km) the largest and the best known sancturay in Tamil Nadu is situated here.

West coast tropical evergreen forests occur in larger patches in the Cherambady range and in small patches in Benne. These are some of the best forest areas from the point of view of height and growth of trees as well as luxurience. The important tree species of these forests are: *Cullenia exarillata, Elaeocarpus serratus, E. tuberculatus, Euodia lunu-ankenda, Meliosma simplicifolia, Litsea wightiana, Olea dioica, Persea macrantha* and *Viburnum punctatum. Allophylus cobbe, Leea indica, Schunmannianthus virgatus, Strobilanthes* spp. (*s.l.*) etc. are the common components in the undergrowth. West coast semi-evergreen forests occur as ecotone zones between the west coast tropical evergreen forests and the mixed deciduous forests in Benne and Cherambady. *Artocarpus* spp., *Bischofia javanica, Dimocarpus longan, Holigarna arnottiana, Radermachera xylocarpa, Schleichera oleosa, Sterculia guttata* and *Toona ciliata* are some of the common trees here.

Southern moist mixed deciduous forests: *Tectona grandis,* with its associates and *Terminalia* spp. are abundnant here. Further the trees attain impressive height and the undergrowhth is rather dense. The other trees are *Antidesma acidum, Cassia fistula, Eriolaena quinquelocularis, Givotia rottleriformis, Gmelina arborea, Haldina cordifolia, Lagerstroemia microcarpa, Mitragyna parviflora, Phyllanthus emblica, Pterocarpus marsupium, Radermachera xylocarpa, Schrebera swietenoides, Semecarpus anacardium, Sterospermum colais, Syzygium cumini, Vitex altissima* and *Ziziphus xylopyrus.* The undergrowth consists of *Andrographis* *serpyllifolia, Byttneria herbacea, Clerodendrum viscosum, Colebrookea oppositifolia, Desmodium pulchellum, D. triangulare, D. velutinum, D. zonatum, Gomphostemma heyneanum, Grewia hirsuta, Helicteres isora, Leea asiatica, Pygmaeopremna herbacea* and *Triumfetta rhomboidea.* Orchids such as *Habenaria plantaginea, Nervilia aragoana* and *Peristylus goodyeroides* are also common in the undergrowth.

In Southern secondary moist mixed deciduous forests, *Alstonia scholaris, Callicarpa tomentosa, Macaranga peltata, Mallotus tetracoccus, Spondias pinnata* and *Trewia nudiflora* are common. The moist Teak forest exhibit variations in growth according to the amount of rainfall. The dry Teak forests occur much of the Doddakatti block and considerable areas of Mudumalai and Teppakadu blocks. The growth of trees are generally poor. There is a dense undergrowth of tall grasses and in certain localities *Lantana* bushes are frequent. *Themeda triandra* is preponderance in drier and more open areas, while *Themeda quadrivalvis* is dominant in less open parts. *Bambusa arundinacea* is common throughout this plateau particularly along the banks of stream. In Cherambady range, large tracts of grasslands are conspicuous feature of the landscape. *Phoenix loureirii*, the dwarf palm, occurs gregariously in these grasslands.

iii) The Sigur plateau

Two main types of vegetations are met with in this region. 1) Tropical dry deciduous forests and 2) Southern cutch thorn forests. The graudual degeneration of the deciduous forest resulting in the formation of thorn forest has been observed in the region and hence the two types of elements are mixed here and there, in places like Bokkapurmam, Moyar and Avaihalla reserve forests. Large trees interspersed with bamboo brakes are restricted to the banks of streams. Throughout this plateau in the tropical dry deciduous forests *Anogeissus latifolia* is predominantly seen. Other common trees are *Allophylus serratus, Buchanania lanzan, Cochlospermum religiosum, Dalbergia lanceolaria, D. latifolia, D. paniculata, Diospyros montana, Cassine glauca, Embelia tsjeriam-cottam, Erythroxylum monogynum, Givotia rottleriformis Gmelina arborea, Diospyros ferrea* var. *neilgherrensis, Madhuca longifolia* and *Pterocarpus marsupium.* Among shrubs and climbers *Argyreia cuneata, Carissa carandas, Maytenus heyaneana, Jasminum cuspidatum, Scutia myrtina* and *Ventilago madraspatana,* are noteworthy. In the Southern cutch Thorn forests *Acacia chundra, A. leucopholea, Ziziphus oenoplia, Z. mauritiana, Z. xylopyrus* etc. are some of the tree species intermixed with *Santalum album*. The open sandal bearing scrub is very characteristic of this area. The following shrubs and climbers are common: *Canthium parviflorum, Capparis sepiaria, Grewia abutilifolia, Opuntia dillenii, Pterolobium hexapetalum, Scutia myrting* and *Securinega leucopyrus.*

iv) The forests of outer slopes

The forests of outer slopes exhibit marked altitudinal zonation from thorny scrub to evergreen forests. The slopes facing Tamil Nadu under the Western block includes Hulical Drug Reserve forest, Pillur slopes Reserve forest and Nellithorai Reserve forest. The forests are of scrub jungles though there are a few patches of dry deciduous forests and evergreen or semi-evergreen along the river banks. Sebastine (1960) and Vajravelu & Chandrasekaran (1981 (1983)) have given a detailed account of these forests. Rare and interesting orchids like *Eulophia pulchra, Thrixspermum muscaeflorum* var. *nilagiricum* and *Vanilla* are found in these forests.

In the north of Palghat gap and to the south-east of the Nilgiris, there is a small group of hills in the form of horse shoe facing Coimbatore and it is said to be the "Spur of the Nilgiris" (Baliga, 1966). The whole forest range is known as Boluvampatti R. F. and the vegetation of hillocks like Vellingiri, Maruthamalai, Kuridimalai and Siruvani has been dealt by Henry (Thesis unpub. 1963), Sebastine (1959), Sreemadhavan (Report, 1965), Subramanian (1966), Subramanyam (1959) and Viswanathan (Report, 1972). Southern tropical thorn forests, Southern dry mixed deciduous forests. Dry Savannah, South Indian subtropical hill Savannah and Southern subtroipical hills forests (evergreen) are encountered here. The occurrence of *Vateria macrocarpa* (Dipterocarpaceae) an endemic tree in the Boluvampatti Range, needs special mention.

SILENT VALLEY

The verdent Silent Valley covering an area of about 8,952 hectares is situated in the south western corner of Nilgiris (on the lower side of Nilgiri plateau) in the Palakkad District of Kerala. The contributions of Aiyar, 1932, 1933 ; Chand Basha, 1977 ; Chandrasekharnan, 1962 ; Iyppu, 1960 ; Krishnamoorthy, 1960 ; Manilal, 1981, 1988 ; Nair, 1981, Nair *et al.*, 1979, 1980, 1980 a ; Rammakrishnan, 1984 ; Singh *et al.*, 1984 a, b ; Swaminathan, 1979 ; Vajravelu, 1990 ; Vohra *et al.*, 1982 enriched the knowledge about the vegetation of the Silent Valley.

The Silent Valley forests represent the only comparatively undisturbed patch of tropical evergreen rain-forests which constitute a rich flora and a valuable gene pool. Most of the features that are commonly attributed to tropical rain-forests are shown to be plentifully displayed by the forests of Silent Valley (Singh *et al.* 1984 a, 1984 b ; Ramakrishnan, 1984). Nair (1981) clearly indicated that Silent Valley has still a vast stretch of relatively undisturbed tropical wet evergreen forest harbouring a rich and complex flora unsurpassed by any tract in Kerala. These forests fall under tropical wet evergreen forests, West coast tropical evergreen forests, High level evergreen forests according to Champion & Seth (1968) & Chandrasekharan (1962). Common in these forests are *Calophyllum polyanthum*, *Cullenia exarillata, Mesua ferrea, Palaquium ellipticum, Persea macrantha* and *Poeciloneuron indicum*. The absence of any Dipterocarpus species is significant. Manilal (1988) on the basis of ecological characters has classified Silent Valley forests into four broad region i) the upland reigion, ii) the riparian reigion, iii) the slopes and iv) the submergible area (in the event of construction of dam). Apart from these forest regions, patches of grassland are also found in the valley. The most magnificient among forests, viz. Tropical wet evergreen forests occur in the Silent Valley. The lofty trees of the top storey might reach a height of 45 m or more. The most common dominant species of the top storey at Silent Valley area are *Actinodaphne campanulata, Agrostistachya borneensis, Calophyllum polyanthum, Cinnamomum malabatrum, Cullenia exarillata, Elaeocarpus glandulosus, Litsea floribunda, Mesua ferrea, Myristica dactyloides, Palaquium ellipticum* and *Poeciloneuron indicum* (Manilal, 1988). Apart from these *Actionodaphne tadulingamii, A. elaeagnoidea* var. *beddomei, Artocarpus heterophyllus, A. hirsutus, Calophyllum apetalum, Canarium strictum, Dipterocarpus indicus, Elaeocarpus munronii, E. tuberculatus, Knema attenuata, Reinwardtiodendron anamallayanum, Tetrameles nudiflora* and *Vateria indica* are the other common trees reported from the top storey (Nair, 1980 ; Vajravelu, 1990). Buttresses are seen in some of these giant trees such as *Dimocarpus longan, Elaeocarpus tuberculatus, Mesua ferrea*. Cauliflory (ramiflory) is exhibited by some of the trees like *Artocarpus heterophyllus, Baccaurea courtallensis, Cullenia exarillata, Diospyros bourdillonii*. Some dominant trees in the middle layer or storey are *Acronychia pedunculata, Actionodaphne malabarica, Antidesma menasu, Bischofia javanica, Cinnamomum macrocarpum, Drypetes longifolia, Glochidion ellipiticum, Homalium zeylanicum, Hydnocarpus alpina, H. pentandra, Macaranga indica, Mallotus beddomei, Xanthophyllum flavescens*, etc. The third storey consists of *Antidesma menasu, Cayratia pedata, Helicteres isora, Isonandra lanceolata, Lasianthus jackianus, Laportea crenulata, Leea indica, Memecylon heyneanum, Nilgirianthus heyneanus* var. *neesii, N. foliosus, Pavetta hispudula, Saprosma fragrans, Syzygium* spp., *Thottea siliquosa* etc. (Vajravelu 1990). Large population of *Calamus rotang* and *Laportea crenulata* makes the forest impenetrable. The following are some of the components of the ground floor. *Anaphyllum wightii, Begonia malabarica, Lepianthus umbellata, Neuracalyx calycinus, Ophiorrhiza hirsuta, Pellionia hirsutula, Rhynchotechum permolle* and *Sarcandra chloranthoides*. Many ferns and fern allies are common as undergrowths. The common woody climbers are *Artabotrys zeylanicus, Bauhinia vahlii, Cayratia pedata, Cissus glyptocarpa, Gnetum ula, Spatholobus parviflorus, Strychnos wallichiana, Tetrastigma sulcatum* and *Zanonia indica*. Thin stemmed climbers include species like *Aristolochia indica, A. tagala, Dioscorea bulbifera, D. oppositifolia, D. tomentosa, Piper nigrum* etc.

Aiyar (1932) mentions the following associations of tree species in the tropical rain forests: 1) The *Cullenia-Palaquium* association 2) The *Palaquium-Mesua* association 3) The *Poeciloneuron-Palaquium* association 4) The Reed-*Poeciloneuron* association 6) The *Mesua-Calophyllum* association 7) The *Vateria-Cullenia* association and 8) The *Vateria-Meseua* association. The association of reed with either *Calophyllum* or *Poeciloneuron* is not prominent now as a result of degradation of these forests, due to human interference (Vajravelu, 1990).

In the riparian region *Euonymus angulatus, Gordonia obtusa, Helicia nilagirica, Lophopetalum wightianum, Pithecellobium monadelphum, Rapanea wightiana, Syzygium hemisphericum* and *Vaccinium neilgherrense* are the common trees. *Erthroxylum obtusifolium, Floscopa scandens, Homonia riparia, Lagenandra meeboldii, Najas indica, Persicaria chinensis, Rotula aquatica, Schumannianthus virgatus* are the common shurbs and herbs. At certain places on the banks of Kunthipuzha a very large populations of *Ochlandra species* occur. *Arenga wightii, Pinanga dicksonii, Schumannianthus virgatus* etc. are also found in large populations on the banks of Kunthipuzha river.

On grassy slopes species of *Phoenix* are usually seen. A good amount of terrestrial orchids are found here including the showy one *Pecteilis gigantea*. Other common components of these grassy slopes are *Aeginetia pedunculata, Crotalaria nana, C. salvifolia, Exacum bicolor, E. sessile, Leucas flaccida* var. *scaberula, Pleocaulus sessilis, Polygala rosmarinifolia, Smithia blanda, Tephrosia pulcherrima*, etc. The common grasses found in these grasslands are *Arundinella ciliata, A. mesophylla, Capillipedium huegeli, Chrysopogon hackelii, Cymbopogon flexuosus, Eleusine indica, Eragrostis cilianensis, E. pilosa, Garnotia schmidii, Isachne gracilis, Oplismenus compositus, Panicum gardneri, Paspalum conjugatum, Setaria palmifolia, Sprobolus piliferus* and *Tripogon bromoides* (Vajravelu, 1990). Among pteridophytes the most rewarding collections are of *Elaphoglossum nilagiricum, Lindsaea malabarica, Lycopodium ornata, Pteris dactyana* and *P. geminata* (Nair, 1981).

Silent Valley harbours a large amount of endemic, (About 65 endemic species of western Ghats from Palakkad District) rare and interesting plants. Many plants new to science, like *Curcuma silentvalleyii, Eria tiagu, Hedyotis silentvalleyensis, Hydnocarpus pendulus, Liparis indiraii, Oberonia bisaccata, Piper nigrum* var. *silentvalleyensis, Porpax chandrasekharanii, Sauropus saksenianus, Silentvalleya nairii* have been described recently from here. Many Indo-Malayan and Sri Lankan plants have been found in Silent Valley whereas some of them have not been collected in recent times even from their original homes (eg. *Dendrobium panduratum*, Sri Lanka orchid).

SOUTHERN GHATS THE ANAIMALAI, PALNI AND CARDAMOM HILLS

Beyond Palghat Gap, the Southern Ghats passes through the states of Tamil Nadu and Kerala and three major tracts, *viz.* Anaimalai, Palni and Cardamon hills are there.

Anaimalai tract

This includes the Anaimalai (Coimbatore District, Tamil Nadu), Nelliamapathy (Palakkad District, Kerala), Parambikulam (Thrissur District, Kerala) and adjacent Anaimudi, Eravikulam National Park and High Range (Idukki District, Kerala). The salient features of the vegetation have been studied by Bhadran & Achaya, 1960 ; Chandrasekaran, 1962; Fischer, 1921; Sebastine & Ramamurthy, 1966 (Parambikulam) ; Sebastine & Vivekananthan, 1968 (Devicolam) ; Shetty & Vivekananthan 1973 (Anaimudi) ; Vajravelu & Joseph, 1971 (Anaimalai) ; Vajravelu, 1990 (Nalliampatty).

The dry and semi-desert type of scrub jungles occur in low eastern region in the Amaravati valley and extend more or less along the foot of Anaimalai hills facing Tamil Nadu between 300 to 500 m. Some of the common species of trees and shrubs that may be found here are *Acacia horrida, A. planifrons, Commiphora berryi, Dichrostachys cinerea, Drypetes sepiaria, Euphorbia antiquorum, Manilkara hexandra, Pterolobium hexapetalum* and *Salvodora persica* var. *wightiana.* Along streams, *Acacia polyantha, Calamus rotang* and *Hopea parviflora* are found (Fischer, 1921). In this scrub jungles plants like *Barleria acuminata, Catunaregam spinosa, Clerodendrum viscosum,* and *Lantana camara* are abundant. Climbers like *Cardiospermum canescens, Cissus repanda, Ipomoea staphylina, Leptadenia reticulata, Loesceneriella obtusifolia* and *Teramnus labialis* are common in the area. The most common undershrubs in the area are: *Asystasia crispata, Barleria prionitis, Cassia hirsuta, Hibiscus ovalifolius, Indigofera hirsuta, I. trita* var scabra, *Justicia glabra, Pavonia procumbens, Tephrosia maxima* and *T. purpurea.* The ground vegetation is composed of the following plants: *Blainvillea acmella, Eragrostis unioloides, Euphorbia hirta, Geniosporum tenuiflorum, Leptochloa unifolia* and *Polycarpaea corymbosa* (Sebastine & Ramamurthy, 1966). In some areas the vegetation in mostly of scrub jungle with a combination of dry deciduous type.

In the outer slopes between 500 to 1200 m, dry deciduous forest occurs with the following common trees : *Albizia odoratissima, Butea monosperma, Buchanania lanzan, Cassia glauca, Cochlospermum religiosum, Eriolaena quinquelocularis, Ficus arnottiana, Givotia rottleriformis, Lepisanthes senegalensis, Shorea roxburghii* and *Sterculia urens.* In the moist deciduous type of forest which occurs between 500 and 800 m, *Tectona grandis* and its associates *Dalbergia latifolia, Lagerstroemia microcarpa, Pterocarpus marsupium* and *Terminalia elliptica* attain their largest dimensions. *Bambusa arudinacea* also occurs here. Mixed Dry deciduous forests with Sandal occurs in the Anjanad valley situated in the leaward side of the Ghats (Chandrasekharan, 1962).

The Moist evergreen forests occur in large areas and also in a few compact but isolated patches in areas like Top slip, Karianshola Palakadavu, Ulandi and Mount Stuat Blocks. The canopy is extremely dense and there is a distinct differentiation into layers or tiers. The dominant trees like *Peociloneuron indicum* attain an height of 50 m or more with plank buttresses. Epiphytes ae numerous, especially aroids, ferns, mosses and orchids. The chief species occurring in the top storey are *Aglaia elaeagnoidea, Aphananmixis polystachya, Artocarpus heterophyllus, Calophllum polyanthum, Canarium strictum, Cullenia exarillata, Diospyros ebenum, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Heritiera papilio, Hopea parviflora, Mesua ferrea, Palaquium ellipticum, Poeciloneuron indicum* and *Vateria indica.* In the second storey *Acronychia pedunculata, Agrostistachys borneensis, Cyclostemon macrophyllus, Eugenia* spp., *Gomphandra coriacea, Goniothalamus wightii, Isonandra lanceolata, Macaranga tomentosa, Archidendron monadelphum, Reinwardtiodendron anamallayanum, Unona pannosa* etc. occur. Species of *Litsea* and *Myristica* are prominent. The understorey is having *Calamus* spp., *Ixora nigricans, Laporta crenulata, Psychotria anamallyana, P. nigra, Sarcandra chloranthoides, Strobilanthes* spp. *(s.l.)* and *Tabernaemontana divaricata* (Bhadran & Achaya, 1960 ; Fischer, 1921).

Different local association or subtypes may be distinguished in Anaimalai evergreen forests. They are *Hopea - Mesua* association in comparatively dry types of Tunacadavu and Ulandi block in which *Hopea parviflora* and *Mesua ferrea* occur in appreciable quantities. The intermediate *Palaquium Mesua* association found in portions of the Punachi range where the preponderate species are *Mesua ferrea* and *Palaquium ellipticum*. The Wet Sholas in regions in the Italar Valley of the Punachi range where the predominating tree species is mostly *Poecilneuron indicum* with a small admixture of *Cullenia exarillata Poecilneuron Cullenia* association. Pascal (1988) divides this region as high altitude montane Shola (*Schefflera* spp. *Meliosma pinnata* ssp. *barbulata Gordonia obtusa*) and medium altitude (*Cullenia exarillata Mesua ferrea Palaquium ellipticum*) types.

The vegetation of high plateau of Anaimalai, Anaimudi and Eravikulam National Park (High Range of Kerala) consists of vast expanse of shrub-savannah (grassland) interspersed with a number of isolated compact woods locally known as sholas. Roughly the grassland constitutes 85% of the vegetation and the shola forest 15%. The following three physiognomic zones are recognised here *viz.* 1) Sholas, 2) tree and shrubby zone at the periphery and 3) Shrub-savannah (Meher-Homji (1967). The principal tree species in sholas being *Actinodaphne bourdillonii, Elaeocarpus recurvatus, Ilex denticulata, I. wightiana, Ligustrum perrottetii, Litsea wightiana* var. *tomentosa, Michelia nilgirica, Microtropis ramiflora, Pithecellobium subcoriaceum, Pittospermum tetraspermum, Schefflera racemosa, S. rostrata, Symplocos pendula* and *Syzygium densiflorum.* Trees found along the fringes of sholas are *Eurya nitida, Photonia integrifolia* var. *sublanceolata, Rhododendron arboreum* ssp. *nilagiricum, Rhodomyrtus tomentosa, Symplocos cochinchinensis* ssp. *laurina, Ternstroemia gymnanthera* and *Turpinia nepalensis.* The shrubs and herbs confined to the margins of sholas are *Berberis tinctoria, Disporum leschenaultianum, Euphorbia rothiana, Gaultheria* *fragrantissima, Hedyotis stylosa, Jasminum bignoniaceum, Leucas lanceaefolia, Moonia heterophylla, Smithia blanda* and *Valeriana arnottiana.* The undergrowth in the shola are *Abelmoschus angulosus, Elatostema surculosum, Impatiens phoenicea, Psychotria nilgiriensis, Strobilanthes* spp. etc. Among the climbers *Piper nigrum, P. schmidtii, Rubia cordifolia, Tylophora pauciflora* etc. are the most frequent. *Aerides ringens, Coelogyne mossiae, C. nervosa, Dendrobium nanum, Eria dalzellii, E. pauciflora, Oberonia sebastiana, O. wightiana, Schoenorchis filiformis* are some of the epiphytic/lithophytic orchids. *Helixanthera obtusata* and *Korthalsella japonica* are the two common parasites. Tree ferns *Cyathea crinita, C. spinulosa* are occurring here. On the margins of streams *Rapanea capitellata* and *Vaccinium leschenaultii* are the characteristic trees. *Impatiens tangachee* with its attractive lilac flowers is growing from the clefts of rocks in the rapid streams.

The shrub-savannahs are extensive and include a complex of grasses, herbs, undershrubs and a few shrubs. Of the many species of grassland the dominant ones are *Dichanthium polyptychum* and *Eulalia phaeothrix.* The other common species are *Agrostis peninsularis, Andropogon lividus, Arundinella purpurea, A. vaginata, Bromus ramosus, Chrysopogon zeylanicus, Indochloa oligantha, Isachne bourneorum, Ischaemum indicum* and *Tripogon bromoides.* Growing amidst these grasses are orchids like *Habenaria heyneana, H. perrottetiana, Malaxis densiflora, Satyrium nepalense* and *Spiranthes sinensis.* There are several other herbs and ligneous elements of which the species of common occurrence are *Anaphalis bournei, A. meeboldii, A. subdecurrens, Bupleurum wightii, Centratherum rangacharii, Cirsium wallichii* var. *wightii, Crotalaria scabrella, Dichrocephala chrysanthemifolia, Gentiana quadrifaria* var. *zeylanica, Geranium nepalense, Hedyotis swertioides, Hypericum mysurense, Impatiens tomentosa, Justicia* spp., *Leucas ternifolia, Neoanotis indica* var. *affinis, Osbeckia leschenaultiana, Pedicularis zeylanica, Pimpinella candolleana, Polygala sibirica, Ranunculus peninsularis, Senecio lavandulaefolius, Sopubia trifida, Swertia corymbosa* and *Wahlenbergia marginata.* In marshy places in the grasslands *Burmannia pusilla, Eriocaulon nilgirense, E. collinum, Fimbristylis kingii, Lobelia heyneana, Lysimachia procumbens, Parnassia mysorensis, Rhynchospora rugosa, Scirpus fluitans, Utricularia graminifolia, U. roseo - purpurea* and *Xyris capensis* var. *schoenoides* are encountered. During the monsoon season there is a great profusion of balsams like *Impatiens modesta, I. omissa* and orchids like *Brachycorythis iantha* and *B. splendida* make their appearance. Extensive patches of *Phlebophyllum kunthianum* are present in certain places. *Pteridium aquilinum* has made considerable inroads in the grassland at several places especially in areas adjoining the tea estates. Southern subtropical hill forests are met with at lower elevations below 1750 m. The principle trees here are *Aporusa fusiformis, Elaeocarpus tectorius, Garcinia papilla, Gomphandra coriacea* and *Mastixia arborea.* Further features of interest in this zone, is the occurrence of plants like *Polypleurium dichotomum, P. stylosum, Willisia selaginoides* and *Zeylanidium* *olivaceum* on semisubmerged rocks in the river beds (Shetty & Vivekananthan, 1971 (1973)).

Vajravelu (1990) reports the occurrence of Tropical wet evergreen forests in Nemmara division and Tropical moist deciduous forests in Seetharkandi area in Nemmara division. Dry deciduous forests have been reported from Pothundry slopes and Mangalam area. Chandrasekaran (1962) deals with the high level evergreen forests of Nelliampathies. *Palaquium ellipticum* is the most dominant tree species. *Calophyllum polyanthum, Cullenia exarillata, Dipterocarpus indicus, Mesua ferrea* and *Hopea racopholea* are the common trees in the first storey. In the second storey *Cinnamomum verum, Dimocarpus longan, Elaeocarpus serratus, Eugenia* spp, *Euodia lunu-ankenda, Hydnocarpus laurifolia* and *Mimusops elengi* are frequent. The undergrowth consists of *Calamus* spp., *Curcuma* spp., *Clausena dentata, Croton malabaricus, Dendrocide sinuata, Pavetta* spp. and *Strobilanthes* spp. *(s.l.)*. Most of the climbers belong to the species of *Derris, Dioscorea, Entada, Hemidesmus* and *Smilax*. Sabastine and Ramamurthy (1966) reported evergreen and deciduous forests in Parambikulam areas. The most common evergreen trees are *Aporusa lindleyana, Baccaurea courtallensis, Chionanthus mala-elengi, Cinnamomum malabatrum, Harpullia arborea, Hydnocarpus laurifolia, Knema attenuata, Persea macrantha* and *Vateria indica*. In the deciduous forests *Dalbergia latifolia, Tectona grandis* and *Terminalia paniculata* are the predominant speices. *Bambusa arundinacea* and *Dendrocalamus strictus* grow abundantly and sometimes, as pure formations.

PALNI TRACT

The contribution of Beddome, 1858 ; Bhadran & Achya, 1960 ; Blatter, 1928 ; Blatter & Hallberg, 1917 ; Bourne, 1897 ; D'Almeida, 1926 ; Gupta, 1960 a, b, 1962 a, b, c; Mackay, 1910 ; Matthew, 1959, 1962, 1965, 1969 ; Matthew *et al.*, 1975 ; Maher-Homji, 1969, 1975 ; Nelson, 1868 ; Pallithanam, 1957 and Sauliere, 1914 enriched the knowledge about the vegetation of Palni and High wavy mountains.

The Plateau of Kodaikanal consists of undulating hills mostly covered with grasslands whose continuity is interrupted by dense patches of evergreen woods locally called "Sholas". The most abundant tree species here are *Daphniphyllum neilgherrense, Elaeocarpus recurvatus, E. serratus, Eurya nitida, Gordonia obtusa, Litsea ligustrina, Meliosma pinnata* ssp. *barbulata, M. simplicifolia* ssp. *pungens, Michelia nilagirica, Phoebe wightii, Syzygium densiflorum, Turpinia nepalensis* and *Vaccinium leschanaultii*. The grassland consists of grasses like *Andropogon lividus, Arundinella purpurea, Chrysopogon orientalis, Cymbopogon* *polyneuros, Eulalia phaeothrix, Heteropogon.contortus, Themeda cymbaria* and *Tripogon bromoides. Phlebophyllum kunthianum,* and *Pteridium acquilinum* are the most conspicuous plants in many grasslands. Other characteristic shrubs in the grasslands are *Berberis tinctoria, Hypericum mysurense, Hedyotis stylosa, Gaultheria fragrantissima, Uraria rufescens, Rubus fairholmianus,* and *Osbeckia aspera* var. *wightiana.* Amidst grasses, *Anaphalis beddomei, A. lawii, A. travancorica, Andrographis neesiana, Asyneuma fulgens, Cassia leschenaultiana, Centella asiatica, Commelina clavata, Cyanotis arachnoidea, Lilium wallichianum* var. *neilgherrense, Micromeria biflora, Prunella vulgaris, Rostellularia japonica, Striga asiatica* and *Wahlenbergia marginata* and orchids such as *Brachycorythis iantha, Habenaria digitata* var. *travancorica* and *Satyrium nepalense* are more frequent. In marshy places *Burmannia pusilla, Drosera burmannii, Gentiana pedicellata* var. *wightii, Hypericum japonicum, Impatiens goughii, Laurembergia coccinea, Rotala rotundifolia, Utricularia grammifolia* and *Xyris capensis* var. *schoenoides* are encountered. The exotic introduced species of *Acacia, Cinchona, Eucalyptus, Geranium, Pyrethrum,* and *Alnus nepalensis,* members of conifer fruit trees, orchids and weeds form the dominant part of the vegetation (Gupta, 1960 a, b ; Matthew, 1962 ; Pallithanam, 1959).

In the moist protected valleys between 1000 and 1400 m evergreen forests prevail surrounded by mixed deciduous forests in Palni hills and Cumbum valley. Transition stages between the two types are occuring along the margins. The chief species that prevails are *Acrocarpus fraxinifolius, Bischofia javanica, Canarium strictum, Chukrasia tabularis, Elaeocarpus serratus, E. tectorius, E. tuberculatus, Eugenia* spp., *Lagerstroemia microcarpa, Myristica* spp. and *Toona ciliata.* Large trees of *Mesua ferrea* occur along streams. The second storey consists of smaller trees such as *Agrostistachys borneensis, A. indica, Dimocarpus longan* and *Euonymus dichotomous.* The characertistic feature is the absence of the genus *Dipterocarpus* in these forests (Bhadran & Achaya, 1960). Pascal (1988) marked the high altitude areas of Palni under *Schefflera* spp. *Meliosma pinnata* ssp. *barbulata* *Gordonia obtusa* while the medium altitude under *Cullenia exarillata* *Mesua ferrea* *Palaquium ellipticum* type.

CARDAMOM HILLS

From the south of Palni, the Ghats from an elevated plateau slanting towards the west, the Periyar plateau, thus named after its most important river. The eastern part of this plateau forms the Elamalai range, better known as the Cardamom hills because of its plantation.

PERIYAR PLATEAU

Periyar, Idukki, Achankoli, Sabarigiri, Kallar valley, Kulathupuzha, Thenmala, Ankumoozhey, Moozhiar (Idukki, Kollam and Pathanamthitta Districts of Kerala) and Sivagiri, Chockampatti hills (Ramanathapuram District, Tamil Nadu) are the important ranges. The contribution of Bhadran & Achaya, 1960 (Ramanathapuram District); Bourdillon, 1893 (Travancore); Chandrasekaran, 1962 (Kerala); Iyppu, 1960 (Kerala); Krishna Moorthy, 1960 (Shendurney, Kulathupuzha and Anachal) ; C. N. Mohanan, 1981 (1983), 1984, 1985 (Kollam, Pathanamthitta and Idukki) ; Nair & Srinivasan 1981 (1983) (Ramanathapuram District) ; Vivekananthan, 1980, 1981 (1983) (Periyar Wildlife Sanctuary, Idukki District) and Zachariah, 1991 (Shendurney) furnishes the salient features of the vegetation of this plateau.

Westcoast tropical evergreen forests occur between 200 and 1000 m. The chief population met within the lower area is that of *Hopea parviflora* and *Vateria indica.* Other large trees occurring in these forests include *Artocarpus hirsutus. Dipterocarpus indicus, Dysoxylum malabricum, Lophopetalum wightianaun* and *Persea macrantha.* Medium sized trees found are *Dimocarpus longan, Knema attenuata, Polyalthia fragrans, Xylopia parvifolia* etc. *Ochlandra scriptoria, O. travancorica* are the chief reeds. The undergrowth consists of *Costus speciosus, Helicteres isora* and *Leea indica.* Between 500 and 1000 m altitudes, populations of *Cullenia exarillata* and *Palaquium ellipticum* occur together with *Dysoxylum ficiforme, Elaeocarpus serratus, Gluta travancorica, Hydnocarpus laurifolia. Clausena heptaphylla* and *Leea guineensis* are occuring as the undergrowth. *Arenga wightii* and *Pinanga dicksonii* are the notable palms. Southern hill-top tropical evergreen forests are occuring in Moozhiar, Pamba and Kulathupuzha regions. *Mesua ferrea* is the dominant species. Other trees include *Dysoxylum malabaricum, Holigarna beddomei* and *Semecarpus anacardium.* The West Coast semievergreen forests occur at altitudes ranging from 100 1000 m. *Bischofia javanica, Hopea parviflora, Lagerstroemia reginae, Terminalia bellirica, T. chebula, T. paniculata* and *Toona ciliata* are the common trees. Giant climbers include *Spatholobus parviflora, Gnetum ula* and *Moullava spicata. Bambusa arundinacea* and *Ochlandra wightii* are usually present here. The Southern moist mixed deciduous forests occurs in large tracts in Kollam and Pathanamthitta Districts. *Dalbergia latifolia, D. sissoides, Pterocarpus marsupium, Tectona grandis, Terminalia* spp. and *Xylia xylocarpa* are the chief tree species in these forests. *Buchanania lanzan, Careya arborea, Dillenia pentagyna, Mallotus phillippensis, Olea dioica* etc. from the middle layer. Wet bamboo brakes (reeds) occur in extensive areas in the hill slopes with a few evergreen trees in areas like Ankumoozhey, Moozhiar and Punalur. *Ochlandra travancorica* and *O. wightii* are the common weeds. Large tracts of grasslands ocecur in the hilltops of Anachal, Murinjakara, Nanattupara, Kattadikunu, Ranni-Konni reserves, Goodrical reserve and Yeroor ranges. *Myristica* swamps are of highly interesting types of vegetation in India and are occuring here. This distinct type of vegetation is found at an altitude of nearly 200 m along the sides of sluggish streams in the flat valleys of Anachal, Kulathapuzha and Shendurnni ranges. Prominent trees here are members of the Myrsticaceae family giving the area the name of *Myristica* swamps. *Carallia brachiata, Gymnacranthera farquhariana,* *Lagerstroemia reginea, Lophopetalum wightianum, Myristica dactyloides, M. fatua* var. *magnifica* and *M. malabarica* are the chief elements. Undergrowth is sparse and consists of aroids, sedges, ferns and grasses along the marign of swamps (C. N. Mohanan, 1981 (1983); 1984 Thesis unpub.). Krishnamoorthy (1960) remarked that this *Myristica* association forms fairly dense forests with a completely closed canopy and the height of the forest is usually about 25 m high with the trees having comparatively slender boles. The association occurs in the midst of tropical evergreen forests. On the edges of the swamps *Hopea* spp., *Humboldia vahliania, Persea macrantha, Vateria indica* occur and *Strobilanthes* spp. *(s.l.)* occur as undergrowth along with various members of Scitamineae. Most of the swamps have been destroyed now due to the clamour for food production.

Riparian forests are more prevalent in the valleys of Periyar. Components of this community are *Cinnamomum riparium, Garcinia wightii, Homonoia riparia* and *Syzygium occidentale. Calophyllum apetlum, Carallia brachiata, Crataeva magna, Hopea ponga, Hydnocarpus pentandrus, Humboldtia vahliana, Pongamia pinnata, Prunus zeylanica* are also present in the riparian forest. *Cyperus pangorei, Polygonum* spp. and *Saccharum spontaneum* are the other noteworthy plants.

Vivekananthan (1980) pointed out that the Periyar Wildlife Sanctuary, in Idukki District is one of the most potential sanctuaries in India with its combination of evergreen and deciduous forests, savanahs and a lake. In the Southern tropical wet evergreen forests occurring here, many of the trees of Southern Western Ghats attain their best development. Examples are *Hopea glabra, Mesua ferrea, Semecarpus travancorica* and *Vateria indica.* Besides these, the other common trees are : *Actinodaphne malabarica, Artocarpus hirsutus, Bhesa indica, Canarium strictum, Cullenia exarillata, Elaeocarpus serratus, Gordonia obtusa, Myristica dactyloides* and *Polyalthia fragrans.* The undergrowth constitutes the following shrubs and herbs: *Calamus* spp., *Chassalia curviflora* var. *ophioxyloides, Gomphandra tetranda, Lepianthes umbellata, Nilgirianthes barbatus, N. beddomei, Psychotria flavida, P. nigra, Sarcandra chloronthoides* and *Thottea siliquosa.* In the areas where moisture content is more *Elatostema lineolatum, Rhynchoglossum notonianum, Rhynchotechum permolle* are common. Climbers like *Capparis moonii, Cayratia pedata, Cynanchum callialatum, Dumasia villosa, Gnetum ula, Jasminmum azoricum, Mucuna hirsuta, Shuteria vestita, Tetrastigma leucostaphyllum* and *Thunbergia mysorensis* are common. Epiphytes such as *Aeschynanthus perrottetii, Hoya pauciflora, Impatiens parasitica, Medinilla beddomei* and *Peperomia wightiana* and epiphytic orchids such as *Coelogyne breviscapa, Dendrobium herbaceum, Eria nana, E. pauciflora, Flickingeria nodosa, Liparis viridiflora, Luisia* spp., *Oberonia* spp., *Polystachya flavescens* and *Sirhookera latifolia* are common in these forests. Some of the common epiphytic/terrestrial ferns reported from this area are *Angiopteris evecta, Asplenium nidus, Egenolfia asplenifolia, Elaphoglossm beddomei* and *Pseudocyclosorus ochthodes.* In the beds of streams, large populations of *Impatiens verticillata* are common. *Ochlandra travancorica* and *O. wightii* are the common reeds.

The moist deciduous forests occur in and around Thekkadi and at lower elevations. *Tectona grandis* is common is this type. *Anogeissus latifolia, Aphanamyxis polystchya, Bombax ceiba, Dalbergia latifolia, Grewia tiliaefolia, Hydnocarpus laurifolia, Pterocarpus marsupium, Phyllanthus emblica, Radermachera xylocarpa, Terminalia chebula, T. paniculata* and *Xylia xylocarpa* are also found here. In the undergrowth the following shrubs are common: *Desmodium triangulare, Grewia* spp., *Helicteres isora* and *Pavetta indica.* Orchids such as *Cymbidium aloifolium, Dendrobium herbaceum, D. macrostachyum, Oberonia* spp., *Pholidota pallida* and *Vanda* spp. are commonly met with. *Bambusa arundinacea* occurs in gregarious patches in some areas of the forest. In the South Indian subtropical hill Savannah (low level grassland) amidst grasses like *Arundinella ciliata, Cymbopogon citratus, Themeda cymbaria, T. tremula* and *T. triandra,* along with *Phoenix loureirii, Crotalaria multiflora, C. walkeri, Emilia sonchifolia, Exacum tetragonum, Smithia bigemina, S. blanda, Sopubia trifida, Tephrosia pulcherrima* and *Vernonia indica* are also common. Amidst grasses ground orchids like *Habenaria heyneana, H. longicorniculata, H. perrottetiana* are also met with. In marshy places and on wet rocks, after rains *Burmannia pusilla, Dimeria ornithopoda, Drosera indica, D. peltata, Eriocaulon* spp., *Gynura pseudo-china, Impatiens* spp., *Sonerila* spp., *Utricularia graminifolia* and *U. fuliginosa* are encountered.

The Sivagiri and Srivilliputhur range in Ramanthapuram District, Tamil Nadu contains a number of patches of evergreen forests. These forests are neither so dense nor so luxurient owing to the fact that the Travancore High Range and upper Palnis keep off much of the rains. The principal species are *Acrocarpus fraxinifolius, Bischofia javanica, Eugenia* spp., *Mangifera indica, Palaquium ellipicum* and *Toona ciliata* (Bhadran & Achaya, 1960). Nair & Srinivasan, 1981 (1983), in their vegetation account of the eastern slopes of the Western Ghats in Srivilliputhur range pointed out that, above an elevation of 1000 m, a number of small patches of evergreen forests occur. *Gordonia obtusa, Meliosma pinnata* ssp. *barbulata, Myristica dactyloides* are the common trees. Amidst grasses like *Heteropogon contortus, Oplismenus compositus,* and *Themeda cymbaria.* Plants like *Anaphalis subdecurrens, Biophytum sensitivum* var. *candolleanum, Crotalaria prostrata, Heracleum sprengelianum, Knoxia sumatrensis, Pouzolzia wightii* var. *nilghirensis* are also common. *Clerodendrum serratum* and *Gnidia glauca* are the noteworthy shrubs. *Habenaria crassifolia, H. langicorna* and *H. rariflora* are the terresterial orchids in the grasslands. *Lilium wallichianum* var. *neilgherrense* also rarely occur here. The semi-evergreen forests occur from an altitude of 400 to 1000 m. Some of the common trees found here are *Dimocarpus longan, Mallotus philippensis, Pterospermum rubiginosum.* The undergrowth consists of *Clerodendum viscosum, Glycosmis mauritiana* and *Helicteres isora. Reissantia indica* and *Ventilago madraspatana* are the climbers seen here. Southern dry teak forests occur in Ayyanarkoil and in the some parts of Sethur forests. Trees like *Albizia lebbeck, A. odoratissima, Chloroxylon swietenia, Dalbergia sissoides,* *Sterculia foetida* and *Tectona grandis* are common. Shrubs encountered here are *Allophyllus serratus, Flacourtia indica, Phelebophyllum spicatum* var. *hypoleucum* and *Phyllanthus polyphyllus*. The climbers include *Aristolochia indica, Cryptolepis grandiflora, Dioscorea pentaphylla* and *Neonotonia wightii*. Southern dry mixed deciduous forests occur in the outermost slopes of the Ghats. Thorny species like *Acacia leucophloea, A. planifrons* are abundant. Other trees such as *Albizia amara, Cochlospermum religiosum, Gyrocarpus asiaticus, Pterocarpus marsupium* and *Terminalia chebula* are also present.

Courtallum (Kuttalam) is a floristically well known area in the Southern Western Ghats ever since R. Wight (1835-36) botanised this region. Ramaswami (1914), Mudaliar & Sunderaraj (1954), Swamy & Govindarjulu (1956), Arachi (1968), K.K.N. Nair & Nayar (1982, 1986) have contributed much to the flora and vegetation of this region.

The mountain ranges here show a considerable diminution both in their height and breadth when compared to the adjacent portion of Southern Western Ghats. The manifold differences manifested in the habitats of the area had given rise to a correspondingly diverse vegetation which falls under three distinct categories, namely the hydrophytic, rheophytic and mesic plants. K.K.N. Nair & Nayar (1982, 1986) discussed the vegeation under the following heads: The monsoon forests of Courtallum comes under four distinct types, namely the southern tropical wet evergreen type, the southern moist deciduous type, the southern dry deciduous type and the Southern thorn forest. In southern tropical wet evergreen forests top layer consists of trees like *Hydnocarpus alpina, H. pentandrus, Fagraea ceilanica* and *Knema attenuata* showing buttressing. *Canarium strictum, Diospyros ebenum, Mesua ferrea, Neolitsea cassia, Pterocarpus marsupium, Symplocos macrocarpa* and *Terminalia* spp. are the other trees. Epiphytic orchids like *Dendrobium macrostachyum* and *Vanda tessellata* are common. Other epiphytes are *Aeschynanthus perrottetii* and *Impatiens auriculata*. Epiphytic ferns *Drynaria quercifolia* and *Pyrrosia adnescens* are more frequent than the orchids. Climbers like *Cissus* spp., *Entada rheedii* and *Salacia oblonga* are also frequent. In the forest floor, *Alpinia malaccensis, Canna indica, Costus speciosus, Elettaria cardamomum, Pouzolzia wightii* and *Thottea siliquosa* are common. Curious ground orchids like *Disperis neilgherrensis, Habenaria crinifera* and *Zeuxine longilabris* are rarely found in the shady, more humid situations. During monsoon a variety of balsams namely *Impatiens acaulis, I. dasysperma, I. floribunda* and *I. grandis* sprout from the wet soil. Other more common herbs in the forest floor are *Begonia malabarica, Crinum latifolium, Dorstenia indica, Elatostema lineolatum, Laportea interrupta, Lepianthes umbelata, Ophiorrhiza mungos* and *Pillionia heynenana*. In the southern moist deciduous forests, the common trees are *Anogeissus latifolia, Cassia fistula, Chionanthus linocieroides, Dalbergia lanceolaria, Gardenia resinifera, Lepisanthes tetraphylla, Mitragyna parviflora, Pongamia pinnata, Pterocarpus marsupium, Schelichera oleosa, Sterculia gutta* and *Tectona grandis*. Some of the common species forming the crown canopy in southern dry deciduous forests are *Albizia lebbeck, Buchanania lanzan, Celtis timorensis, Dalbergia sissoides, Dolichandrone atrovirens, Lannea coromandelica, Strychnos potatorum, Phyllanthus emblica, Zizyphus xylopyrus.* In Southern thorn forests *Acacia ferruginea, Capparis divaricata, Dichrostachys cinerea, Dodonea viscosa, Erythroxylum monogynum, Euphorbia nivulia* and *Ficus hispida* are some of the more common plants.

Along the banks of the mountain streams, *Polypleurum stylosum* are flourishing. Along the sides of the streams, *Bergia ammanioides, Biophytum intermedium, Commelina ensifolia, C. paludosa, Eragrostis gangetica, Hydrocotyle javanica* and *Paspalaum conjugatum* are common. *Sopubia delphinifolia* become gregarious during monsoon in the soil between rocks. *Cyperus tenuispica, Eriocaulon quinquangulare, Ludwigia octovalvis* ssp. *sessiliflora, Polygonum glabrum, Utricularia graminifolia, U. polygaloides* are the semiaquatic plants on the banks of streams. *Utricularia striata* growing abundantly carpeting the wet faces of the rock in large patches. The rheophytes grow here are *Atylosia albicans, Cardamine hirsuta, Cleome monophylla, C. viscosa, Drymaria cordata, Hedyotis nitida, H. puberula, Indigofera linnaei, Phyllanthus urinaria, P. virgatus, Spermacoce hispida, S. ocymoides, Aristida setacea, Carex filicina, Chloris dolichostachya, Cyperus iria, Digitaria ciliaris, Heteropogon contortus, Perotis indica* and *Scleria lithosperma* also add to the formation (P.K.K. Nair & Nayar, 1986).

AGASTHYAMALAI TRACT

This tract is in the tail end of Western Ghats in Tirunelveli and Kanniyakumari Districts of Tamil Nadu and Thiruvananthapuram District of Kerala. The Agastyamalai is the fabled abode of the sage Agasthiar, the legendary father of Tamil language. This tract includes compact block of areas and hills like Agasthyamalai, Pothikaimalai, Agastyarkudam, Aduppukkal mootai, Mundanthurai, Kalakkadu, Mahendragiri, Muuthukuzhivayal, Neyyar, Peppara Wildlife Sanctuaries and Ponmudi and surrounding areas. The contributions of Abraham, 1962 (Thiruvananthapuram); Beddome, 1877 (Tirunelveli District); Binoy *et al.,* 1992 (Western slopes of Agasthyamalai) ; Bourdillon, 1893 (Erstwhile Travancore); Henry, 1970 (Thesis unpub. Agasthyamalai) ; Henry *et al. 1984* (Agasthyamalai and environs); Henry & Subramanyam, 1981 (1983) (Agasthyamalai); Henry & Swaminathan, (1983) (Kanniyakumari District) ; Joseph & Chandrasekaran, 1982 (Neyyar Wildlife Sanctuary); Lawson, 1894 (Travancore); M. Mohanan, 1981 (1983) (Thiruvananthapuram District); M. Mohanan, 1984 (Thesis unpub. Thiruvananthapuram District); Mudaliar & Sundararaj, 1954 (Tirunelveli District); Nagam Ayya, 1906 (Thiruvananthapuram); Parthasarathy & Mahadevan, 1987 (Kalakkadu); Ramaswami, 1914 (Tirunelveli hills); Rangachari, 1919 (Tirunelveli District); Shankaranarayanan, 1960 (Tirunelveli District); Sharma *et al.* 1973 (1976) (Mahendragiri); Vajravelu *et al.* 1987

(Kalakkadu) and Velu Pillai, 1940 (Thirivananthapuram) and have enriched the knowledge about the vegetation of the tract.

Since the ecosystem diversity is quite high, almost all vegetation types known from the Western Ghats occur in this region, depending on the altitudinal zontation such as Southern tropical thorn forests, Southern tropical dry deciduous forests, Grasslands at low altitudes.

Southern tropical moist deciduous forests, Southern tropical wet evergreen forests, Subtropical montane forests and Grassy Swards at high altitudes. Southern tropical thorn forests: This type can be seen at an altitude of about 200 m and occurs around Papanasam, Kalakkadu, Tirukkurungudi beyond Panakudi, way to Sengamal and Pioneer estates. In these scrub jungles trees like *Acacia chundra, A. horrida, A. planifrons, Euphorbia antiquorum, Vitex altissima, Zizyphus oenoplia, Z. xylopyrus* are common. Amidst these trees, shrubs frequently met with are *Carissa carandas, C. congesta, Cassia auriculata, Dichrostachys cinerea, Dodonaea viscosa, Jatropha gossypifolia, Maytenus wallichiana, Flueggea leucopyrus* and *F. virosa.* The climbers are represented by *Abrus precatorius, Cadaba trifoliata, Cissus quandrangularis, Clitoria ternatea, Derris scandens, Jasminum calophyllum, Tylophora indica* and *Wattakaka volubilis.* The common herbs found are *Aerva lanata, Ageratum conyzoides, Barleria nitida, Eragrostis aspera, Evolvulus alsinoides, Hackelochloa granularis, Hedyotis puberula, Leucas aspera, Manisuris myuros, Mollugo pentaphylla, Polycarpaea corymbosa, Spermacoce hispida, Trachys muricata* and *Tragus roxburghii.*

Southern tropical dry deciduous forests extend up to an altitude of 350 m and are located in Kalakkadu R.F., Papanasam R.F., Singampatti R.F., Kottur R.F., and Thulukamparai. The common trees seen are *Albizia amara, A. lebbeck, Anogeissus latifolia, Commiphora caudata, Dillenia pentagyna, Haldina cordifolia, Pterocarpus marsupium, Semecarpus anacardium* and *Terminalia chebula.* Shrubs like *Acacia pennata, Chassalia curviflora* var. *ophioxyloides, Desmodium triangulare, Ecbolium viride* var. *laetevirens, Phyllanthus polyphyllus* etc. are found frequently. The herbaceous species of common occurrence are *Chrysopogon hackelii, Desmodium triflorum, Indigofera trifoliata, Rostellularia simplex* and *R. pumila.* Amongst climbers, mention be made of *Atylosia trinervia, Canavalia gladiata, Mucuna atropurpurea* and *Rhynchosia densiflora.* Parasitic plants found commonly on trees include *Dendrophthoe falcata, Helicanthus elastica, Taxillus cuneatus, Viscum articulatum* and *V. monoicum.* Along rocky riversides, *Mangifera indica* is commonly met with.

Vast stretches of grasslands at lower elevations below 500 m occur beyond scrub jungles and deciduous forests. Trees like *Mundulea sericea* and *Terminalia chebula* occur frequently in these grasslands. Two main species of grasses occuring in this type are *Cymbopogon coloratus* and *Themeda cymbaria.* Amidst these grasses, *Euhorbia cristata* and *Rhynchosia rufescens* are frequent.

Southern tropical moist deciduous forests occur up to an altitude of about 500 m and covering extensive areas. The top canopy consists of trees like *Acronychia pedunculata, Bombax ceiba, Dalbergia coromandeliana, D. latifolia, D. malabarica, Gyrocarpus asiaticus, Pterocarpus marsupium, Terminalia chebula* and *T. paniculata.* Some of the common shrubs found in these forests are *Barleria courtallica, Blachia calycina, Helicteres isora, Ixora brachiata, Mussaenda belilla* and *Psychotria connata. Spatholobus parviflora* and *Gnetum ula* are the conspicuous lianas met with. The notable climbers are *Calycopteris floribunda, Cynanchum tunicatum, Dioscorea oppositifolia, Jasminum rottlerianum, Maesua oblongifolia* and *Sarcostigma kleinii.* Some of the common herbs forming the undergrowth are *Alysicarpus rugosus, Justicia betonica* and *Waltheria indica. Ensete superbum* also occur in this region.

Southern tropical wet evergreen forests occur between 750 m and 1500 m and are located around Mahendragiri peak, Agasthyamalai peak, Muthukuzhivayal, Naterikal to Sengaltheri, upper Kodayar and Athiramalai. The top canopy is extremely dense represented by gigantic trees like *Artocarpus hirsutus, Canarium strictum, Cullenia exarillata, Diospyros ebenum, Elaeocarpus tuberculatus, Hopea utilis* and *Palaquium ellipticum.* The second storey consists of medium-sized trees and shrubs like *Actinodaphne campanulata, Cinnamomum malabatrum, Garcinia echinocarpa, Kingiodendrum pinnatum, Isonandra lanceolata, Mallotus distans* and *Syzygium mundagam* etc. *Nageria wallichiana* the only indigenous gymnosperm are found in these forests. Under the canopy of these trees, small trees or shurbs like *Antidesma menasu, Celtis timorensis, Callicarpa tomentosa, Chassalia curviflora var. ophioxyloides, Diotacanthus albiflorus, Ixora nigricans, Lasianthus cinereus, L. dichotomous, Leea indica, Memecylon heyneanum, Rauvolfia densiflora, Sarcandra chloranthoides* and *Tabernaemontana gamblei* are found frequently. Climbers like *Ancistrocladus heyneanus, Aristolochia indica, Erythropalum populifolium, Piper nigrum, Pothos scandens* and *Senecio walkeri* also found. The following herbs and undershrubs form the ground layer: *Acranthera grandiflora, Begonia malabarica, Carex filicina, Elatostema lineolatum, Ophiorrhiza eriantha, Psychotria urviflora, Saprosma corymbosum, Thottea barberi* etc. Wild variety of *Elettaria cardomomum* is seen in some patches. Amongst the dense tract of these forests *Ochlandra travancorica* and *Schumannianthus virgatus* occur extensively. Some of the common ferns are *Angiopteris evecta, Arachnoidea aristata, Asplenium tenuifolium, Cyathea gigantea, Marattia fraxiena* and *Polystichium auriculatum.* Epiphytic orchids like *Coelogyne nervosa, Dendrobium wightii, Oberonia brunoniana* and *Sirhookera latifolia* are commonly seen on tree trunks. Subtropical montane forest occurs as continuous expanse of the evergreen forests generally above 1500 m around Agashyamalai peak, Mahendragiri peak and Kakachi. The sheltered faces and moist depressions of peaks after a foothold for these types of forests where the trees are stunted nature due to the high velocity of wind and high atltitude. The height of trees rarely exceeds 6 m and are densely clothed with lichens, mosses, ferns and orchids. Some of the dominant species are *Byrsophyllum tetrandrum, Canthium neilgherrense, Eugenia mabaeoides, Euphorbia santapaui, Hedyotis purpurascens, Impatiens leschenaultii, Lasianthus blumeanus, L. cinereus, Ligustrum decaisnei, Moonia heterphylla* and *Polyscias acuminata*. Bhadran & Achaya (1960) recognised three main associations of the predominant species in the topmost tier of evergreen forests (i) *Hopea - Mesua* association in and around Sengaltheri and Mahendragiri, (ii) *Palaquium Mangifera* association in middle portion of Sengaltheri and Sigampatti and (iii) *Cullenia - Calophyllum* association in Muthukuzhiayal area.

The grasslands in higher elevations on the southern side of Mahendragiri consists of grasses like *Apocopis courtallensis, Chrysopogon orientalis, C. zeylanicus, Eulalia phaeothrix* and *Themeda tremula. Hedyotis purpurascens* and *Uraria rufescens* are also found here. Amidst the grasses the common herb like *Cyanotis arachnoidea, Fimbristylis quinqueangularis* var. *crassa, Habenaria perrottetiana, Phyllanthus gardnerianus, Scutellaria colebrokiana* and *Striga asiatica* are found. The grasslands at the eastern side of Mahendragiri have *Arundinella ciliata, A. mesophylla, Eulalia trispicata* and *Ichaemum timorense* as the common grasses. Associated with these are herbs like *Crotalaria albida, C. calycina, Leucas biflora* and *Vernonia divergens*. Species like *Didymocarpus tomentosus, Eriocaulon cinereum* and *E. melaleucum* are found growing on the moist rocks. *Burmannia pusilla* and *Utricularia striatula* are also seen frequently.

Grassy swards are seen in smaller dimension on the exposed rocky surfaces at high altitudes especially around Agastyamalai peak, Muthukuzhivayal and Kakachi. Some of the common grasses met with are *Arundinella purpurea, Chrysopogon orientalis, Eulalia phaeothrix, Isachne walkeri, Themeda tremula* and *Zenkeria sebastinei*. An interesting herbaceous member of the Dilleniaceae- *Acrotrema arnottianum* and other herbs like *Centratherum rangacharii, Exacum travancoricum, Heracleum candolleanum, Leucas vestita* and *Smithia blanda* are frequently met with (Sharma *et al.* 1976; Henry *et al.* (1984).

Henry & Subramanyam (1983) in their studies on the flora of Agastyamalai and surrounding regions broadly classified the vegetation into i) Southern tropical wet evergreen and 2) Subtropical montane forest type interspersed with grassy swards. The top layer is characterised by gigantic trees like *Artocarpus hirsutus, Cullenia exarillata, Diospyros ebenum, Elaeocarpus tuberculatus, Gluta travancorica, Hopea utilis, Mesua ferrea, Palaquium ellipticum* and *Strombosia ceylanica*. The rocky slopes are often colonised by the endemic palm *Bentinckia condapanna*. One striking peculiarity of the vegetation of these hills lies in the preponderance of several typical Sri Lankan plants. There is also a very appreciable endemic elements in the flora and many plants new to science have been described from these hills.

Binoy *et al.* (1991) on studying the flora of Agasthymalai hills coming under the Kerala pointed out that it has got one of the richest and most diverse vegetation in Western Ghats. Its unique flora harbours many endemic plants estimated between 100 to 150 such as *Byrsophyllum tetrandrum, Eugenia floccosa, E. mabaoides, Euphorbia santapaui, Exacum travancoricum, Hedyotis albo-nervia, H. travancorica, Paphiopedilium druryi* etc.

Vajravelu *et al.* (1987) dealt with about the vegetation of Kalakkadu under the following heads, *viz.* 1. Scrub jungles below 200 m at the foot of the Ghats. 2. Deciduous forests at elevation ranging from 200 to 800 m and 3. the Evergreen forests occurring over 800 m on the Ghats. In the evergreen forests *Palaquium ellipticum* and *Mangifera indica* often form the common type. *Pandanus furcatus* is found in large patch in a swamp called Thalaiyodai near Sengaltheri and endemic plants like *Ampelocissus arnottiana, Aralia malabarica, Anaphyllum beddomei, Caralluma pauciflora, Didymocarpus fischeri, Diospyros barberi, Ellertonia rheedii, Ficus guttata, F. macrocarpa, Hedyotis eualata* var. *agastyamalayana, Lasianthus cinereus, Saprosma corymbosum, Sonerila sadasivanii, Symplocos wynadense* and *Vernonia ramaswamii* have been reported from the Sengaltheri forests. Parathasarathy & Mahadevan (1987) recognised seven distinct types in Kalakkad R.F. : i) Evergreen forests, ii) Semievergreen forests (iii) Mixed deciduous forests, iv) Dry teak forest, v) Scrub jungle, vi) High altitude grasslands and vii) Low altitude grasslands. In the evergreen forests the major tree species are *Calophyllum austroindicum, Cullenia exarillata, Hydnocarpus laurifolia* and *Nageia wallichiana.* They have reported Semievergreen forests which corresponds "Tirunelveli semi-evergreen forests" of Champion and Seth (1968) in areas around Thalaiyodai from an altitude of 725 m to 820 m. In these forests, both evergreen and deciduous elements are intermixed with lianas and shrubs. The evergreen species include *Antidesma alexiteria, A. menasu, Cinnamomum malabaricum, Erythroxylon lanceolatum, Filicium decipiens, Gomphia serrata, Gordonia obtusa, Holigarna arnottiana, Mangifera indica* etc. *Careya arborea* and *Terminalaia chebula* are some of the deciduous species. Small trees such as *Benkara malabarica, Mallotus distans, M. philippensis, M. stenanthus,* and shrubs like *Clausena heptaphylla, Psychotria nigra, Stenosiphonium russelianun* etc. are frequent. Lianas like *Ancistrocladus heyneanus, Entada rheedei, Gnetum ula* etc. are commonly found. Herbs like *Centratherum sengaltherianum, Dianella ensifolia, Scutellaria wightiana* etc. grow on the forest floors and on roadsides.

Pascal (1988) pointed out the occurrence of semi-evergreen climax forests on the eastern slopes in Papanasam, Kalakkadu, Mahendragiri etc. between 300 and 500 m. These formations were climax forests and have been classified by Champion & Seth (1968) in the group "Tirunelveli semievergreen forests following the working Plant of Lasardo (1934). Bhadran & Achaya (1960) have also followed the same. The top storey is about 30 m and the evergreen species are *Artocarpus heterophyllus*, *Bischofia javanica*, *Hopea parviflora*, *H. utilis* and *Kingiodendron pinnatum*. The deciduous species include *Chukrasia tabularis*, *Dalbergia latifolia*, *Pterospermum diversifolium*, *P. rubiginosum* and *Stereospermum colais*. In the second storey all the trees are evergreen: *Aglaia elaeagnoidea* var. *courtallensis*, *A. barberi*, *Carallia brachiata*, *Dimocarpus longan*, *Drypetes venusta* and *Diospyros* spp. The undergrowth consists of *Strobilanthes* sp. *(s.l.)* and *Glycosmis mauritiana*. *Dipterocarpus bourdillonii* and *D. indicus* are absent on the eastern slopes. They are replaced by another Dipterocarp *viz*., *Hopea utilis* which is very abundant here.

M. Mohanan (1983, 1984) recognised seven major types of forests in Ghat portion Thiruvananthapuram District, Kerala. West Coast tropical evergreen forests occur in higher slopes along the eastern border especially in upper sources of river Kalar, Karamana, Neyyar and high peaks of Agastyarkudam, Chemungi and Ponmudi. The trees of first storey are *Antiaris toxicaria*, *Calophyllum apetalum*, *Caryota urens*, *Cullenia exarillata*, *Diospyros bourdillonii*, *Hopea parviflora*, *Mesua ferrea*, *Palaquium ellipticum* and *Poeciloneuron indicum*. Southern hill top tropical evergreen forest occurs at 1000-1200 m altitude in high ridges like Churuttumoola and Ponmudi. *Gluta travancorica* and *Semecarpus travancorica* are the common trees in upper storey. Southern subtropical hill forests occur in Agastyarkudam, Chemungi and Ponmudi at an altitude of 1200 to 1600 m. West Coast semi-evergreen forests are seen along the riversides of Kallar, Peppara, Kaviur and Suryakanthi. Southern secondary moist mixed deciduous forests are in the lower elevations. Wet bamboo brakes are seen in the slopes of hills and valleys of Agastyarkudam and Chemungi. *Ochlandra bracteata*, *O. scroptoria*, *O. travancorica*, *O. wightii* are the common bamboos encountered here. *Myristica* swamps are seen at Kottur R.F. which is characterised by the looped knee roots at the ground. These swamps are usually found in valleys often subjected to inundation. The common elements in the swamps are *Myristica dactyloides*, *M. malabarica*, *Gymnocranthera farquhariana*, *Knema attenuata*, *Hydnocarpus alpina* and *Lophopetalum wightianum*. Large population of *Lagenandra ovata* are also met with on the edges of the forests. *Hopea parviflora* and *Humboldtia vahliana* with a dense undergrowth of *Nilgirianthus* spp. are also found. In addition to the above seven types Southern tropical moist deciduous riverine forests are also found along the major rivers like Neyyar, Karamana and Vamanapuram. The main elements found in this type are *Agrostistachys borneensis*, *Ixora nigricans*, *Lagerstroemia microcarpa*, *Homonia riparia*, *Lophopetalum wightianum*, *Hydnocarpus pentandra*, *Vateria indica* and *Vitex altissima*.

The observations of Henry & Swaminathan (1983) on the vegetation of Kanniyakumari reveals that it is similar to the adjacent Tirunelveli and Thiruvananthapuram districts types.

6. ENDEMISM

The Western Ghats protected by the sea along the western side, Vindhya and Satpura ranges on the northern side, semi-arid Deccan plateau on the eastern side and the Indian Ocean on the south is like an oceanic island and become the abode of a large number of endemic plants. These endemic plants throw vistas on the biogeography of the area, centres of speciation, vicariance, adaptive evolution of the flora and areas of extinction. Peninsular regions are always considered a close second to oceanic islands in having conditions favourable for endemism (Turril, 1864). Summits of Western Ghats in Penninsular India are comparable to islands (Subramanyam & Nayar, 1974) or act like "islands amidst islands" (Shetty & Vivekananthan, 1991). Even though, there are no endemic families in India, the abundance of endemic taxa in India and Peninsular India has been brought to light by Chatterjee, 1940, 1962 ; Maheswari, 1976 ; Nayar 1980, 1982 ; Rao 1972, 1979 ; Sarkar, 1990 ; and Subramanayam & Nayar, 1974. Southern Western Ghats from the most important centre of endemism and aspect has been highlighted by Ahmedullah & Nayar 1987, Blasco, 1970, 1971; Nair, 1980, 1991; Nair & Daniel, 1986; Nayar & Ahmedullah, 1984; Pascal, 1988; Ramesh & Pascal, 1991 and Subramanyam & Nayar 1974.

According to Nayar (1980) there are 56 genera, endemic to Peninsular India, most of them are confined to the Western Ghats. Among them, 49 are considered endemic to the Western Ghats. The occurrence of such large number of endemic genera in the Western Ghats as compared to the 84, from the rest of India indicate that it is an ancient flora. Nair & Daniel (1986) recorded the number of endemic genera that occur in the Western Ghats as 57 of which 46 are monotypic. Later, Nair (1991) made a minor modification stating that there are only 51 endemic genera in Western Ghats as per cent findings. The statistics of endemism often vary with the findings of more and more botanical explorations and increasing knowledge about the distribution of species at global level. In addition, frequent updating of taxonomic status by recent revisions and monographs either increase or decrease the numbers (Ramesh & Pascal, 1991). Following are the endemic genera of Southern Western Ghats:

1. *Anaphyllum* Schott (2 species) ARACEAE
2. *Ascopholis* C. Fischer CYPERACEAE
3. *Baeolepis* Decne. ex Mosq. PERIPLOCACEAE
4. *Blepharistemma* Wight ex DC. RHIZOPHORACEAE
5. **Carvia* Bremek. ACANTHACEAE
6. *Chandrasekharania* V.J. Nair *et al.* GRAMINEAE

7. **Danthonidium* C.E. Hubb. GRAMINEAE

8. ***Diplocentrum* Lindley (2 species) ORCHIDACEAE

9. **Erinocarpus* Nimmo ex J. Grah. TILIACEAE

10. **Glyphochloa* W. Clayton (8 species) GRAMINEAE

11. *Haplothismia* Airy Shaw BURMANNIACEAE

12. *Hubbardia* Bor GRAMINEAE

13. *Hyalisma* Champ. TRIURIDACEAE

14. *Indobanalia* A.N. Henry & Roy AMARANTHACEAE

15. **Indopoa* Bor GRAMINEAE

16. *Indotristicha* Royen (2 species) PODOSTEMACEAE

17. *Janakia* Joseph & V. Chandra. PERIPLOCEAE

18. *Jerdonia* Wight GESNERIACEAE

19. *Kanjarum* Ramam. Acanthaceae

20. **Lamprachaenium* Benth. COMPOSITAE

21. *Meteoromyrtus* Gamble MYRTACEAE

22. **Moullava* Adans. CAESALPINACEAE

23. **Nanothamnus* Thoms. - COMPOSITAE

24. **Nilgirianthus* Bremek. (20 species) ACANTHACEAE

25. *Otonephilium* Radlk. SAPINDACEAE

26. *Paracautleya* R.M. Smith ZINGIBERACEAE

27. **Pleocaulus* Bremek. (3 species) ACANTHACEAE

28. *Poeciloneuron* Beddome (2 species) BONNETIACEAE

29. **Polyzygus* Dalz. UMBELLIFERAE

30. *Silentvalleya* V.J. Nair *et al.* GRAMINEAE

31. *Taeniandra* Bremek. ACANTHACEAE

32. *Utleria* Beddome ex Benth. PERIPLOCACEAE

33. *Vanasushava* P.K. Mukherjee & Constance UMBELLIFERAE

34. *Willisia* Warm. PODOSTEMACEAE

35. *Xenacanthus* Bremek. (3 species) ACANTHACEAE

Of these, 11 genera marked with an asterisk extend their distribution to the northern portion of Western Ghats beyond Goa. The remaining twenty four genera are exclusively endemic to Southern Western Ghats. The genus *Diplocentrum* with double asterisks doubtfully extend to Sri Lanka from Southern Western Ghats. Of these twenty nine are monotypic and this is rather quite high when compared to the total number of 115 monotypic endemic genera reported in India. This clearly indicates that the Southern Western Ghats are the important centres of speciation and nurseries of speciation. Endemic genera reported earlier namely *Campbellia, Griffithella, Proteroceras* and *Pseudoglochidion* are now reduced congeneric to widely distributed genera.

The familes Acanthaceae and Poaceae have six endemic genera each followed by Periplocaceae with three endemic genera. Other families having more than one genus are Compositae, Podostemaceae and Umbelliferae. All these are advanced families according to evolutionary theorey. The herbaceous genera are predominant here. The arborescent genera include *Blepharistemma, Erinocarpus, Metoromyrtus, Otenephilium* and *Poeciloneuron.* All these are monotypic except *Poeciloneuron* which has two species. Shrubs and undershrubs are represented by genera like *Carvia, Nilgirianthus, Taeniandra* and *Xenacanthus* which have got a peculiar life span (Pleistials) and periodicity of flowering rhythm, thus making as unique flora.

The presence of 27 common endemic genera in Peninsular India and Sri Lanka is interesting from the phytogeographical angle. Nayar (1984) indicate their common genetic stock with divergent phenotypic variations due to geographical and ecological barriers. Out of the 27 common endemic genera with Peninsular India and Sri Lanka, the following 20 are occurring in Western Ghats. 1) *Brysophyllum* Hook. f. (Rubiaceae), 2) *Chloroxylon* DC. (Flindersiaceae), 3) *Cottonia* Wight (Orchidaceae), 4) *Cullenia* Wight (Bombacaceae), 5) *Didyplosandra* (Rubiaceae), 7) *Humboldtia* Vahl (Fabacae), 8) *Kendrickia* Hook. f. (Melastomataceae), 9) *Leptacanthus* Nees (Acanthaceae), 10) *Mackenziea* Nees (Acanthaceae), 11) *Mischodon* Thw. (Euphorbiaceae), 12) *Neurocalyx* Hook. (Rubiaceae), 13) *Sirhookera* O. Kuntze (Orchidaceae), 14) *Stenosiphonium* Nees (Acanthaceae), 15) *Torniola* Tul. (Podostemaceae), 16) *Thelepaepale* Bremek. (Acanthaceae), 17) *Theriophonum* Bl. (Araceae), 18) *Thraulococcus* Radlk. (Sapindaceae) 19) *Vateria* L. (Dipterocarpaceae), and 20) *Zenkeria* Trin. (Gramineae).

Chatterjee (1962) records about 2045 species of endemic Dicotyledons and about 500 endemic Monocotyledons in Peninsular India as against 3169 Dicotyledons and 1000 Monocotyledons in Himalayas which has the largest number of endemic species. Ahmedullah and Nayar (1987) in their analysis of endmic taxa in Peninsular India have reported 1932 taxa (1384 - Dicots belonging to 96 families while the remaining 548 endemic taxa under 14 families of Monocots) spread over 108 families of flowering plants (Table I). Out of the 1932 endemic taxa 958 taxa are herbaceous while the rest are woody or arborescent. Gramineae, Rubiaceae, Acanthaceae, Orchidaceae and Leguminosae have the largest representation of endemic taxa (Table II). Most of them are palaeoendemics with favourable ecological niches in the hill ranges on either side of the Peninsula.

A large concentration of endemic species is found in the tropical moist deciduous and tropical semievergreen patches of Western Ghats. Blasco (1970) has shown that the south Indian hill tops (Southern Western Ghats) are having abundant endemic species. Blasco's (1971) compilation of the terrestrial dicotyledonus occurring in that portion of W. Ghats extending between the Karnataka and the Travancore hills clearly indicates this. Out of the total number of 667 terrestrial dicotyledons recorded at moderate elevation (between 800 and 1800 m) in the above mentioned parts of W. Ghats, 442 (66%) are endemics. In the montane zone (above 1,800 m), the endemic dicots are 208 out of the total of 365 (54%). Of these, the Nilgiris provide the maximum number: 36 endemics at moderate and 65 at higher altitude making it an important centre of speciation. There are about 28 endemic taxa confined to the Kundah alone in Nilgiris (Shetty & Vivekananthan, 1983). Henry *et al.* (1984) observed that the Agastyamalai area in the Tirunelveli-Travancore hills have 150 localised endemic species. Binoj *et al.* (1991) estimated that about 100 to 150 species are endemic to Agastyamalai and enumerated 57 on the western slopes coming under Kerala region alone. Blasco (1971) compiled 92 endemics all at moderate elevation in Travancore sector. Blasco (1970) records 18 taxa in Palni hills and 13 in the Anaimalais. The high range in Idukki District, Kerala harbours 29 taxa exclusively for the area (Shetty & Vivekananthan, 1991). Vajravelu (1987) records 65 endemic species from Palghat District, Kerala which include 20 species from Silent Valley R.F. alone. The Wynaad-Kodagu contribute only 12 endemics, once again below 1800 m (Blasco, 1971) (Table III). Raghavan & Singh (1983) indicated about 46 species, endemic to the W. Ghats of Karnataka portion.

The family Gramineae has the largest number of endemic species, viz. about 169 (Ahmedullah & Nayar, 1987) or about 155 (Karthikeyan, 1983). The Splinter genus *Strobilanthes* (now split up to *Carvia, Gantelbua, Nilgirianthus, Phlebophyllum, Pleocaulus, Taeniandra* and *Xenacanthus)* represents most of the endemics of the family Acanthaceae. *Nilgirianthus* and *Phlebophyllum* alone account for nearly 27 endemic species. The family Orchidaceae is notable one with high percentage of endemism. Out of the 131 genera and 956 species recorded in India, about 123 taxa are endemic to Peninsular India (Ahmedullah

& Nayar, 1987). Western Ghats harbour 267 species, 3 subspecies and 2 varieties of orchids belonging to 72 genera. Of these, 72 species, 2 subspecies and 2 varieties are confined to Western Ghats. Five genera, *viz. Cottonia, Diplocentrum, Ipsea, Seidenfadeniella* and *Sirhookera* are found only in Southern India and Sri Lanka (Satishkumar, 1991). Rathakrishnan & Chitra (1984) while reporting the distribution of 65 endemic orchids belonging to 27 genera in Karnataka, Kerala and Tamil Nadu showed that all of them except one species (with a vague distribution) are confined to Southern Western Ghats.

Legumoinosae, the third largest family of flowering plants are of special interest because, nearly 80, out of about 340 taxa belong to this family are endemic to Western Ghats. Sanjappa (1991) in his studies on endemic taxa of Leguminosae of Western Ghats pointed out that *Crotalaria* is the largest genus with 19 endemic taxa confined to Central and Southern Ghats, while the arborescent genera like *Calliandra, Dialium* and *Humboldtia* are confined to Southern Western Ghats. The other arborescent genera like *Kingiodendron, Ormosia, Sophora* and *Spatholobus* each with a single species in India are restricted to Central and Southern Western Ghats. Rau & Narayana (1985) in a review of the tribe Vernonieae of Compositae recorded that Tirunelveli, Palni, Anaimalai and High Range in Cardamon Hills form an important distribution centre with limited amplitude for the genera *Vernonia* and *Centratherum* which accommodate several endemic species. The genus *Vernonia* being the predominently herbaceous and weedy, has two arborescent endemic species, *viz. Vernonia monosis* and *V. travancorica* and many shrubs of *Vernonia* are exclusively confined to Southern Western Ghats.

Muktesh Kumar (1991) recorded 24 species belonging to 8 genera of Bamboos from Western Ghats (about 136 species belonging to the 24 genera were recorded from India). Renuka (1991) in her resources in Western Ghats recorded 25 species of *Calamus* against a total number of 4 genera and 51 species of the family Arecaceae. Among the three major zones of rattans in India, Western Ghats from one zone. None of the rattan species reported from Western Ghats are present elsewhere in India (except *C. thwaitesii* and *C. rotang* that occur in Sri Lanka. *C. rotang* also occurs in Eastern India). Within Southern Western Ghats 6 species are endemic mostly in Kodagu District of Karnataka.

A nonendemic genus which has a considerable number of endemic taxa on the Western Ghats is *Impatiens* and it is one of the largest genera among angiosperms in India and World. There are about 86 speices on the Western Ghats. Their restricted distribution in Southern Ghats clearly indicates the feeble dispersal mechanism and nichespecificity. Barnes (1939) recorded 39 species of balsams in High Range, Kerala and the occurrence of more than 30 species within a radius of 16 km of Munnar clearly indicates that "there seems little doubt, that in respect of species of balsams, the high Range is the richest area in Western Ghats and consequently of the world" Nair (1991) showed that there are 17 and 20 species of endemic *Impatiens* respectively, for Nilgiris and neighbourhood and Anaimudi and High Range. As far as this genus is concerned these two areas of Southern Western Ghats are centres of speciation.

Pascal (1988) has tabulated 86 important endemic taxa found in the evergreen forests of the Western Ghats belonging to 28 families. He has also pointed out that the highest percentage of endemism is found in Western Ghats, south of Palghat Gap *i.e.*, in regions with shortest dry season: 43.4% and 44.3%. This is much higher than the average percentage of endemism (31%) given by Blasco (1971) for the whole of South India. To the north of Palghat, percentage of endemism does not vary significantly with the lengthening of the dry season. It remains between 34% and 37.4%. The woody habit in endemic group is always considered as a relict character (Table IV). Ramesh & Pascal (1991) in their studies on endemic arborescent evergreen species in the Western Ghats which are confined to low and medium elevations of evergreen forests have shown the following trends. Out of the nearly 490 woody taxa found represented in the low and medium elevation of evergreen forests 308 are endemic to the Western Ghats. They spread over 58 families with largest representation in Euphorbiaceae and Rubiaceae each with 34 taxa followed by Lauraceae with 33 and Myrtaceae with 30. *Arenga wightii, Bentinckia condapanna* and *Pinanga dicksonii* of Arecaceae are the only arborescent endemic representations from monocotyledons.

The southern part (8^0 - 10^0 30' N) which corresponds to former Travancore and the hills south of Palghat Gap comprises 87% of the total endemic tree species of the Western Ghats while 37% of the total are restricted to this area alone. It constitutes the main centre of endemism in South India. In North Kerala and part of Nilgiris (10^0 30' 12^0 N) nearly 60% of the species are endemic to the Western Ghats with 5.2% confined exclusively to this area. This is followed by nearly 43% between the latitudes 12^0 13^0 30' N (Southern Western Ghats of Karnataka); 26% between 15^0N and 16^0 30' N. (Northern Western Ghats of Karnataka); 11% between 15^0 and $16^0$30' N (Konkan).

Sarcar (1990) pointed out that the Himalayan taxa are obviously neoendemics whereas the Peninsular flora contains neoendemics as well as palaeoendemics. In the former the flora is in the first stage of theory of Genetic cycles (Cain, 1944) whereas in the latter the flora is possibly in their last stage. Many palaeoendemics which usually occur in geologically old landmass are found here. Example: *Baeolepis, Utleria* etc. *Hubbardia* is the genus adapting to a particular ecological niches and *Haplothismia* being the taxonomically isolated genus (Ahmedullah & Nayar, 1987). Some of the heavily exploited species like *Calophyllum apetalum, Dipterocarpus bourdillonii, Hopea parviflora* and *Vateria indica* are also typical examples of paleoendemism which has a wider distribution in the past but presently confined to a limited area (Induchoodan & Balasubramanyan, 1991). Neoendemics are newly evolved endemic taxa of recent origin from an activity evolving genetic stock occurring in a particular ecotone. In this light, the narrow endemism exhibited by many endemic species of *Impatiens* of the Southern Western Ghats may indicate that they are neoendemics (Engler, 1882; Nair, 1991).

Western Ghats in general and Southern Western Ghats in particular is the second largest abode for endemic angiosperms in India. The high rate of endemism is mostly due to the short dry period with two monsoons. In addition these ghats are numerous segments of divergent alignments, geographic diversity and perhaps of even different age (De Souza & Sadashivaiah, 1976). Thus the complex hills system with several peaks comprising Nilgiris, Anaimalai, Pulni, High Range, Agastyamalai and Kalakkad hills and provided various habitats and niches suitable for endemic taxa.

7. RARE AND THREATENED PLANTS

Western Ghats being the interesting biologically distinct geographical zone have a total area of *ca* 1,60,000 sq km of which one-third of the area *i.e.* 53,333 sq km is forested. Evergreen forest of principal conservations interest (the most complex and diverse biomass) cover an area of about 15,000 sq km or 9% of the area of Western Ghats (Sastry & Sharma, 1991). Based on a FAO report, Raven (1977) pointed out that with a reduction of 2.79% forest cover in India in 7 years (1972-75 to 1980-82) it is left with a mere 14.1% of the total forest cover now. The shrinkage of forested area in the four states wherein the Southern Western Ghats lie, *viz.* Goa 2.15%, Karnataka 1.99%, Kerala 3.17%, and Tamil Nadu 2.69% in the 7 years (1972-75 to 1980-82) clearly indicates, the amount of destruction of forest lands in this area with the accelerated population growth (Anonymous, 1983). The census of population grown between 1971 and 1981 clearly shows, the coastal region having reached the saturation point, the population growth is now in the region of the Ghats. The seven taluks of Kerala where the population growth has registered an increase of over 30%, are all situated in or at the foot of Western Ghats. Considering an average population growth of 17.2% for whole of Tamil Nadu, 27.2% for Nilgiri (Pascal, 1988) alone, also clearly indicates this aspect. Added to this, large areas have been brought under cultivation of commercial crops like coffee, cardamom, eucalyptus, rubber, tea, wattle etc. The extension of teak plantation has also revealed in the unprecedented destruction of virgin forest areas. The establishment of large number of hydro-electric projects, irrigation dams resulting in submersion of catchment areas, mining and clearing of areas rich in vegetation have further accelerated in the regressive changes in the forest flora of the region. The destruction of forests resulted in a pronounced imbalance in the effectiveness of precipitation, maintenance of water table and percentage of humidity and transpiration. Nair & Daniel (1986) aptly indicated, that the desforestration and the resultant habitat destruction has been the multifaceted major threat leading to degradation, depletion and disappearance of the biological diversity of the Western Ghats threatening the ecological balance.

Large tracts of Sholas and Southern subtropical hill forests in Nilgiris, Anaimalai, High Range and Palni have been cleared and a seral stage known as Southern montane wet scrub occurs in large tracts at present, with stray species of native flora. Various kinds of pure formations like *Pteridium acquilinum* or *Hypericum mysorense* are seen here. Many exotics like *Ageratum conyzoides*, *Chromolena* spp., *Erigeron karnivinskianum*, *Helichrysum bracteatum*, *Sarothamnus scoparius* and *Ulex europeus* are now naturalised and form dominant floristic elements. Further the most dominant undergrowth of reeds and in evergreen forests has been almost wiped out in many areas, due to commercial exploitation. In sourthern parts of Western Ghats the undergrowth of evergreen forests have been completely cleared off for cardamom cultivation. Due to degradation and depletion of forest types, the threat to many endemic species which are highly restricted in distribution and having small population is alarming. A number of them including members of Araceae, Burmanniaceae, Gramineae, Orchidaceae, Podostemaceae, etc., being monotypic genera with a poor dispersal mechanism and niche specificity, are prone to destruction.

Recent studies on the rare and threatened plants revealed that more than 500 species of flowering plants in the Western Ghats are rare and threatened. The various publication brought out on these lines indicate that among the 600 taxa considered to be rare or threatened in the flora of the Peninsular India, about 90% are in the Western Ghats (Sastry & Sharma 1991). The catalogues of Henry *et al.* (1979), Jain & Sastry (1980), Raghavan & Singh (1983) and Vajravelu & Daniel (1983) revealed that a large number of threatened plants are recorded from Southern Western Ghats in Peninsular India. The several papers presented in the symposium on rare and endangered and endemic plants of the Western Ghats in the year 1991 clearly indicated that the Southern Western Ghats are the original locality from where a number of endangered and rare plants have been recorded. The three volumes of the Red Data Book on Indian Plants (1987, 1988, 1990) present infomation on 614 taxa of Vascular plants for whole of India. Out of these, 185 taxa of flowering plants are reported from Southern Western Ghats alone, under various categories of threatened plants. Several species reported from this area have not been relocated even from the type locality, showing that they have probably become extinct. Raghavan & Singh (1983) enumerated a list of 20 species which could not be relocated in the Western Ghats of Maharashtra and Karnataka. Many species recorded by Beddome (1866) from Anaimalai could not be relocated by subsequent collectors in the area. Sharma *et al.* (1977) could not recollect several species, reported earlier from Nilgiris. Shetty & Vivekananthan (1991) reported 17 taxa from High Range of Kerala which could not be relocated from their type localities.

Habitat destruction along the fragmentation of ecological niches coupled with anthropogenic factors has already taken its toll in Southern Western Ghats. Many of the interesting plants described from here, have not been relocated after their type collection. The possibly or probably extinct taxa recorded from here are mostly narrow endemics or extremely rare and nich specificity species. Most of the causes for extinction are due to anthropogenic interference in the form of habiat destructions or over exploitation. The other causes for extinction like environmental factos, ecological substitutes, biological factors and pathological causes are yet to be known, after detailed studies. Even arborescent plants like *Eugenia argentea* (Wynaad), *E. sigampattiana* (Tirunelveli hills), *Humboldtia bourdillonii* (Ghats of Peermade and Courtallam), *Dialium travancorium (Ponmudi)*, *Madhuca bourdillonii* (Kollam hills), *Syzygium bourdillonii* (Ghats in Thiruvananthapuram and Kollam) and *S. palghatense* (Palakkad Hills) have been lost for ever, due to large scale clearing of evergreen forests for commercial planation. The undergorwth strata plants like *Acranthera grandiflora* (Tirunelveli hills), *Desmos viridifloris* (Anaimalai, Peermade), *Impatiens johinii* (High Range), *Sageraea grandiflora* (Kollam hills) and *Ophiorrhiza brunis* (Ghats in Tamil Nadu, Kerala and Karnataka) has also faced the same crisis. Construction of hydro-electric projects, irrigation dams and submersion and clearence of forests may be the cause for extinction of plants like *Eriochrysis rangacharii* (Pykara), *Haplothismia exannulata* (Parambikulam), *Hubbardia heptaneuron* (Gersoppa falls Sharavathi power project), *Ophiorrhiza pykarensis* (Pykara), *Senecio kundaicus* (Kundah), *Syzygium gambleanum* (Kothyar) etc. Plants like *Anaphalis barnesii* (High Range), *Carex christii* (Nilgiris), *Habenaria flabelliformis* (Anaimudi), *Hedyotis beddomei* (Palakkad hills), *Vernonia multibracteata* (Peermade), *V. pulneyensis* (Palnis), and *V. recurva* (Anaimalia) have been lost due to grassland clearance. *Impatiens munnarensis* (Munnar) and *Pavetta wightii* (Coonoor-Nilgiris) could not be relocated due to large scale cultivation of coffee and tea and urbanisation in these areas. Due to large scale commercial exploitation certain endemic bamboos and rattans are facing extinction and they are *Ochlandra ebracteata* (Thiruvananthapuram), *Oxytenanthera bourdillonii* (Ghats of Kerala), *Calamus nagbettai* (Kodagu and Dakshina Kannada) and *C. prasinus* (Kodagu, Shimoga).

TABLE I : ENDEMICS IN INDIA, HIMALAYAS, PENINSULAR INDIA AND WESTERN GHATS

		INDIA	HIMALAYAS	PENINSULAR INDIA	WESTERN GHATS
1)	Chatterjee (1940, 1962)	134 — Genera 6850 — species Spread over 47 families (BRITISH INDIA)	3169 species — Dicots 1000 species — Monocots	34 — Genera — Dicots 2045 species — Dicots 500 species — Monocots	
2)	Rao (1972)	164 Genera (BRITISH INDIA) (121 — 40 Dicot families, 40 — 8 Monocot families)			
3)	Maheshwari (1976)	6700 — species	3165 species — Dicots 1000 species — Monocots	2045 species — Dicots 500 species — Monocots	
4)	Nayar (1980)				49 — Genera
5)	Nair and Daniel (1986)				57 — Genera (46 Monotypic)
6)	Ahmedullah and Nayar (1987)			58 — Genera (47 Monotypic) — Spread over 25 families 1364 species — Dicots (90 families) 548 species — Monocots (14 fomilses)	
7)	Sarçar (1990)	142 — Genera (spread over 46 families 35 — Dicots 11 — Monocots)			
8)	Chand Basha and Nair (1991)				+ 1932 species (48% of the total species of + 4000 species
9)	Nair (1991)				51 Genera (43 Monotypic)
10)	Sastry and Sharma (1991).				1375 taxa. 75% endemic taxa of Peninsular India

TABLE II : DENSITY OF ENDEMISM IN SOME LARGEST FAMILIES OF WESTERN GHATS

FAMILY	INDIA		PENINSULAR INDIA		WESTERN GHATS	
	GENERA	SPECIES	GENERA	SPECIES	GENERA	SPECIES
1) GRAMINEAE	13	+ 155[2]	13[1]	178[1]	10[1]	98[1]
	17[3]			155[2]		
2) ACANTHACEAE	20[3]			143[1]	6[1]	99[1]
3) RUBIACEAE	43			132[1]	1[1]	117[1]
4) ORCHIDACEAE	8 or 9[3]	144[3]		111[1]	1[1]	76[3]
5) LEGUMINOSAE	4[3]	206[4]		103[1] (Fabaceae alone)	—	80[4]
6) BALSAMINACEAE	Nil		Nil	72[1]	—	82[6]

1. Ahmedullah and Nayar (1987)
2. Karthikeyan (1983)
3. Sarkar (1992)
4. Sanjappa (1991)
5. Satish Kumar (1991)
6. Barnes (1939)

TABLE III : DISTRIBUTION OF ENDEMIC SPECIES ALONG THE SOUTHERN WESTERN GHATS

	AREA	NUMBER OF SPECIES			
		DICOTS		MONOCOTS	
		Moderate altitude 800 1800 m	Higher altitude above 1800 m	Moderate altitude 800 1800 m	Higher altitude above 1800 m
1)	Nilgiris	36	65	17	16
2)	Palnis	18	14	4	3
3)	Anaimalai	10	11		
4)	Travancore hills	92			
5)	Wynaad-Coorg and Bababudangiri	12			
6)	Kundah range Nilgiris	7	19	—	2
7)	High Range-Idukki Dt.	—	23	—	6
8)	Agastyamalai and surrounding regions	100 to 150 (Dicots + Monocots), 57 in Western slopes of Kerala			

1-5. Compiled from Blasco (1971) and Meher-Homji (1978)
6-7. Compiled from Shetty and Vivekananthan (1983 ; 1991)
8. Compiled from Henry *et al.* (1984) ; Bloxy *et al.* (1991)

TABLE IV : ENDEMISM AMONG WOODY PLANTS IN THE WESTERN GHATS

	Endemic genera	Endemic species	Total endemics with percentage in low and medium elevation of evergreen forests	No. of endemic species in low and medium elevation of evergreen forests
1) Ahmedullah and Nayar (1987)	1) *Blepharistemma* 2) *Erinocarpus* 3) *Meteromyrtus* 4) *Otonephilium* 5) *Poeciloneuron* 1 4 : Monotypic 5 : 2 species	1) *Litsea* 15 spp. 2) *Symplocos* 14 spp. 3) *Syzygium* 14 spp. 4) *Actinodaphne* 9 spp. 5) *Grewia* 9 spp. 6) *Glochidion* - 9 spp. 7) *Diospyros* 8 spp. 8) *Drypetes* 6 spp. 9) *Cinnamomum* 7 spp. 10) *Jambosa* 7 spp. 11) *Dalbergia* 7 spp. 12) *Hopea* 6 spp. 13) *Mallotus* - 6 spp. 14) *Humboldtia* 5 spp. 15) *Holigarna* " 16) *Euonymous* " 17) *Terminalia* " 18) *Garcinia* " 19) *Cryptocarya* " 20) *Aglaia* "		
2) Ramesh and Pascal (1991)			308 taxa out of 490 taxa occurring here. 62.8% spread over 58 families	1) Euphorbiaceae : 34 taxa 2) Rubiaceae : 34 " 3) Lauraceae : 33 " 4) Myrtaceae : 30 " 5) Dipterocarpaceae : 12 " 6) Ebenaceae : 12 " 7) Arecaceae - 4 "

5.8b. SOUTHERN-WEST COAST

(E. Vajravelu and K. Vivekananthan)

The coastal region comprises diverse ecosystems presenting very interesting aspects for ecological, physiological and phytogeographical studies. Only certain physiologically specialised and ecologically adapted plants grow in these sensitive ecosystems influenced by salinity. The coast line in India is subjected to the wave actions of the oceans. The west coast line is long and more or less straight starting from Kanniyakumari in the south and ending in the Kutch at north and covering the states of Tamil Nadu, Kerala, Karnataka, Maharashtra and Gujarat. The west coast is narrower than the east coast. Further the gradient is rather steep on west coast whereas it is gradual in the east coast. Between the coast line and the adjacent plains lie the two major in shore ecosystems. They are the Strand and Estaurine vegetations. The soil type of the coastal region is varied. There are exposed horizontal beds of several hundred meters in thickness consisting of clays, sandstones and conglomerates. The Deccan traps dominate the Maharashtra coast, but further south along the Karnataka and Kerala shows up to Kanniyakumari the most important formation is recent alluvium though Pleistocene alluvium, Archaean gneissic complex, laterities and Miocene sand stones are also met with.

The climate along the coast line is relative uniform and it has been classified on the basis of moisture index into the following five climatic groups. They are perhumid, humid, subhumid, semi and arid. Humid climate exists along the south western shores stretching into the states of Maharashtra, Karnataka and Kerala. The influence of the maritime climate on the upland part of the coastal biosphere is very much affected by the combined action of the prescription and local topography and the all pervading influence of the sea is felt only in the low lying areas of the coast. The nature of the vegetation is greatly influenced by the upland sandy relief which alters the influence of climate and the properties of soils due to variations environmental factors. On the contrary, the effect of the land climate is not effective in the low lying areas of the coast. Here they are chiefly influenced by tides, wave action, sea winds, saline water and nature of substratum (Rao & Sastry, 1974).

The vegetation of coastal regions exhibits distinct complexity. The classification proposed by Champion and Seth (1968) is i) Littoral and Tidal Swamp forests and ii) Littoral forests which are modified by Rao & Sastry (1972) as i) Coastal vegetation and ii) Strand vegetation respectively. The Indian coastal type categorised into two subtypes viz. Strand vegetation and Estuarine border land vegetation.

1. STRAND VEGETATION

It is characterised by open mat-forming pioneers in varing proportions followed by scattered herbs, shrubs and trees dispersed on a relief beyond the high tide limit designated "Supra littoral zone" or "backshore" This is further divisible into 3 subtypes viz. sand, rock and coral strands which correspond to the underlying substratum and show marked differences in the vegetation pattern and floristic compositions each subtype there are zonations which include the open pioneer zone, the closed herbaceous zone, the middle or bushy zone and the inner woodland zone; each of them exhibiting characteristic plant groupings (Rao & Sastry, 1974).

In the subtype strand sand mat forming species like *Canavalia maritima, Cyperus* spp., *Ipomoea pes-caprae, Launea sarmontosa, Spinifix littoreus, Sporobolus virginicus* and *Zoysia matrella* occur. In the open pioneer zone, which is succeeded by a herbaceous zone where herbs like *Aristolochia bracteata, Borreria articularis, Enicostemma hyssopifolium, Euphorbia rosea, Geniosporum tenuiflorum, Gloriosa superba, Halophyrum mucronatum, Ipomoea pes-carprea, Launea sermentosa, Perotis indica, Phyllanthus rotundifolius, Polycarpaea corymbosa, Polycarpon prostratum, Sesasum prostratum, Spinifix littoreus, Trachys muricata* etc. are found. The herbaceous zone is suceeded by a middle mixed or bushy zone in which the strand shrubs and under shrubs like *Allmania nodiflora, Calotropis procera, C. gigantea, Cassia auriculata, Clerodendrum inerme, C. indicum, C. aquileatum, Crotalaria trifoliastum, Dodonea viscosa, Oldenlandia umbellata, Perotis indica, Phyllanthus maderaspatensis, Sericostoma pauciflorum, Spinifix littoreus, Synostemon bacciformis, Tamarix dioica, Tephrosia hirtra, T. lanceolata, T. purpurea, Vitex negundo* etc. occur. This zone of creepers, herbs and shrubs, gradually merges with a few species attaining tree status to form an open inner woodland zone. The most common trees and plants are, *Acacia planifrons, Barringtonia asiatica, Calophyllum inophyllum, Euphorbia nivulia, Hibiscus tiliaceaus, Pandanus odoratissimum, Phoenix sylvestris, Pongamia pinnata, Premna serratifolia, Syzygium ruscifolium, Thespesia populnea* etc. Some of the commonly cultivated trees are *Anacardium occidentale, Casuarina equisetifolia, Cocos nucifera, Pithecellobium dulce* etc. *Prosopis juliflora* usually forms a gregarious dense thickets in certain places. The subtype strand rock is distributed along the coast and is more predominant along the west coast rather than east coast. This strand gets a heavy rainfall since it is bordered by Western Ghats. The ingeneous rocks constitute this strand. The interesting feature of the rocky relief is the occurrence of a few species which are found in the similar habitats in inland. The three distinct features exhibited by this strand are the formation of steep slopes with pot holes, solution cups and crannies; wave cut rocky with undulating upper surfaces having crevices and land ward rocky sandy strand gradually merging with the upland relief. These tranisitions are accompaind by a change in the floristic composition as well.

Some of the plants that can withstand this situation are *Atriplex stocksii, Fagonia cretica, Limonium stocksii, Polycarpaea spicata, Enicostemma hysspifolium, Kicxia ramosissima, Lindenbergia indica, Portulaca quadrifida, Pulicaria angustifolia* and *Tephrosia purpurea* are some of the bushy and shrubby plants found here. Adjacent to middle slope, on the midland, species like *Blumea obliqua, Convolvulus auricomus, Hibiscus ovalifolius, Heliotropium tuberculosm, Polygala erioptera, Polycarpaea corymbosa, Pulicaria foliosa, Sida ovata* and *Taverniera cuneifolia* are found.

The subtype strand coral is of restricted occurence and usually found along oceanic islands like Laccadive, Amindiv groups and Gulf of Mannar, Krusadi group of Islands. Hence the vegetation of this strand on west coast is very very meagre. However, species like *Atriplex stocksi, Salicornia brachiata, Pemphis acidula* etc. occur in the pioneer zone.

2. ESTUARINE VEGETATION

This type of vegetation is characterised by dense and gregarious growth of woody plants, shrubs, succulent herbs. Usually this habitat is under the constant influence of saline tidal and fresh water resources. Further this type of vegetation is predominant in the deltoic regions and riverine mouths along the east coast whereas it is confined to sea inlets small river mouths, lagoons, bays and back water systems along the west coast. The mangrove vegetation in the east coast is composed of good number of species attaining density and stature, whereas along the west coast they are poor in quality, extent and species composition. The esturarine vegetation can be dealt under two distinct soil-vegetational types. They are euestuarine and proestuarine. In the euestuarine type the plants grow on areas situated closest to the estuarine water and the land is subjected to the rhythm is tides, whereas the proestuarine type is a composite type in which the vegetation is related to the nature of the relief and tidal influence, showing three distinct vegetational subtypes like Tidal mangroves, Prohaline and Euhaline. The west coast estuarine vegetation which is mostly along the banks of the backwater systems in Malabar coast the euestuarine species are completely absent. The common tree species found in the tidal mangrove zone are *Avicennia officinalis, A. alba, Kandelia candel, Rhizophora mucronata, R. apiculata* etc. The species like *Acanthus ilicifolius, Barringtonia racemosa, Bruguiera gymnorrhiza, Cerbera manghas, Ceropegia tuberosa, Excoecaria agallocha, Hibiscus tiliaceus, Gloriosa superba, Lummitzera racemosa, Sonneratia apetala, Tylophora tenuis, Vitis vitigenia, V. quadrangularis* etc. constitute the components of the prohaline zone. The herbs like *Crinum asiaticum, Parsonsia helicandra, Sphenoclea zeylanica* and

Xyris indica occur in this zone. The fern species *Arcostichum aureum* occurs in disturbed areas and forest clearings and *Pandanus odoratissimum* is found in large clumps. The estuarine vegetation in Karnataka and Maharashtra states exhibits similarities in floristic composition. *Aegiceras corniculatum, Avicennia alba, A. officinalis, Bruguiera gymnorrhiza, Clerodendrum inerme, Excoecaria agallocha, Lumnitzera racemosa, Rhizophora mucronata* and *Sonneratia apetala*, are the predominant prohaline species of the tidal mangroves whereas the species of euestuarine zone is not represented. The common taxa found in the euhaline zone are *Acanthus ilicifolius, Aeluropus lagopoides, Arthrocnemum indicum, Atriplex stocksii, Fimbristylis cymosa, Scirpus ferrugineus, Sporobolus virginicus, Suaeda nudiflora* etc. *Acrostichum aureum, Cynometra iripa* and *Heritiera littorale* form a conspicuous mosaic of the prohaline belt of the estuarine vegetation in the Karnataka coast.

Though the above mentioned vegetation types are of common occurrence along the coast in general, there are certain plants which are predominently found in certain regions only. The strand plants along the Malabar coast are as follows: *Canavalia maritima, Colubrina asiatica, Cyperus pedunculatus, Euphorbia rosea, Parsonsia helicandra, Scaevola taccada* and *Wedelia biflora*. Species like *Acrostichum aureum, Calophyllum decipiens*, and *Flagellaria indica* are further extending into the coast of Karnataka. Along the coast of Karnataka, the noteworthy strand plants are *Crotalaria nana, Cyperus pedunculatus, Euphorbia rosea, Indigofera uniflora, I. aspalathoides, Neanotis carnosa, Scaevola taccada, S. plumieri* etc.

With regard to the estuarine vegetation, the species diversity along the Malabar coast is perhaps the highest. *Avicennia officinalis, Barringtonia racemosa, Bruguiera gymnorrhiza, Ceropegia tuberosa, Flagellaria indica, Parsonsia helicandra, Rhizophora apiculata* etc. are the most common species found in Kerala and Karnataka coastal areas for the entire west coast. Species like *Cynometra iripa, Heritiera littoralis, Sonneratia caseolaris* etc. are frequent along Karnataka coast. *Juncus maritimus* and *Urochondra setulosa* are also found only along western coast.

Some of the species of strand vegetation found on the coast, represent elements of the western and eastern hemispheres. Apart from the above trend, some of the endemics are also noticeable on the coast. For example *Indigofera uniflora* and *Oldenlandia pruinosa* are found distributed only along the western coast. *Crotalaria nana, Dimorphocalyx glabellus, Dolichos ciliatus, Geniosporum tenuiflorum, Hydrophylax maritima, Indigofera aspalathoides, Osbeckia zeylanica* and *Stylosanthes mucronata* are usually present along both the coasts and also extend to Sri Lanka. Some of the strand flora of Sri Lanka are also found on the west coast. *Cyperus pedunculatus, Halophyrum mucronatum, Polycarpaea spicata, Scaevola plumieri* and *S. taccada* have spread along the shores of Kerala and Karnataka.

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5.8c. L A K S H A D W E E P

(E. Vajravelu and K. Vivekananthan)

The Union Territory of India, Lakshadweep, is an archipelago consisting of twelve atolls, three reefs and five submerged banks in the Arabian sea off the West coast of peninsular India, with the capital at Kavaratti. This group of Coral Islands lying between 8^0 and 12^0 3' north latitude and 71^0 and 74^0 east longitude is about 220 to 440 km from the coastal city of Cochin in Kerala. The territory comprising in all 36 small scattered coral islands covering an area of 32 sq km of which only ten *viz.* Agatti (2.7 sq km), Amini (2.6 sq km), Andrott (4.8 sq km), Bitra (0.1 sq km), Chetlat (1.0 sq km), Kadmat (3.1 sq km). Kalpeni (2.3 sq km). Kavaratti (3.6 sq km), Kiltan (1.6 sq km) and Minicoy (4.4 sq km) are inhabitated with a total population of about 40568. (Mannadiar, 1977; Nayar & Giri, 1988). Bangarum, uninhabited till recently is now being developed as a tourist resort. All the islands except Andrott, extend along north-south direction. Most of them are crescent shaped with an extensive lagoon on the western side. Rivers, streams and ground water are absent. Seepage water occurs a couple of metres below the land surface.

TOPOGRAPHY AND SOIL

All the islands are almost plain, the highest point being not more than 5 m above m.s.l. The soil is poor, the top layer consisting chiefly of finely disintegrated coral, forming a white sandy layer with an admixture of vegetable humus. In general, the soil is shallow in the beach and deeper towards the centre. The humus layer does not go very deep. In certain islands like Agatti, Andrott and Kavaratti humus does not exist at all since the islanders are in the habit of burning the humus. The soil is open to wind erosion. The depth of the sand layer varies from island to island. In general, the soil is shallow near the beach and is deeper towards the centre. The usual depth is about 1- 1. 75 m. At this depth, there is a compact but porous crest of lime stone conglomerate of about 30 cm thickness. In the island of Agatti, Kalpeni and Minicoy, this crest is not so well formed, being soft and powdery but in the other islands it is very hard, quarried out and used for building construction. On boring through the conglomerate, there is a bed of fine sand through which potable water infiltcrates (Krishnaswami, 1955).

CLIMATE AND RAINFALL

The islands enjoy a humid tropical climate which prevails all along the Malabar Coast. The miniumum and maximum temperatures range between 17°-18°C and 35°-38°C (Saldanha, 1989). The months of March to May, just before the break of the south-west monsoon are extremely hot and humid, like the west coast of the mainland. During the rainy season of June-August, wind blows very fast from the west bringing rains along with it. Though the lagoons protect the shore from the waves, the damage caused by the wind is usually considerable. The relative humidity of over 70 per cent is highly conducive to plant growth.

The islands have the benefit of both the south-west and north-east monsoons but most of the rainfall is from south-west monsoon in the months of June to August. The period from December to April is almost dry except for occasional drizzling. The average annual rainfall of the islands varies between 1500 mm in the northern islands to 1640 mm in southern islands.

PREVIOUS BOTANICAL EXPLORATIONS

Isolation from the mainland, scattered nature of islands and inaccessibility are the main causes for the fragmentary knowledge of the vegetation of these islands (Sivadasan & Joseph, 1981). The earliest account of the vegetation is of Andrott island by Prain (1892) who reports of the visit of Woods during the year 1834. Hume (1896), who visited the islands in 1875, for an ornithological survey has also reported on the plants, collected by him. Later a series of expeditions were made by a group of scientists in a steamer H.M.I.M. "Investigator" and contributed much to the knowledge of botany of Lakshadweep (Prain, 1889, 1892, 1893, 1984). Prain had exhaustively explored and described about 190 species of flowering plants. Willis (1901) have also provided some floristic information. Wadhwa (1960, 1961) has also studied the vegetation and furnished the additions to the flora of these islands. Sivadasan & Joseph (1981) during their botanical trip have collected 99 species spread over 44 families. Saldanha (1989) made an environmental impact assessment study of these islands along with Andaman and Nicobar. Ellis (1924), Krishnaswami (1955) and Mannadiar (1977) have also dealt with the flora of these islands and other aspects.

VEGETATION AND PHYTOGEOGRAPHICAL AFFINITIES

Due to the paucity of information about the area, flora and vegetation, several authors, who have divided India into several biogeographic regions, have not included Lakshadweep group of islands in their works. Hooker (1904), and Takhtajan (1988) included the coral Lakshadweep group of islands under "Malabar" phytogeographical region of India, while Puri (1960) treats it as an additional, distinct botanical zone of India.

The vegetation and floristic composition are alomst the same, throughout these islands, due to similar conditions of soil, climate and rainfall. The shallow soil with a high water table severely limits the variety of plants that can grow on the islands (Sivadasan & Joseph, 1981). But the environmental factors such as effect of tides, wave action, sea winds and saline water play an important role in determining the nature of vegetation (Nayar & Giri, 1988). Hooker (1904) includes these islands under Malabar and points out its vegetation is Malayan with no endemic species and consists of coral islets fringed with coconut palms. The trees, mostly introduced by man, are *Areca catechu, Artocarpus heterophyllus, Morinda citrifolia, Pisonia grandis, Syzygium jambos, Terminalia catappa, Thespesia populnea* etc. Other being probably the result of ocean-borne seeds like *Guettarda speciosa, Hernandia nymphaeifolia, Ochrosia oppositifolia, Pandanus fascicularis* etc. The herbaceous plants are chiefly the weeds of Western Peninsula. The littoral grass *Spinifix littoreus* is probably bird or wind borne.

Champion and Seth (1968) have not mentioned anything about the vegetation type of these islands. But their "Littoral and Tidal Swamp forests" are consolidated under a broad group "Coastal vegetation" and the term "Strand Vegetation" is used as a substitute for "Littoral forests" by Rao & Sastry (1972, 1974). Rao *et al.* (1963), Rao & Sastry (*l.c.*) further divided this as Strand Coral, Strand sand and Strand rock. Of these Strand coral occurs in oceanic islands like Lakshadweep and Maldives, and coral reefs along the coasts of Andaman and Nicobar Islands. It also occurs in the Islands and reefs in the gulf of Mannar, Mandapam and Krusadai group of islands in Tamil Nadu. Sivadasan & Joseph (1981) classified the vegetation of these islands under "Strand coral" which usually has an open pioneer zone characterised by the presence of *Cordia subcordata, Pemphis acidula, Scaevola taccada* and *Suriana maritima* and an inner woodland zone having *Dodonaea viscosa, Guettarda speciosa* and *Thespesia populnea, Syringodium isoetifolium* and *Thalassia hemprichii* are the sea grasses reported adjacent to the seashores. Wadhwa (1960, 1961) reports the occurrence of *Cyrtococcum trigonum, Cyperus eleusinoides, Digitaria ciliaris, D. longifolia, Eragrostis ciliaris, E. tenella* and *Paspalum vaginatum* in sandy soil near shores. *Thurea involuta* is the only grass reported in the Strand coral (Rao & Sastry, 1974).

Due to increase in human population and biotic interference, the natural flora is now consists only of psammophytic herbs and shrubs. Littoral trees which were once prominent are only scattered remnants of the original vegetation represented by the scrub *Scaevola* (Saldanha, 1989).

The common trees in the islands are *Alstonia scholaris, Azadirachta indica, Bombax ceiba, Calophyllum inophyllum., Ficus religiosa, Terminalia catappa, Thespesia populnea* and *Zizyphus mauritiana. Casuarina littorea* and *Delonix regia* are often planted as avenue trees. The other ornamental plants common in gardens and roadsides are *Bougainvillea spectabilis, Catharanthus roseus, Codiaeum variegatum, Cosmos sulphureus, Hibiscus rosa-sinensis, Nerium* *oleander* and *Pedilianthus tithymalodies. Areca catechu, Cocos nucifera* and *Piper betle* are cultivated in almost all the islands. The important economic product of the territory are coconut and coir. Other fruit plants cultivated as inter-crops are banana, papaya, guava, sapota and different varieties of citrus.

Even though no endemic plant is reported so far, plants like *Hernandia ovigera, Lepturus radicans, L. repens* and *Thurea involuta* hitherto reported from Lakshadweep, Sri Lanka and Nicobars are yet to be located along the Indian shores (Rao, 1971). An analysis of the vegetation reveals that it is a mixture of Malesian, Polynesian and Australian affinity. Many of eastern elements occurring here extend up to South Western Peninsula from Malesian islands through Malacca, Andaman & Nicobar Islands, Moulmein, Tenasserim, Sunderbans, Coromandal coast and Sri Lanka (Rao & Sastry, 1974).

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5.9. D E C C A N

(A.N. Henry, N.C. Rathakrishnan & T. Ravisankar)

INTRODUCTION

Geographically the word "Deccan" has been variously defined (Hooker & Thomson 1855; Hooker (1904) 1907 ; Clarke 1898 ; Chatterjee 1940 & 1962 ; Turrill 1953; Razi 1955 ; Maheshwari *et al.* 1965 ; Mahabale 1966 & 1979 ; Croizat 1968 ; Takhtajan 1969 & 1986 ; Meher-Homji 1973; and Good 1974). In this chapter the area south of Central Indian highlands comprising part of North Deccan Plateau, part of Eastern Plateau, and South Deccan Plateau have been included. This area is bounded on the eastern side by a discontinuous mountain chain, - the Eastern Ghats and on the west by the Western Ghats, and forms a broad - based inverted triangle comprising a part of Madhya Pradesh and the plains and tablelands of Maharashtra, Karnataka, Andhra Pradesh and Dharmapuri district of Tamil Nadu. The boundaries of Western Ghats and Deccan are not sharp, as large number of spurs of Western Ghats enter into Deccan and merge with the mountains of the Eastern Ghats.

This region, mostly of the "Deccan Trap Country", with a comparatively dry elevated tableland interspersed with numerous isolated hills, has generally light rainfall and dry climate. The relatively low rainfall and humidity strikes the floristic differences with the rich Western Ghats which is the contiguous botanical region. The flora has fewer endemic elements. The most characteristic formations are moist deciduous, dry deciduous and thorn forests. Some of the typical plants of the dry area are *Santalum album, Toona ciliata, Soymida febrifuga, Capparis* spp., *Grewia* spp., *Phyllanthus* spp., *Euphorbia hypericifolia, Borassus flabellifer, Phoenix sylvestris, Flacourtia* spp., *Xeromphis* spp. and *Diospyros* spp. The plateau blooms with greenary in rainy season but gets parched up in summer.

EVOLUTIONARY HISTORY OF THE FLORA

Past Floras of the Deccan (Mostly based on Mahabale 1966)

(i) Glossopteris flora : A bewildering variety of igneous and sedimentary Archaean rocks are exposed in the Deccan. They are all unfossiliferous and give no idea about the early vegetation. However, beds containing a mixture of lower and upper Gondwana plants such as *Glossopteris indica, Schizoneura*

gondwanensis, *Cladophlebis* sp. with *Neocalamites* spp., *Araucarites cutchensis* and *Elatocladus jabalporensis* are found in the Godavari valley in areas near Maleri a little beyond Sironcha at the confluence of Pranhita river near Godavari. They are also called the "Transitional beds" and constitute the Middle Gondwanas which suggest advent of Triassic age in the Deccan in the Gondwana era.

The most striking flora of the Deccan is its Tertiary flora belonging to Eocene period. It possibly continued much later till the middle Miocene, and is preserved well in the Intertrappean Cherts. A number of intertrappean beds are found all along the edge of the present day Deccan. It is this flora which is really the starting point of the present day flora of Deccan, comprising a number of relict forms which have continued in the flora of Deccan today.

(ii) The Deccan intertrappean flora : The first report of the Deccan Intertrappean flora was as early as 1838. Mahabale (1966) enumeraed about 150 species spread over 60 genera belonging to 35 families, the most outstanding assemblage is that of aquatic plants, dicots and monocots, especially palms and water ferns. Amongst these, palms form a striking group, and resemble with *Phoenix, Borassus, Bactris, Astrocaryum* and *Cocos*. It is interesting to note that some of these genera are members of the present Deccan flora ; for example *Phoenix sylvestris* is spread all over the plains and low hills of Deccan along the streams and rivulets forming long stretches of palm woods. Another significant element in this flora is the genus *Musa*. Among pteridophytes two important genera found in ponds and riversides in Deccan are *Azolla* and *Marsilea*.

Among the flowering plants the families Euphorbiaceae, Combretaceae, Fabaceae, Lecythidaceae, Simaroubaceae and Apocynaceae seem to be dominating, besides Arecaceae and Musaceae under monocots. Generally the woody members of these families are preserved and easily recognised, while their herbaceous counterparts are yet to be recognised. For example, along with the woody members of Fabaceae, Euphorbiaceae and Combretaceae, the herbaceous *Desmodium* as well as the aquatic *Aeschynomene* could be found. It is generally believed that the main features of the Deccan trap country have been fixed mostly in the Upper Pleistocene period after which they have remained more or less stable. It is also presumed that more humid and warm conditions of the Eocene period in the Deccan became warmer and drier in Miocene, allowing only dry deciduous and thorny elements to survive on the plateau and evergreen ones pushed into the pockets of ghats where the rainfall is more than on plateau.

With the advent of Pliocene, maximum uplift of the Himalayas took place, and many plants from the drier regions of the Middle East invaded the north-west provinces of India spreading dry and desert species in this valleys of Indus, Thar desert and thence into the Indo-gangetic Plain. Some of these reached the Central

Indian Plateau including Deccan through Vindhyan passes. Fate of these plants again changed with the onset of Pleistocene period in the late Tertiary. Towards the middle of Pleistocene the Deccan region became fairly stable and its monsoon pattern more or less fixed. The short pluvial period followed by the long dry period year after year would have affected vegetation, soil erosion, drainage system vis-a-vis plants.

(iii) Pleistocene flora of Deccan : Pleistocene flora in the Southern India is mostly restricted to the Nilgiris at higher altitudes, and is poorly represented on Deccan plateau. A stump of *Terminalia* sp. constitutes the only authentic record of this age in the Deccan area.

PHYSIOGRAPHY

The peninsular plateaus constitute the largest physiographic division, facing the Bay of Bengal in the east and the Arabian Sea in the West. The Deccan consists of three distinctive physiographic subdivisions. 1. North Deccan plateau: Maharashtra Plateau ; 2. South Decan Plateau and 3. East Deccan Plateau: part of Dandakaranya.

1. North Deccan Plateau : Maharashtra Plateau

The Sahyadri at its northern end almost touches the east-west tending Satpura range and descends eastwards to a typical Deccan country. To the south of Satpura range lies the Maharashtra plateau. The west-flowing river Tapti forms the northern boundary and the river Purna coming from the east through the cotton growing plains of Berar, forms the north-eastern boundary of the plateau.

Nearly the whole of this plateau is formed of plateau basalt, which on weathering has given rise to rolling plains with intervening shallow valleys. The upper reaches of Godavari, Bhima and Krishna rivers lie in this region, besides hundreds of small perennial streams fed by excessive rainfall in the Sahyadri flow through this area, making it agriculturally productive. The river Godavari enters the Maharashtra Plateau at Nasik and flows eastwards to the farthest end, receiving on its right bank the Pravara and Sinphana rivers and on its left bank the combined water of the Dudna and Purna.

2. South Deccan Plateau

2.1. Telangana Plateau : The South Deccan plateaus are curved out of Archaean gneissic rocks. The Godavari divides the Telangana plateau into two sections. The northern section is bounded on the north by the east-flowing Wardha and on the east by the south-flowing Pranhita, a tributary of Godavari. This region is hilly and well forested. The surface of the plateau in the southern section is dotted with low hills and shallow depressions.

2.2. Rayalaseema Uplands: Geologically the whole area forms a part of Deccan shield and most of the area is covered by Precambrian granites which are highly magnetised. The oldest rocks exposed in the district are a group of metamorphic rocks belonging to the lower Pre-Cambrian or Archaen era and consists of Peninsular gneisses, Phyllites, Schists and Amphibolites. Recent formations like old and new alluvium are also found along river courses and areas adjacent to them. Laterites are found only in some areas.

The main rivers and rivulets of this area are Penna, Chithravathi, Vedavathi, Papagni, Palar, Swarnamukhi, Bahuda, Kusasthali, Thungabhadra, Krishna, Hundri, Kunderu and Gundlakamma. The river Tunghabhadra forms the northern border for Kurnool in Rayalaseema.

2.3. Karnataka Plateau : The Karnataka Plateau has been divided into two sections : The North Karnataka Plateau and Mysore Plateau. The rivers Krishna and Thungabhadra flow through the northern section. The Krishna changes its course from south to east on entering this plateau and flows for 400 km before entering Telangana Plateau. The Mysore Plateau is the loftiest and most well-defined plateau of southern India. This plateau abuts against the Sahyadri on the west and is bounded on the east by the Eastern Ghats. Along its southern boundary rises the Nilgiris. Mysore Plateau may be divided into two sections : Malnad and Maidan. Malnad portion is the hilly area bordering Sahyadri; it is dissected into steep hills and deep valleys with dense forests. The Maidan is an area of rolling plains with low granite hills. The river Cauvery entering the Mysore Plateau flows eastwards then widens and forms the first island Sriangapatnam ; it flows for about 200 km in the Mysore Plateau, before entering Tamil Nadu.

2.4. Tamil Nadu Uplands : This region is the southeast extension of the 'Maidan" of the Karnataka Plateau and lies south of Kolar district. The whole area stretches mostly as one piece of land at the foot of Melagiris in Dharmapuri district of Tamil Nadu.

3. East Deccan Plateau : Part of Dandakaranya : The tract known as Dandakaranya occupies a very sparsely populated and rugged terrain falling in three districts : Bastar, Kalahandi and Koraput. It was developed for rehabilitating displaced persons. The river Indiravati flows in the middle of this region from east to west. The terrace developed around Jagdalpur extending westwards to Chirakot where the river leaps over a precipitous cliff forming one of the most beautiful waterfalls in the Peninsular India. Below the falls the river enters another dissected terrace finally joining the Godavari river near Bhopalpatnam. The southern part is drained by the south-flowing Sabari river which rises from the western slope of Eastern Ghats and flows through deeply dissected hills.

VEGETATION

1. North Deccan Plateau : Maharashtra Plateau

The vegetation of the Maharashtra Plateau may be classified under moist tropical and dry tropical Forests.

MOIST TROPICAL FORESTS

These forests formed on the slopes of the hilly uplands are scattered all over the plateau. They are subdivided as follows:

(a) Moist teak forests : These are high forests restricted mainly to the hilly terrain. Teak is the dominant species throughout along with *Haldina cordifolia, Terminalia bellirica, T. crenulata, Wrightia tinctoria, Anogeissus latifolia, Lagerstroemia parviflora*, *Mitragyna parvifolia*, *Acacia chundra*, *Bombax ceiba* etc. forming the top storey. Lofty trees of *Tectona grandis* , *Haldina cordifolia* and *Mitragyna parvifolia* are seen in the Alapalli forests in Chandrapur district. The second storey consists of *Bauhinia racemosa*, *Butea monosperma, Careya arborea, Cassia fistula, Albizia procera, Diospyros melanoxylon*, *Holoptelea integrifolia*, *Kydia calycina*, *Mangifera indica*, *Sterculia urens* and *Miliusa tomentosa*, The shrubs include *Carvia callosa, Carissa congesta*, *Casearia graveolens*, *Helicteres isora*, *Meyna laxiflora*,*Woodfordia fruticosa* and *Ziziphus caracutta*.

(b) Southern tropical moist mixed deciduous forests : In these forests teak is present occasionally along with *Acacia chundra*, *Anogeissus latifolia*, *Bombax ceiba, Dalbergia lanceolaria, Garuga pinnata, Haldina cordifolia*, *Lannea coromandelica, Ougeinia oojeinensis, Pterocarpus marsupium, Terminalia bellirica*, *T. crenulata* and *T. chebula*. The second storey consists of *Acacia polyacantha, Butea monosperma*, *Careya arborea*, *Cassia fistula*, *Grewia tiliaefolia*, *Holoptelea integrifolia*, *Mallotus philippensis*, *Mangifera indica*, *Pongamia pinnata*, *Syzygium cumini* and *Wrightia tinctoria*. The shrubs include *Carissa congesta*, *Carvia callosu*, *Meyna laxiflora, Flacourtia indica*, *Woodfordia fruticosa* and *Ziziphus caracutta*.

Climbers such as *Abrus precatorius*, *Acacia pinnata, Ampelocissus latifolia*, *Combretum albidum*, *Cryptolepis buchananii* and *Dioscorea* spp. are commonly met with.

DRY TROPICAL FORESTS

These are found in the drier areas of the plateau.

(a) Southern tropical dry deciduous forests : In these forests small trees and shrubs are the chief woody components which include *Anogeissus latifolia, Boswellia serrata, Ziziphus mauritiana, Ficus racemosa, Tectona grandis, Cochlospermum religiosum, Butea monosperma, Dalbergia latifolia, Lagerstroemia parviflora, Madhuca longifolia* var. *latifolia* and *Hardwickia binata.* They are scattered and form the canopy of the area. The understorey of these slopes and other open forest areas consist mainly of shrubby species like *Acacia chundra, Maytenus emarginatus, Securinega leucopyrus, Helicteres isora* and *Xeromphis spinosa.* The common climbers and woody twiners include, *Hemidesmus indicus, Celastrus paniculatus, Abrus precatorius, Cocculus hirsutus, Combretum ovalifolium,* and *Ventilago denticulata.*

(b) Southern tropical thorn forests : The forests are blank and with shallow soils. The grasses are stunted due to poor soil. The forests, being scattered and surrounded by cultivation on all sides, are subjected to heavy grazing and illicit felling. In the areas of rivulets and streams there are savannah formations composed of open grasslands with few scattered shrubs and trees.

Trees such as *Acacia chundra, A. nilotica* ssp. *indica, Anogeissus latifolia, Terminalia crenulata* and *Ziziphus mauritiana* frequent this area. However, the typical members of scrub forests are shrubs like *Canthium parviflorum, Carissa congesta, Dichrostachys cinerea, Maytenus emarginatus, Mimosa hamata, Cassia auriculata, Rhus mysorensis, Ziziphus oenoplia* and *Z. nummularia,* The common climbers are *Aspidopterys cordata, Cardiospermum halicacabum, Cocculus hirsutu, Mukia maderaspatana, Rivea hyprocrateriformis* and *Wattakaka volubilis.*

Thorny scrub jungle mixed with dry deciduous forest type is seen in small valleys and slopes of hills. The hill tops in some of these areas are barren.

During the rainy season a luxuriant and dense growth of herbs including grasses cover the floor of these forests and open areas with the following common species : *Alysicarpus vaginalis, Chlorophytum* spp., *Crotalaria* spp., *Cassia pumila, Cleome viscosa, Indigofera cordifolia, Polygala* spp., *Sida spp., Trichodesma sedgwickianum* and *Rostellularia* spp. The grasses and sedges include *Apluda mutica, Arundinella pumila, Aristida adscenscionis, Echinochloa colonum, Eragrostis* spp., *Heteropogon contortus, Fimbristylis* spp., and *Cyperus* spp.

In addition to these main types of vegetation there are certain charateristic associations which are as follows :

HYDROPHYTES AND MARSHY PLANTS

Throughout the plateau are numerous relatively shallow ponds and lakes in which rich aquatic vegetation is found. In Nagpur-Vidarbha area many water plants appear to have concentrated in ponds with Archaean base in Umred area. The general vegetation in most of the perennial ponds is of a seasonal rooted herbs like *Nymphaea* spp. and similar plants such as *Aponogeton natans, Nymphoides* *cristatum* and *Potamogeton nodosus.* The other attached and submerged hydrophytes include *Hydrilla verticillata, Limnophila indica* and *Vallisneria spiralis.*

The free-floating forms include *Eichhornia crassipes, Ipomoea aquatica, Marsilea minuta, Utricularia exoleta, Pistia stratiotes, Trapa natans* var. *bispinosa* and *Wolffia arrhiza.*

The wet places around cultivated fields, margins and edges of tanks, lakes and nallahs are generally colonized by *Aeschynomene aspera. A. indica Alternanthera sessilis, Ammannia baccifera, Bacopa monnieri, Bergia ammannioides, Brachiaria reptans, Caesulia axillaris, Cardamine trichocarpa Chrozophora prostrata, Coix* spp., *Commelina* spp., *Echinochloa colona, Eclipta prostrata, Eragrostis* spp., *Fimbristylis* spp., *Hydrolea zeylanica, Lindernia* spp., *Ludwigia* spp., *Phyla nodiflora, Polygonum* spp., and *Rotala* spp. These are rooted to the soil that is saturated with water at least in the early part of their life.

The river beds are moist alluvial or sandy but at some places they are stony and rocky. The river beds are frequented by *Homonoia riparia, Crinum defixum, Tamarix ericoides, Rotula aquatica* and *Crotalaria sericea*

During monsoon, herbaceous species like *Eclipta prostrata, Alysicarpus bupleurifolius, Cyperus* spp., *Alternanthera sessilis, Paspalidium flavidum Hygrophila auricularia, Veronica anagallis-aquatica, Polygonum* spp. and *Dentella repens* are met with in moist alluvial soil.

WEED FLORA

The wasteland components are *Argemone mexicana, Abutilon* spp., *Acalypha indica, Achyranthes aspera, Aristolochia bracteata, Acanthospermum hispidum, Cynodon dactylon, Ageratum conyzoides, Lagascea mollis, Gomphrena celosioides, Cleome viscosa, Tridax procumbens, Euphorbia hirta, Triumfetta rotundifolia, Heteropogon contortus, Bidens biternata, Calotropis* spp., *Cassia tora, Crozophora prostrata, Croton bonplandianus, Echinops, echinatus, Plumbago zeylanica* etc.

The monsoon weeds of cultivated fields of Jowar, Groundnut, Rice and Cotton include *Acalypha indica, Ammannia baccifera, Borreria articularis, Caesulia axillaris, Cassia tora, Celosia argentea, Cleome viscosa, Cyperus rotundus, Corchorus* spp., *Emilia sonchifolia, Leucas* spp., *Portulaca* spp., *Vernonia cinerea* and *Xanthium indicum Indigofera* spp., *Rotala* spp., *Euphorbia hirta* etc.

Mainly along the bunds of cultivated fields tall grasses like *Chrysopogon fulvus, Cymbopogon martinii, Heteropogon contortus, Ischaemum pilosum, Ophiuros exaltatus* and *Themeda quadrivalvis* are seen scattered ; some of these are also seen in open grassland.

2. SOUTH DECCAN PLATEAU

2.1. Telangana Plateau

Telangana region includes Adilabad, Nizamabad, Karimnagar, Warangal, Medak, Rangareddi and a part of Nalgonda districts of Andhra Pradesh. The hills and forests of granite region are all devoid of top soil except a few patches here and there in the plains. Black cotton soil occurs in several places while laterite soil is common throughout the area. The black cotton soil which is richer than the granite areas, retains moisture for a considerably longer time and is therefore covered with good vegetation.

The vegetation in this area is determined by factors like climatic, edaphic and biotic coupled with altitude and is generally of dry deciduous type whereas moist deciduous type is also available in some places.

SOUTHERN TROPICAL DRY DECIDUOUS FORESTS

The upper canopy of these forests is formed by a mixture of trees which are deciduous during dry season and mostly consists of *Aegle marmelos, Albizia procera, Anogeissus latifolia, Boswellia serrata* (occurs almost as a pure stand on shallow soils and hilltops), *Bridelia montana, Diospyros melanoxylon, Holoptelea integrifolia, Madhuca longifolia* var. *latifolia, Polyalthia cerasoides, Pterocarpus marsupium, Soymida febrifuga, Sterculia urens, S. villosa, Terminalia bellirica, T. chebula* and *T. coriacea.*

The lower storey consists of *Acacia chundra, Buchanania axillaris, B. lanzan, Casearia tomentosa, C. graveolens, Cassia fistula, Ceriscoides turgida, Cleistanthus collinus, Diospyros montana, D. sylvatica, Erythroxylum monogynum, Gardenia gummifera, G. latifolia, Gmelina arborea, Holarrhena antidysenterica, Ixora pavetta, Manilkara hexandra, Tamilnadia uliginosa, Wrightia arborea* and *W. tinctoria.*

The shrubs found in this area include *Baliospermum montanum, Bauhinia racemosa, Canthium parviflorum, Capparis sepiaria, Cassia auriculata, Catunaregam spinosa, Clerodendrum phlomidis, C. serratum, Dichrostachys cinerea, Dodonaea viscosa, Grewia rothii, Indigofera cassioides, Leea macrophylla, Maytenus emarginata, Mimosa intsia, Pavetta indica, Phoenix sylvestris, Vitex negundo* etc.

The common climbers available are *Argyreia sericea, A. setosa, Butea superba, Calycopteris floribunda, Cayratia auriculata, Celastrus paniculatus, Cissus vitiginea, Cryptolepis buchananii, Dalbergia volubilis, Derris scandens, Dioscorea pentaphylla, Gymnema sylvestre, Ichnocarpus frutescens, Mucuna pruriens, Olax* *scandens, Operculina turpethum, Opilia amentacea, Pueraria tuberosa, Rivea hypocrateriformis* and *Ventilago denticulata.*

The common grasses and herbs met with are *Aerva lanata, Andrographis paniculata, Apluda mutica, Aristida setacea, Atylosia scarabaeoides, Dipteracanthus prostratus, Enicostema axillare, Eragrostis atrovirens, Eulaliopsis binata, Indigofera glandulosa, I. astragalina, Tephrosia purpurea* and *Saccharum spontaneum* etc.

SOUTHERN TROPICAL MOIST DECIDUOUS FORESTS

The tree species available are *Anogeissus acuminata, Barringtonia acutangula, Bridelia montana, Canthium dicoccum, Glochidion zeylanicum, Haldina cordifolia, Lagerstroemia parviflora, Miliusa tomentosa Semecarpus anacardium, Strychnos nux-vomica, Syzygium cumini, Terminalia cuneata, Woodfordia fruticosa, Xylia xylocarpa,* The common shrubs are *Helicteres isora, Homonoia riparia, H. retusa, Syzygium heyneanum.*

Allmania nodifolia, Costus speciosus, Flemingia strobilifera, Habenaria roxburghii, Hybanthus enneaspermus, Portulaca oleracea, Sutera dissecta, Verbascum chinense, Xanthium indicum etc. form the undergrowth in these forests.

The common parasites and epiphytes of both types of forests are *Cassytha filiformis, Cuscuta reflexa, Dendrophthoe falcata, Vanda tesellata, Scurrula cordifolia, Viscum articulatum* etc. *Rhynchostylis retusa* is a rare epiphytic orchid found in this area. Fern and its allies common in this area are *Actinopteris dichotoma, Adianthum caudatum, Marsilea minuta* and *Ophioglossum gramineum.*

WEED FLORA

Weeds are common in cultivated fields, fallow lands and open wastelands. They mainly comprise species like *Argemone mexicana, Acalypha indica, Achyranthes aspera, Alternanthera pungens, Cynodon dactylon, Gomphrena celosioides, Cleome gynandra, Croton bonplandianum, Echinops echinatus, Tridax procumbens, Tribulus terrestris, Plumbago zeylanica* and *Xanthium indicum.*

The common aquatic marshy plants occurring in the area are *Ammannia baccifera* var *aegyptiaca, Bacopa monnieri, Caesulia axillaris, Crinum defixum* var. *ensifolium, Limnophila indica, Marsilea minuta. Rotula aquatica* and *Typha angustata.*

2.2. RAYALASEEMA UPLANDS

This region comprises the plains and uplands of Anantapur, Chitoor, Kurnool and Cuddapah districts of Andhra Pradesh.

The vegetational pattern of the forests in this area is very much varied due to geographical location, topography, climate and a wide range of physiognomic features. The forest types vary from dry, mixed deciduous to thorny scrub with occasional patches of dry evergreen.

SOUTHERN TROPICAL DRY DECIDUOUS FORESTS

This type of forests is widespread in the area. The dominant tree species are *Albizia amara, Anogeissus latifolia, Bauhinia racemosa, Cassia fistula, Chloroxylon sweitenia, Cleistanthus collinus, Cochlospermum religiosum, Commiphora caudata, Dalbergia latifolia, Diospyros chloroxylon, Erythroxylum monogynum, Gardenia gummifera, Gyrocarpus asiaticus, Hardwickia binata, Pterocarpus marsupium, Terminalia arjuna, T. alata, T. bellirica, T. chebula* and *T. pallida.*

The other tree species include *Aegle marmelos, Buchanania axillaris, Lagerstroemia parviflora, Phyllanthus emblica, Soymida febrifuga, Vitex altissima* and *Wrightia tinctoria. Santalum album* is sparsely distributed in this area.

Some common shrubs occurring here are *Canthium dicoccum, Carissa carandas, Cissus pallida, Grewia hirsuta, Helicteres isora, Indigofera mysorensis, Pleiospermum alatum* and *Tarenna asiatica.*

The herbaceous and shrubby climbers met with are *Ampelocissus tomentosa, Cansjera rheedii, Cayratia pedata, Celastrus paniculatus, Cocculus hirsutus, Combretum albidum, Gymnema sylvestre, Hiptage benghalensis, Pachygone ovata, Ventilago madraspatana* and *Ziziphus oenoplia.*

The forest undergrowth includes *Andrographis paniculata, Byttneria herbacea, Decaschistia crotonifolia, Crotalaria calycina, C. medicaginea, Desmodium gangeticum, Triumfetta rhomboidea* and *Waltheria indica* etc.

The dominant species of grasses are *Aristida adscensionis, A. setacea, Brachiaria ramosa, Chrysopogon asper, Eragrostis atrovirens, Oplismenus compositus, Panicum notatum* and *Sporobolus wallichii.*

SOUTHERN TROPICAL DRY EVERGREEN FORESTS

This type of forests occurs in gorges, ravines and valleys. The forests are dense and luxuriant and are seen intermixed with deciduous species. The cheif components are *Albizia amara, Atlantia monophylla, Cassine glauca, Catunaregam spinosum, Diospyros ferrea, Drypetes sepiaria, Manilkara hexandra, Memecylon umbellatum, Santalum album* and *Syzygium cumini.*

SOUTHERN TROPICAL THORN FORESTS

Generally scrub forests occur along the fringes of dry and moist deciduous forests, due to intensive biotic interference. The plants here show xeromorphic adaptations. In general the vegetation is dominated by thorny species.

The vegetation is composed of *Acacia chundra, Albizia amara, Bauhinia racemosa, Cassine glauca, Canthium dicoccum, Gardenia latifolia, Glycosmis pentaphylla, Ehretia aspera, Dichrostachys cinerea, Hugonia mystax, Ixora pavetta, Jatropha gossypifolia, Prosopis chilensis, Tarenna asiatica* and *Ziziphus xylopyrus.*

WEED FLORA

Weeds are common in wastelands, cultivated fields and fallow fields. The common species are : *Boerhavia diffusa, Cassia auriculata, C. occidentalis, C. tora, Cleome gynandra, Croton bonplandianum, Datura metel, Hybanthus enneaspermus, Martynia annua, Lantana camara, Acanthospermum hispidum, Achyranthus aspera, Ageratum conyzoides, Alternanthera pungens, Alysicarpus bupleurifolius, A. vaginalis, Argemone mexicana, Aristida hystrix, Aristolochia bracteata, Barleria prionitis, Biophytum nervifolium, Bothriochloa pertusa, Celosia argentea, Chrozophora rottleri, Chloris gayana, Corchorus trilocularis, Cynodon dactylon, Cyperus rotundus, Dactyloctenium aristatum, Eragrostis atrovirens, Euphorbia geniculata, E. hirta, E. indica, Evolvulus alsinoides, Gisekia pharnaceoides, Glossocardia bosvallea, Gomphrena celosioides, Lagascea mollis, Leucas aspera, Malvastrum coromandelianum, Mimosa pudica, Lindernia parviflora, Panicum paludosum, Parthenium hysterophorus, Phyllanthus amarus, P. maderaspatensis, Portulaca quadrifida, Rottboellia cochinchinensis, Sida acuta, Solanum nigrum, S. surattense, Sopubia delphinifolia, Sporobolus, indicus* var. *diander, Tribulus terrestris, Trianthema portulacastrum. Tridax procumbens, Triumfetta rhomboidea, Zornia gibbosa* and *Waltheria indica.*

HYDROPHYTES

Aquatic plants are common along rivers, streams, in ponds, puddles and tanks. They are *Aponogeton natans, Aeschynomene indica, Ammannia baccifera,* *Eichhornia crassipes, Elaeocharis atropurpurea, Ipomoea aquatica, I. carnea, Limnophila indica, Lymnophyton obtusifolium, Ludwigia octovalvis, L. perennis, Monochoria vaginalis, Neptunia oleracea, Ottelia alismoidea, Pistia stratiotes, Polygonum barbatum, P. glabrum, Potomogeton* spp., *Nymphaea pubescens, N. nouchali, Utricularia exoleta, Typha angustata* and *Vallisneria spiralis.*

2.3. Karnataka Plateau

The Karnataka Plateau is mainly an upland of varying heights comprising eleven districts, namely Bidar, Gulbarga, Bijapur, Raichur, Bellary, Chitradurg, Tumkur, Bangalore, Kolar, Mandya and parts of Mysore bordering Andhra Pradesh and Tamil Nadu. Physiographically they are "Maidan" or the plain country with the landscape either flat or rolling. This plateau can be divided into two sections as northern (Karnataka) plateau covering roughly the northern half, and the southern (Mysore) plateau covering roughly southern half.

The terrain in the northern half is generally flat with an average height of 300-600 m. The terrain in the southern half is generally undulating or rolling except Bellary district where it is mainly flat. But the hill ranges in this portion are well pronounced as in the case of Nandi hills in Kolar district with a height of *ca* 1500 m. The hill ranges are rarely in continuously connected chains and arrange themselves into systems crossing the area longitudinally in directions almost parallel to the Eastern Ghats depending on their proximity.

The upland deciduous vegetation of Karnataka may be grouped under moist deciduous, dry deciduous and upland thorn and scrub. They may correspond to Southern moist deciduous forests, southern tropical dry deciduous forests, and Southern tropical thorn forests (Champion & Seth 1968). However, these types gradually merge with each other. Sampathkumaran (1924) followed by Razi (1950) distinguished three parallel zones of belts of forests in Karnataka based on the quantum of rainfall. They are : 1. The evergreen belt where heaviest rainfall occurs along the Western Ghats ; 2. The deciduous forest belt with intermediate rainfall to the east of the evergreen belt and 3. The dry deciduous tract and scrub occupying the rest of the region bordering the ceded districts of Andhra Pradesh with least rainfall.

SOUTHERN TROPICAL MOIST DECIDUOUS FORESTS

On the leeward side of the ghats the vegetation of the hilly upland is generally of the climax moist deciduous type having a brief leaf fall, a non-stratified under-storey of shrubs and climbers as well as a number of epiphytes, mostly orchids (Saldanha, 1984). *Careya arborea, Rerminalia paniculata, Toona ciliata, Butea monosperma, Radermachera xylocarpa* and *Schleichera oleosa* are common among the canopy trees. *Cordia macleodii* and *Erinocarpus nimmonii* are met with only in the northern regions.

The scrubs include *Ardisia solanacea, Holarrhena antidysenterica* and *Ligustrum gamblei, Argyreia pilosa, Holostemma annulare* and *Jasminum malabaricum* are some of the common climbers found in the region.

Epiphytic orchids occur in profusion. They include *Dendrobium barbatulum, D. natans, Aerides crispum* and *Rhynchostylis retusa.*

The undergrowth during rainy season consists of aroids like *Amorphophallus paeoniifolius, Arisaema leschenaultii A. tortuosum* and orchids like *Liparis nervosa* and *Nervilia aragoana.*

SOUTHERN TROPICAL DRY DECIDUOUS FORESTS

This type of forests is found throughout the area but in small blocks wherever the rainfall is above 750 mm and it merges with the thorn forests where the rainfall is low. The trees are generally drought resistant and have greater adaptability and do not have any appreciable girth to promote economical use. Bamboos are poor and confined to very restricted areas. Depending on the presence or absence of teak these forests can be calssified into dry teak forests and dry mixed forests.

(a) Dry teak forests: These are open forests yielding poor quality teak and other deciduous species. The trees may attain a height of up to 15 m but are short-boled, twisted and branching low. The trees here coppice freely and propagate by root suckers also. This type of forest is found in Gulbarga, Bellary and to some extent in Tumkur district. Teak occurs frequently in Bidar district also, but is completely absent in Bijapur and Kolar districts.

Besides *Tectona grandis* the other characteristic species are *Anogeissus latifolia, Boswellia serrata, Cochlospermum religiosum, Sterculia urens, Terminalia alata* and *Acacia chundra. Hardwickia binata* and *Pterocarpus marsupium* are reported only from the southern half. The occurrence of *Polyalthia cerasoides* in Bellary district and *Aglaia eleagnoides* in these forests is an indication that these were once evergreen or semi-evergreen forests degraded to deciduous type in the course of time due to climatic changes.

The other common tree species are *Buchanania lanzan, Chloroxylon sweitenia, Dalbergia latifolia, D. paniculata, Diospyros melanoxylon, Grewia pilosa, Lannea coromandelica, Lagerstroemia parviflora, Soymida febrifuga, Terminalia paniculata, T. bellirica, Wrightia tinctoria, Ixora arborea, Madhuca longifolia* var. *latifolia, Acacia leucophloea, Aegle marmelos, Albizia lebbeck, A. amara, Bauhinia racemosa, Givotia rottleriformis* and *Semecarpus anacardium. Ficus amplissima, Mallotus philippensis* and *Morinda tomentosa* are occasionally met with.

The following species have sporadic distribution: *Buchanania axillaris, Cassine glauca, Diospyros montana, Acacia polyacantha, Limonia acidissima,* *Terminalia crenulata, Bombax ceiba, Bridelia crenulata, Dalbergia lanceolaris, Eriolaena quinquelocularis, Garuga pinnata, Gmelina arborea, Schleichera oleosa, Terminalia chebula, Gyrocarpus asiaticus* and *Premna tomentosa. Tamarindus indica* is often found wild throughout the forests. Though *Santalum album* is frequently seen, its presence is not felt significant due to poor and stunted growth. Bamboo is represented by *Dendrocalamus strictus.*

Most common among shrubs are *Lantana camara, Flacourtia indica, Xeromphis spinosa, Cassia auriculata, Canthium parviflorum, Carissa spinarum, Dodonaea viscoa, Gardenia gummifera, G. resinifera, Grewia latifolia, G. hirsuta, Indigofera cassioides, I. wightii, Kirganelia reticulata, Maytenus emarginatus, Securinega leucopyrus, Erythroxylum monogynum, Tarenna asiatica, Cipadessa baccifera, Holarrhena antidysenterica* and *Helicteres isora.* Climbers and climbing shrubs are few in number and they are *Ventilago denticulata, Combretum ovalifolium, Cryptolepis buchananii, Jasminum auriculatum, Sarcostemma acidum, Celastrus paniculatus, Clematis gouriana, Hiptage benghalensis, Argyreia pilosa, A. sericea, Ampelocissus tomentosa* and *Ichnocarpus frutescens.*

Common herbs found in these forests are *Lavandula bipinnata, Pupalia lappacea, Euphorbia cristata* and *Cyanotis tuberosa.* Other herbs which occur occasionally are *Barleria cristata, Chlorophytum laxum, Euphorbia laciniata, Andrographis paniculata, Rhynchosia rufescens, Crotalaria mysorensis, C. calycina, Impatiens balsamina, Leucas ariostoma, Rhinacanthus nasutus, Anisomeles indica, Curculigo orchioides, Cyanotis cristata, Dyschoriste vagans, Knoxia sumatrensis, Tephrosia tinctoria, Linum mysurense, Pseudarthria viscida* and *Indigofera mysorensis.*

Apluda mutica, Heteropogon contortus and *Perotis indica* are the grasses seen throughout the area. Other grasses sporadically seen are *Cymbopogon fulvus, C. martinii, Eragrostis unioloides, Eulalia phaeothrix* and *Hackelochloa granularis.*

Orchids are rare in these areas. Epiphytic orchids like *Aerides crispum, A. ringens* and terrestrials like *Habenaria grandifloriformis, H. longicorniculata, H. marginata, H. plantaginea* and *Geodorum densiflorum* are reported.

Ferns are represented by *Diantum indicum, Cheilanthus mysorensis, Actinopteris australis, Hemionites arifolia* and *Selaginella wightii.*

(b) Southern dry mixed deciduous forests: The general composition of these forests is similar to those of dry teak forests with the exclusion of teak and predominance of some xerophytic species. They occur in Gulbarga, Kolar and Bellary districts. *Anogeissus latifolia* is the dominant tree species found ususally in association with *Terminalia alata.* The other species characteristic of these forests are *Boswellia serrata, Chloroxylon swetenia, Hardwickia binata,* *Soymida febrifuga, Wrightia tinctoria, Acacia chundra, Albizia amara* and *Shorea roxburghii.*

SOUTHERN TROPICAL THORN FORESTS

The trees in this type of forests are generally short-boled, branched, low and composed of comparatively a few species. Bamboos are generally absent. The grasses are noticed only during rainy season and remain dry with bare soil in summer months. Some of the dry deciduous species may occur here but their growth is much stunted. The thorn forests are mostly confined to central portion.

The tree species are constituted by *Acacia chundra, A. leucophloea, A. horrida, Albizia amara, Ziziphus mauritiana, Z. oenoplia, Z. caracutta, Z. xylopyrus, Acacia nilotica* subsp. *indica, Prosopis cineraria,*. Deciduous species like *Diospyros melanoxylon, Anogeissus latifolia, Dalbergia paniculata, Boswellia serrata, Hardwickia binata, Soymida febrifuga* are found along the ,fringes of forests bordering the deciduous type. *Givotia rottleriformis* and *Gyrocarpus asiaticus* are seen either in pure formation or in association with each other.

Shrubs are larger in number when compared with tree species and some of them are scandent in habit. These include *Dichrostachys cinerea, Flacourtia indica, Cadaba fruticosa, Canthium parviflorum, Lantana camara, Maytenus emarginata, Rhus mysorensis, Securinega leucopyrus, Xeromphis spinosa, Dodonaea viscosa, Argyreia cuneata, Carissa spinarum, Cipadessa baccifera, Erythroxylon monogynum, Toddalia asiatica, Acacia eburnea, Calotropis gigantea,* Capparis zeylanica, *Cissus woodrowii, Euphorbia nivulia, E. antiquorum, Barleria prionitis, Kirganelia reticulata, Capparis sepiaria, C. divaricata* and *Opuntia dillenii.*

The climbers frequently met with are *Rivea hypocrateriformis, Gymnema sylvestre, Tylophora indica, Corallocarpus epigaeus, Cryptolepis buchananii, Hemidesmus indicus; Sarcostemma acidum, Ventilago denticulata, Derris scandens, Leptadenia reticulata, Acacia pennata, A. sinuata, Asparagus racemosus* and *Passiflora foetida.*

Among herbaceous species the frequently seen are *Dipteracanthus patulus, Echinops echinatus, Lavandula bipinnata, Pupalia lappacea, Waltheria indica, Aerva lanata, Andrographis serpyllifolia, Barleria buxifolia, Borreria articularis, Celosia argentea, Euphorbia cristata, Phyllanthus virgatus, Sopubia delphinifolia, Andrographis paniculata Rhinacanthus nasutus, Leucas eriostoma, Sebastiania chamaelea, Allmania nodiflora* var. *angustifolia, Blepharis maderaspatensis, B. repens, Bidens bipinnata, Blumea oliqua, Justicia glauca, J. simplex, J. prostrata, Andrographis echinoides, Crotalaria bifaria, C. pusilla.*

Among the grasses *Apluda mutica, Heteropogon contortus, Perotis indica, Aristida adscensionis, Chrysopogon fulvus, Lophopogon tridentatus, Cymbopogon caesius, Dichanthium pertusa, Setaria glauca, S. intermedia, Oropetium roxburghianum, Tragus roxburghii, Hackelochloa granularis* and *Themeda triandra* are commonly seen.

Shrub savanna occurs in Bijapur region representing the least degraded stage of thorn forests. The forests are open with trees and shrubs reaching a height of 6 m or less with a grass carpet varying in density due to biotic factor.

The shrubs are *Acacia leucophloea, A. horrida, A. nilotica* ssp. *indica, Ziziphus mauritiana, Zxylocarpus, Bauhinia racemosa, Dolichandrone falcata, Diospyros melanoxylon, Dichrostachys cinerea, Capparis decidua, C. divaricata, Flacourtia indica, Maytenus emarginata, Catunaregam spinosa, Balanites aegyptiaca, Euphorbia neriifolia, Securinega leucopyrus* and *Cassia auriculata.*

The grass cover is composed of *Ischaemum pilosum, Sehima sulcatum, S. nervosum, Heteropogon contortus, Aristida funiculata* and *A. redacta.*

The deciduous forests of Deccan when degraded lead to two types of physiognomies the savanna type and thicket type. In savanna type fire is the important factor. When all the trees are destroyed, only shrubs and grasses are left with. Sometimes the trees are spared due to special adaptatin of bark in resisting fire or protected on account of their edible fruits. The tree canopy is mostly constituted by *Hardwickia binata, Anogeissus latifolia, Phyllanthus emblica, Albizia amara, Dalbergia paniculata, Diospyros melanoxylon, Wrightia tinctoria, Bridelia retusa, Phoenix humilis, Boswellia serrata, Acacia chundra* and *A. horrida.*

HYDROPHYTES AND MARSHY PLANTS

The maidan is dotted with numerous irrigation tanks and ponds usually supporting a rich aquatic vegetation. The free-floating forms include *Eichhornia crassipes, Pistia stratiotes, Lemna perpusilla, Spirodela polyrhiza* and *Utricularia exoleta,* Among the rooted aquatics *Aponogeton natans, Potamogeton nodosus, Limnophyton obtusifolium, Nymphaea nouchali, Nymphoides cristatum, N. indicum* are commonly met with. As the depth of water decreases *Cyperus pangorei* and *Typha angustata* begin to establish themselves.

The margins of ponds and puddles are generally colonised by *Ipomoea aquatica, Leersia hexandra, Polygonum glabrum,* and *Oryza rufipogon.* The grassy meadows around the tanks are interlaced with *Centella asiatica* and *Phyla nodiflora* or studded with *Drosera burmanii.*

Vallisneria spiralis and *Ottelia alismoides* usually grow along the canals draining the irrigation tanks.

Pandanus fascicularis and *Ampelopteris prolifera* are commonly met with along the river banks. The other species of riverine vegetation are *Pennisetum hohenackeri, Saccharum spontaneum, Vetiveria zizanioides, Coix lacryma-jobi, Cyperus corymbosus, Homonoia riparia, Ludwigia perennis, L. adscendens, Lindernia* spp. and *Polygonum* spp. In exposed rocks along river courses several species of Podostemaceae occur.

2.4. Tamil Nadu uplands

In general the vegetation is dry and the entire range is no better than sparse thickets of thorny shrubs. Most of the areas are barren, rocky and with shallow hillocks, and the majority of species exhibit xeromorphy. Even the few trees seldom reach 10 m tall, but are hard-wooded.

SOUTHERN TROPICAL THORN FORESTS

The vegetation in this area is represented by species like *Acacia, ferruginea, Aleucophloea Alangium salvifolium, Albizia amara, Capparis sepiaria, C. zeylanica, Carissa spinarum, Cassia auriculata, C. hirsuta, Dichrostachys cinerea, Dodonaea viscosa, Jatropha glandulifera, Lantana camara, Mimosa rubicaulis, Toddalia asiatica,* var. *gracilis, Wrightia tinctoria* and *Ziziphus oenoplia.*

WEED FLORA

The common weeds are *Aerva lanata, Argemone mexicana, Dipteracanthus prostratus, Barleria buxifolia, Lantana camara, Cassia tora, Calotropis gigantea, Cleome gynandra, C. monophylla, Opuntia dillenii, Waltheria indica, Andrographis paniculata, Borreria articularis, Phyllanthus virgatus, Euphorbia hirta, Mollugo pentaphylla, Tribulus terrestris, Tridax procumbens, Sopubia delphinifolia, Blepharis maderaspatensis, B. repens, Bidens bipinnata, Justicia glauca, Croton bonplandianum, Aristida hystrix* and *Heteropogon contortus.*

3. East Deccan Plateau : part of Dandakaranya

SOUTHERN TROPICAL DRY DECIDUOUS FORESTS

This type of forests occurs in Bastar district and adjoining areas with *Shorea robusta* as the dominant species. The other trees encountered are *Buchanania lanzan, Terminalia alata, T. bellirica, Anogeissus latifolia, Madhuca longifolia* var. *latifolia, Haldina cordifolia, Lannea coromandelica, Lagerstroemia parviflora, Albizia procera, Mitragyna parviflora, Acacia lenticularis, Chloroxylon swietenia, Pterocarpus marsupium, Dalbergia latifolia, Diospyros melanoxylon,* *Schleichera oleosa, Semecarpus anacardium, Erythrina suberosa, Cassine glauca, Garuga pinnata, Ougeinia oojeinensis, Bauhinia racemosa, B. malabarica, Polyalthia cerasoides, Boswellia serrata, Hymenodictyon orixense, Phyllanthus emblica, Careya arborea, Acacia catechu, A. leucophloea, Casearia graveolens, C. elliptica, Kydia calycina* and *Butea monosperma.*

The following species constitute the shrub vegetation: *Flacourtia indica, Cipadessa baccifera, Clerodendrum viscosum, Helicteres isora, Wendlandia exserta, W. tinctoria, Lantana camara, Grewia hirsuta, Indigofera cassioides, Flemingia chapper, Woodfordia fruticosa, Gardenia gummifera.* Climbing shrubs and lianas are *Acacia caesia, Ziziphus xylopyrus, Calycopteris floribunda, Combretum album, Acacia pennata, A. tora, Bauhinia vahlii, Butea superba, Spatholobus parviflora, Butea superba, Ventilago denticulata* and *V. madraspatana.*

Herbaceous plants are represented by *Acalypha ciliata, Crotalaria linifolia, Boerhavia diffusa, Rungia parviflora, R. repens, Vernonia cinerea, Mimosa pudica* and *Sida cordata.* Among grasses *Arundinella setosa, Heteropogon contortus, Imperata cylindrica, Cymbopogon martinii* and *Eragrostis japonica* are worthy to mention.

Along the streams and river banks a peculiar type of vegetation is seen. The riparian vegetation constitutes evergreen or deciduous plants. They are: *Syzygium heyneanum, Homonoia riparia, Terminalia arjuna, Diospyros malabarica, Pongamia pinnata, Mangifera indica, Ficus racemosa, Saccharum spontaneum, Scirpus articulatus* and *S. lateriflorus.*

In parts of Bailadila range (Bastar District) semi evergreen forests occur and the tree stratum is represented by *Celtis timorensis, Callicarpa tomentosa, Eurya nitida, Symplocos cochinchinensis* ssp. *laurina, Wendlandia gamblei, W. heynei, Rhus paniculata* and *Glochidion velutinum.* The characteristic shrubs and herbs are *Anaphalis adnata, Plectranthus barbatus, Micromeria biflora, Leucas montana, Aeginetia indica, Costus speciosus, Curcuma amada, Globba marantina* and *Exacum tetragonum.*

In Kalahandi, natural teak occurs in the valley mixed with the Sal. In certain places Sal is ousted by *Bambusa arundinacea* in the lower elevations. In the upper slopes and in ravines characteristic species of evergreen and moist deciduous type such as *Actinodaphne angustifolia, Elaeocarpus robustus, Persea macrantha, Ficus hispida, Mesua ferrea, Saraca asoca, Ficus macrophylla, Michelia champaca, Dillenia pentagyna, Pavetta indica, Phoebe lanceolata, Phoenix acaulis, Pittosporum napaulense, Mallotus philippensis, Bauhinia variegata, Ehretia laevis, Aegle marmelos, Flemingia congesta, Colebrookea oppositifolia, Vernonia divergens, Xylia xylocarpa* and *Grewia tiliaefolia* are worthy to mention. Perennial grasses like *Themeda triandra* and *Thysanolaena maxima* are seen in patches where the forests have been cleared.

ENDEMISM

Peninsular Indian region has a high degree of endemism making it the second richest endemic centre after the Himalayas (Ahmedullah & Nayar, 1987). About 2000 taxa of flowering plants are estimated to be endemic to Peninsular India. These endemic species are mostly palaeoendemics as evidenced by their high degree of isolation and having found favourable ecological niches in the hill range of either side of the Peninsula. A large concentration of endemic taxa is found in the moist deciduous and evergreen patches of Western Ghats and to a much lesser degree in the Eastern Ghats.

On the basis of the distribution of the endemic plants several centres of endemism in Peninsular India have been identified by Ahmedullah & Nayar, *(op. cit.)* Deccan region is not identified perhaps due to its poor representation of endemic taxa. The following endemic plants, however, occur in the Deccan region: *Hardwickia binata, Pterocarpus santalinus, Terminalia pallida, Syzygium alternifolium, Shorea tumbugaia, Crotalaria sandoorensis, Brachystelma ciliata, B. kolarensis, B. elenaduensis, Schizachyrium sudhanshuii, Manisuris ratnagirica, Pimpinella tirupatiensis, Cycas beddomei, Boswellia ovalifoliolata, Stenosiphonium setosum* and *Staurogyne perpussila.* Some of these species extend their distribution in the adjoining hills of Eastern Ghats.

PHYTOGEOGRAPHICAL SIGNIFICANCE

As stated by Ahmedullah & Nayar (1987) the distribution and concentration of endemic plants in a particular region is an index to overall phytogeography of the area. Deccan plateau being neither a centre of endemism nor speciation/genetic diversity in Peninsular India, it has least biogeographical significance. The chorionomic boundaries of the Deccan are not well defined and there are several transitional areas between the adjoining phytogeographical divisions Western Ghats and Eastern Ghats, especially in large river valleys. The flora of Deccan when compared with the rich flora of Western Ghats, has fewer Malesian elements, and in some dry semi-arid areas it contains an admixture of the Omano-Sindian elements (Takhtajan 1986). The characteristic/special floristic assemblage required for a natural phytogeographic region is perhaps lacking in the Deccan.

Meher-Homji (1965 & *seq.*) after analysing the floral elements of the dry regions of India recognised two zones: one in the north contiguous to the desert of Thar, extending into Rajasthan, the Punjab, parts of Uttar Pradesh, and north Gujarat. The other semi-arid zone, situated in the south, included the Deccan plateau and parts of Coimbatore, Ramanathapuram, and Tirunelveli districts of Madras". He further added that the concentration of the "Tropical and North

African Indian Desert" element is in the northern semi-arid zone rather than in the Deccan. Also the sub-desertic climate does not enter the Deccan. Only a very negligible percentage of the flora of Sudan and S W Arabia occurs in the Deccan thereby establishing the relative floristic individuality of the Deccan from the rest of the Sudanian territory.

The woody temperate members, though very few, that are found in the present day flora of Deccan region suggest that they are the ones which have been left over after the Pleistocene glaciation. The monsoon emphimeral flora also exhibits temprate elements which are intrpolations in the tropical elements of the palaeocene Flora. Such elements of temperate type would have gradually disappeared as the aridity increased on the whole Deccan plateau.

The Deccan flora now consists more elements of Dipterocarpaceae than that of Verbenaceae. It is obvious that Sal (*Shorea robusta*) and not Teak (*Tectona grandis*) was dominant in the earlier days. But Teak occurs at intervals nearly all over the Deccan and Sal which is still common in the north of Godavari river is completely absent beyond the south of Godavari. How the occurrence of Sal is restricted in the southern part of Deccan is a question worthy of investigation.

The rich black cotton soil that is prevalent over large areas in the Deccan deserves worthy mention and cotton is the exclusive commercial crop of this region.

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5.10a. EASTERN GHATS

(M. S. Swaminathan & J. L. Ellis)

The Eastern Ghats, forming the eastern border of the Peninsular plateau of India, are the assemblage of discontinuous ranges, hills, plateau, escarpments, buttes, tore, narrow basins, gorges with elevations ranging from a few metres to 1750 m (Biligirirangan Hills). They are situated between 77^0 22' and 85^0 20' E longitudes and 11^0 30' to 20^0 0' N latitudes. The Eastern Ghats extend in a north-east south-west direction in the Indian peninsula covering an area of about 75,000 sq km with an average width of about 100 km in the south and about 1750 km in length, traversing the length of the Coromandel coast, over parts of the states of Orissa, Andhra Pradesh, Tamil Nadu and a small part of Karnataka. These hill ranges extend from Mahanadi in Orissa in the north to the Nilgiris in the south, up to Vaigai river (Mani, 1974 & Nayar *et al.* 1984), by West Bastar, Telangana, Karnataka plateau and Tamil Nadu uplands in the west to the Coromandel coast in the east. The Eastern Ghats do not form a continuous range being separated from one another by major rivers like Mahanadi, Godavari, Krishna, Pennar and Cauvery having taking their origin in the Western Ghats. They form a continuous range only in Nallamalai Hills of Kurnool District, Andhra Pradesh and a few strips in Cuddapah District of Andhra Pradesh. Nallamalai is found to consist of sharp finger-like narrow parallel ranges each representing minor upfold.

The northern end of the Eastern Ghats in the Orissa state is a series of broken mountain systems which apparently is a continuous range of hills broken by the Mahanadi valley. Some of the peaks of this range are Mahendragiri (1501 m), Meghasini (1250 m) and Malyagiri. Here, the E. Ghats extend over Koraput, Kalahandi, Ganjam and Phulbani districts in the southern part of the Orissa state. The Eastern Ghats region of Orissa, constitutes about 36 per cent of the total geographical area of the State. The hill ranges in the E. Ghats region of Orissa, contain extensive plateaus, most of which have elevations between 300 to 450 m. Also this region has the river Tel and tributaries in the north, Vansadhara and Nagavalli in the south-east. In the south-west portion of this region flows Machkund river which is a tributary of Sileru river. An interesting overlapping of southern and northern types of forest is observed in the region of Monuskunda, Sindhrimal and Tarlakota blocks of Koraput District where Sal forests of the north merge into southern Teak forests (Dani, 1982). Parlakimedi and its immediate neighbourhood mark the southernmost limit for Sal. Parlakimedi is the continuation of the E. Ghats and Devagiri (1382 m) is the second highest peak. Gamble (1892) considered the flora of E. Ghats in Mahendragiri "extremely interesting", as Mahendragiri seems to be a meeting ground for the northern, Himalayan and the southern Nilgiris floras.

About 50 per cent of Andhra Pradesh forest area lies in E. Ghats of which one million ha lie in northern Eastern Ghats and 2.2 million ha lies in Southern E. Ghats. Nearly 60 per cent of the Andhra Pradesh's rural population depends on the resources of E. Ghats. Northern forested portion of E. Ghats includes the Godavari, Sileru-Machkund basins and covers the districts of Srikakulam, Vijayanagaram, Visakhapatnam and East and West Godavari. The southern portion of E. Ghats of Andhra Pradesh covers the districts of Guntur, Prakasam, Nellore, Kurnool and extends into the adjoining Cuddapah and Chittoor districts. Some of the prominent hill ranges in the Eastern Ghats portion of Andhra Pradesh are Velikonda, Palakonda, Nallamalais, Erramalais, Tirupathi, Balapalle (Seshachalam), Rampa and Gudem Agency. Though Biligirirangan hills in the south-east corner of Karnataka are a group isolated from the other hill ranges of W. Ghats and Nilgiris, many treat them as a part of E. Ghats. The Biligirirangan hills consist of a double range with ridges rising from 600 to 1800 m in altitude and one even reaching to about 2000 m. The two ranges are separated by a valley of about 1300 m above sea level.

According to Mani (1974) and Nayar *et al.* (1984) the southern most boundary of E. Ghats extends up to Pulneys. However, many scientists like Legris & Meher-Homji, 1982, are of the opinion that the E. Ghats run in a west-south-west direction, meeting the Western Ghats in the Nilgiris. The prominent hill ranges of E. Ghats in Tamil Nadu are Pachamalais, Javadi Hills, Kollimallais and Shevaroys. The Javadi hills and Yelagiri hills situated in the North Arcot district of Tamil Nadu are interesting ranges of hills as they contain vast untapped potential, possessing the valuable foreign exchange earner, the Sandal wood (*Santalum album*). This range extends to a maximum length of 60 km and a width of 25 km, the average altitude being 833 m, with Kumbukudi (1275 m) being the highest point.

The Pachamalais occupy the north-western border of the Trichy district of Tamil Nadu, rising to an altitude of 950 m. Irregular in outline, they have a maximum length of 32 km. The Pachamalais of Trichy district is separated from Kollimalais of Salem district by a narrow Thammampatty valley.

The Shevaroy Hills are a range of hills situated in the Salem district of Tamil Nadu, with Yercaud as the prominent hill station and a summer resort. The maximum altitude of this range is 1803 m. Other prominent hill ranges of Salem district are Kalrayan (1336 m), Kollimalai, Bodamalai (666 m). The river Cauvery cuts the range transversely, forming the Hogenakal water-falls. Melagiri a well defined range, stretches north-east from the northern bank of Cauvery, its highest peak rising to 1395 m.

PHYTOGEOGRAPHIC ZONES

Several workers have attempted to divide India biogeographically since 1855, but none of them has treated E. Ghats as a separate entity.

Hooker & Thomson (1855) make 4 primary divisions of then British India as 1. Hindoostan 2. Himalayas 3. Eastern India and 4. Afghanistan and while dealing with the physical features of Hindoostan divide them further into 18 provinces, in which E. Ghats primarily fall under Orissa, Carnatic and partly in Karnataka.

Hooker (1904) divides India on the basis of general flora. He divides E. Ghats region under Deccan and states. ". the whole Peninsula south of the Ganges Valley and east of the Malabar ghats as one botanical region; it is primarily divisible into 2 subregions; one the elevated, usually hilly sometimes mountainous plateau terminating eastward more or less abruptly at no great distance from the sea in what are called E. Ghats"

Clarke (1898) dividing India on the basis of the distribution of the taxonomic group Cyperaceae, includes E. Ghats and Coromandel Coast with part of Deccan under Coromandelia, with Rewa in north ; Cape Comorin in south ; Bay of Bengal in east and Deccan with Karnataka in west as the boundaries.

Reference is also made by Prain (1905) in his work on Bengal Plants about E. Ghats on the basis of comparative humidity, rainfall and dryness of the region, and he places E. Ghats & Coromandel under "India subaquosa".

Razi (1955), while making observations on the plants of south Indian Hill Tops and their distribution, divides India under 21 provinces, in which E. Ghats come under Carnatic & Orissa. Puri (1960) describing the botanical regions of India depending on Forest Ecology includes E. Ghats in the Deccan.

Takhtajan (1986) while analysing the floristic regions of the world, treats the E. Ghats as a portion under Deccan Province. According to him "the chronic boundaries of the Deccan Province are not well defined and there are some transitional areas between the adjoining provinces. It is especially difficult to indicate the exact boundary between Deccan and Malabar provinces" He further quotes Hooker (1904 & 1907) as "in the large river valleys and those of the higher hills, types of Malabar Flora penetrate far to the east".

Recently in the botanical regions of India as recognised by the Indian Council of Agricultural Research, Deccan region includes E. Ghats (also See Puri, *et al.* 1983).

Mani (1974) and Nayar *et al.* (1984, 1987) treat E. Ghats as a separate phytogeographic region extending from Orissa to Madurai between the river Mahanadi and Vaigai, including eastern edge of Pulneys. Mani (*l.c.*) while giving the vegetation and Phytogeography of E. Ghats states ". the two major phytogeographical divisions of the E. Ghats, generally recognised by the botanists, are based on restricted concept of the ghats, viz. 1. the nothern *Sal* division ; 2. the southern Deccan division. We consider here the extreme southern parts of the Peninsula, especially the eastern edge of the Palni and Nilgiri Hills, the trends of which coincide with those of the other sections, as the third phytogeographical division of E. Ghats ."

Recently Meher-Homji (1991) recognises 11 phytoclimatic zones mainly on the distribution of vegetational types, and according to him, they show close links with the climatic and edaphic factors. Groups of allied vegetation types constitute a phytoclimatic zone. Zones under which the Eastern Ghats come are : Teak zone, Teak-Sal transition zone, Sal zone, *Hardwickia* zone and *Albizia amara* zone.

VEGETATION

Depending mainly on three factors viz., climate, soil and past treatment, Champion & Seth (1968) have grouped the types of vegetation, giving importance to the ranges in temperature, rainfall, evaporation, transpiration and the length of dry and wet seasons as influenced by southwest and northeast monsoons. According to them the following are the main types of vegetation met within E. Ghats with certain others which have restricted distribution confined generally to a few small localities.

1. Northern Tropical moist deciduous forests

The forests included under this type fall into two categories, i.e. Sal forests and the rest. The northern and southern moist mixed deciduous forests are very similar in all respects, south having a slightly more varied flora.

The Sal forests, which are predominant with the presence of only *Shorea robusta* are more resistant to fire, gregarious in habit, coppicing in power, adaptable to soil and site conditions and exhibiting longevity. The Sal generally forms high forest and constitutes 60-90 per cent of the top canopy which is fairly closed and regular. In the Eastern Ghats, such forests occur in Orissa state only.

Based on the rainfall and humidity Champion and Seth (*op. cit.*) futher divide the above into various types of Sal forests, of which the following occur in the Eastern ghats regions of Orissa state. Moist Peninsular high level Sal; Moist Peninsular low level Sal and Peninsular coastal Sal forests. According to Gamble (1884), Ganjam district, especially Ghumsur taluk, including Sudador contains large area of Sal forests, the best portion of which lies at the foot of the ghat range in the valleys of Gullery and Mahanadi rivers. The Sal trees chiefly occur on level lands and in valleys and slopes of the hills. Extensive areas of the Eastern Ghats in Orissa are subjected to shifting cultivation by the tribals, due to which the natural vegetation has been destroyed, and in the end results in scrub forests or bamboo forests or grasslands with ot without trees.

In certain pockets close to the sea in Puri district and adjoining these pockets in Ganjam district of Orissa, Sal (*Shorea robusta*) attains very large dimensions due to favourable edaphic and climatic conditions. These are called coastal Sal forests.

Overlapping of Southern and northern type of forests is observed in the region of Monuskunda, Sindhrimal and Tarlakota, blocks of Koraput district where Sal forests of north merge into Teak forests. It is interesting to note Parlakimedi and its immediate neighbourhood mark the southern most limit of Sal.

In these forests *Shorea robusta* is seen in association with trees like *Albizia procera, Anogeissus latifolia, Buchanania lanzan, Careya arborea, Chloroxylon swietenia, Dalbergia latifolia, Dillenia pentagyna, Diospyros melanoxylon, D. montana, Haldinia cordifolia, Holarrhena antidysenterica, Madhuca longifolia, Pterocarpus marsupium, Soymida febrifuga, Syzygium cumini* and *Terminalia alata.* Shrubs commonly seen in these forests are *Alstonia venenata, Ardisia solanacea, Cipadessa baccifera, Clerodendrum viscosum, Colebrookea oppositifolia, Grewia hirsuta, Indigofera cassioides* and *Helicteres isora.* Common grasses of these regions are *Arundinella setosa, Thysanolaena maxima, Themeda triandra.* Common herbs include *Adiantum incisum, Curcuma pseudomontana, Globba marantina* and *Tacca leontopetaloides.*

In coastal Sal forests *Shorea robusta* is associated with *Aphanamixis polystachya, Elaeocarpus robusta, E. tectorius.* Here the ground is rich and *Amomum dealbatum* is seen at many places. The top canopy consists of trees like *Bridelia retusa, Dillenia pentagyna, Haldinia cordifolia* and *Terminalia alata.* Some of the second storey trees of this region are *Polyalthia cerasoides, Protium serratum* and *Syzygium cumini. Bambusa arundinacea* and *Dendrocalamus strictus* are the common bamboos seen here. Climbers like *Bauhinia vahlii, Butea superba, Combretum decandrum, Ziziphus oenoplia* are seen with *Ardisia solanacea* and *Macaranga peltata.*

2. Southern Tropical moist deciduous forests :

These foretsts otherwise called non Sal forests, are seen in Gudem-Rampa Agency, parts of west Godavari district, Gundlabrahmeswaram in Nallamalais, some E. Ghats portions of Tamil Nadu, and Bedguli hill in Biligirirangan Hills.

Apart from Gundlabrahmeshwaram which is "heart of Nallamalais" these forests can also be seen in Rollapenta, between upper and lower Ahobilam and a few more plateaus in Nallamalais. Rao *et al.* (1982) state that this type of vegetation occurs as localised small patches along the valleys and near perennial streams in the E. Ghats area at 400-1000 m along the habitats with high moisture and humous content. These regions are well sheltered and retention of water in the soil is by the fallen leaves and clayey type of soil. Also many seasonal rivers feed them. The trees commonly attain a height of 30-35 m, the dominant species being mostly deciduous. Here although intimate mixture of species is the rule, a relatively small number of species together forms the greater part of the canopy and relatively pure associations are fairly frequently met with. For part of the year these forests give the appearance of evergreen as the evergreen elements of the lower storey are more developed.

Here canes are restricted to wet ground and epiphytes mostly to post-climate in damp shady places. Climbers are abundant and large. The undisturbed soil cover mainly consists of more or less evergreen shrubs with little grass. The absence of small trees and saplings of the large trees is due to frequent fires and grazing. Only teak seedlings are best adapted to survive these injuries. The chief feature of the moist deciduous forests is a leafless period in the dry season which may or may not begin with cold weather, but is typically most general in March-April when the top tree layer is almost entirely leafless. But a good number of deciduous trees come into new leaf long before the monsoon. Also during the above period a good number of evergreens can be seen in the undergrowth and shrub cover. This type is seen in all soils occurring in India within the tropics from sandy alluvium to old red soils. It is seen best in lateritic soils.

Some of the common trees seen in the top and lower canopy are : *Albizia odoratissima, Anogeissus latifolia, Ardisia solanacea, Bauhinia racemosa, Bridelia retusa, Careya arborea, Dalbergia latifolia, Dillenia pentagyna, Diospyros malabarica, D. sylvatica, Garcinia xanthochymus, Haldinia cordifolia, Kydia calycina, Litsea chinensis, Mangifera indica, Mitragyna parvifolia, Polyalthia suberosa, Pterocarpus marsupium, Schleichera oleosa, Schrebera swietenioides, Syzygium cumini, Tectona grandis, Terminalia alata* and *Xylia xylocarpa.* Where soil is shallow and rocky, *Cleistanthus collinus, Holarrhena antidysenterica, Phyllanthus emblica* and *Strychnos potatorum* are commonly seen.

Some of the common shrubs and herbs encountered in these forests are : *Costus speciosus, Curcuma amada, C. pseudomontana, Desmodium gangeticum, Emilia sonchifolia, Flemingia chappar, Helicteres isora, Liparis prazeri, Nyctanthus arbortristis* and *Pavetta indica.* Common climbers include *Bauhinia vahlii, Butea superba, Clematis gouriana, Entada rheedei, Milletia auriculata* and *Smilax zeylanica. Dendrocalamus strictus* forms bamboo brakes in these regions occasionally with *Bambusa arundinacea.*

Three species of rice i.e. *Oryza meyeriana* var. *granulata, O. minuta,* and *O. sativa* are seen in Gundlabrahmeshwaram area. The evergreen *Athyrium hohenackerianum, Piper hymenophyllum* and *P. nigrum* are seen in Gundlabrahmeshwaram along with *Ophioglossum reticulatum.*

Along the hill streams and the river Godavari, the forests seen, are of The common trees of these forests are : *Anogeissus acuminata, Barringtonia acutangula, Bombax ceiba, Crateva magna, Mitragyna parvifolia, Pongamia pinnata, Strychnos nux-vomica, Terminalia cuneata* and *T. indica.* Common shrubs include *Homonoia riparia, Rotala aquatica, Syzygium heyneanum* and *Tamarix ericoides.* Grasses like *Brachiaria distachya* and *Digitaria ciliaris* are commonly seen along with herbs like *Euphorbia dracunculoides, Indigofera linnaei* and *Pedalium murex.*

3. Southern Tropical wet evergreen forests

These forests which are most extensive and common along Western Ghats are seen very rarely in Eastern Ghats. In these forests the trees are lofty, dense, with a height of about 40 m, carrying epiphytic aroids, ferns and orchids and are characterised by the almost absence of ground vegetation. These patches can be seen in a few valleys of Shevaroy hills and Bedguli in Biligirirangan hills.

Common trees seen here are *Callicarpa tomentosa, Cinnamomum zeylanicum, Elaeocarpus serratus, Meliosma microcarpa, Symplocos laurina,* and *Toona ciliata.* These trees are heavily laden with mosses and harbour several orchids and ferns like *Aerides cylindricum, Bulbophyllum fuscopurpureum, Coelogyne nervosa, Dendrobium heterocarpum, Oberonia brunoniana, Microsorium membranaceum* and *Pyrrosia acrostichioides.*

4. Orissa Tropical semi evergreen forests

These are the moist deciduous forests mixed with evergreen elements, where the number of top storey trees are deciduous and are leafless for a short time only and not simultaneously and the second storey is almost evergreen. In Eastern Ghats this type of forests is seen mostly in Orissa, i.e. Simplipal forests of Mayurbhanj district ; Atai and Malayangiri forests and Banguru forests in Keonjhar district; some parts of Puri district; some parts of Ganjam and Koraput district above 800 m in moist valleys and hills. Also in Anantagiri, Minumuluru, Galikonda of Visakhapatnam district and Nulakamaddi, Maredumilli areas of East Godavari district. Also near Krishnanandi area of Nallamalais a small patch of semi-evergreen forest is seen.

The top layer consists of trees such as *Artocarpus lakoocha, Bridelia tomentosa, Dillenia pentagyna, Firmiana colorata, Mangifera indica, Michelia champaca* and *Xylia xylocarpa.* Small trees like *Aphanamixis polystachya,* *Macaranga peltata, Mesua nagassarium, Murraya koenigii, Phoebe lanceolata, Pittosporum nepaulense* and *Polyalthia cerasoides* form the middle layer of these forests.

Climbers such as *Ampelocissus latifolia, Bauhinia vahlii, Cissus repanda, Entada rheedei, Ichnocarpus frutescens, Smilax zeylanica* along with *Gnetum ula* are common in this forest. Small evergreen perennials like *Ardisia solancea, Boehmeria platyphylla, Curcuma aromatica, Leea crispa, Psychotria fulva* and *Zingiber roseum* form the ground layer. *Calamus rotang* is seen growing gregariously in patches at Krishnanandi.

5. Southern Tropical dry deciduous forests

This is the main vegetational type seen in most of the areas of Eastern Ghats and is a climatic-climax type of forest with rather dense upper canopy, though usually uneven in density. The top layer is formed by a mixture of trees, most of which are deciduous during the dry season, often for several months and most of the species occurring even in moist deciduous forests. The number of species is much less than the other evergreen and moist deciduous types, but the dry deciduous forests provide the clearest examples in tropical India outside the Sal forest of natural single species crops. The lower canopy of these forests are entirely deciduous with inconspicuous presence of evergreen and semievergreen species near moist and sheltered places. While bamboos are often seen growing well, the canes and palms are absent. Also climbers, epiphytes and ferns are rather rare. These forests merge into thorn forest wherever the rainfall drops below 750 m.

These forests occupy about 60-70 per cent of the forests along the Eastern Ghats portion of Andhra Pradesh, Orissa and Tamil Nadu. It extends along the slopes of Eastern Ghats to the eastern side of the Western Ghats, very commonly above 500 m, particularly along Nallamalais in Kurnool Dt. of Andhra Pradesh and in areas like Ahobilam, Chelama Basin, Gundlabrahmeshwaram, Diguvametta and many parts of Srisailam. It can also be seen in Kathederargudi in Biligirirangan Hills of Karnataka, above 900 m and in Javadi Hills of Tamil Nadu. Stunted Sal occurs in some forests of Srikakulam district and north of it, whereas stunted teak occurs in some of the southern forests.

Some of the trees commonly encountered in these forests are: *Alangium salviifolium, Anogeissus latifolia, Bridelia retusa, Buchanania lanzan, Careya arborea, Cassia fistula, Chloroxylon swietenia, Cleistanthus collinus, Dalbergia latifolia, Dolichandrone arcuata, D. falcata, Elaeodendron glaucum, Gardenia gummifera, G. resinifera, Hardwickia binata, Lagerstroemia parviflora, Madhuca longifolia, Premna tomentosa, Pterocarpus marsupium, Sterculia urens, Tectona grandis, Terminalia alata, T. cuneata T. bellirica* and *T. chebula.* Common shrubs of these forests include *Catunaregam spinosa, Grewia hirsuta* and *Helicteres* *isora*. Climbers seen commonly are *Ampelocissus latifolia, A. tomentosa, Celastrus paniculata, Cissampelos pareira* var. *hirsuta, Cissus repanda, Cryptolepis buchananii, Dioscorea pentaphylla, D. tomentosa, Marsdenia tenacissima, Mucuna pruriens, Olax scandens* and *Tinospora cordifolia.* The Dipterocarpaceae are virtually absent in these forests except *Shorea roxburghii* and *Shorea tumbuggaia* in some pockets.

Shrubs which are seen commonly in the dry deciduous forests are *Canthium parviflorum, Colebrookea oppositifolia, Desmodium pulchellum, Grewia flavescens, G. hirsuta, G. rothii, Indigofera mysorensis, I. tinctoria, Tarenna asiatica* and *Woodfordia fruticosa.* Some of the common herbs include *Crotalaria calycina, C. medicaginea, C. mysorensis, Geodorum densiflorum, Globba marantina, Habenaria roxburghii, Ludwigia perennis, Plumbago zeylanica, Tacca leontopetaloides, Tephrosia purpurea, T. tinctoria, Triumfetta rhomboidea* and *Uraria picta. Dendrocalamus strictus* is the common bamboo of these forests.

6. Red sanders bearing forests

The Red Sanders, *Pterocarpus santalinus*, are the pride of the Eastern Ghats, growing well on the slopes and plateau of Cuddapah, northern portions of Chittoor, southern portions of Kurnool adjoining Cuddapah district, Dharmapuri and Sheravoys. Roughly it may be stated that these forests occur along the middle and southern sections of the Eastern Ghats. In these forests, *Pterocarpus santalinus* prominently dominates and is often seen in vast areas. Teak is absent in these forests. As these forests are periodically burnt, they are open with heavy growth of grass. Associated with *Pterocarpus santalinus* are the following trees : *Anogeissus latifolia, Hardwickia binata, Shorea tumbaggaia, Sterculia urens, Syzygium alternifolium, Terminalia alata* and *T. chebula.* The middle canopy consists of trees like *Chloroxylon swietenia, Dalbergia paniculata, Dolichondrone atrovirens, Gardenia gummifera, G. latifolia, Strychnos potatorum, Vitex altissima* and *V. leucoxylon.* Some of the common shrubs of these forests are: *Catunaregam spinosa, Grewia subinaequalis, Helicteres isora* and *Tarenna asiatica.*

7. Tropical dry evergreen forests

These forests are often seen along the east coast from Nellore down to Tirunelveli, the prominent areas among them are Sriharikota island near Nellore, Mamandoor valley in Chittoor division, Nagavera in S. Cuddapah division of Andhra Pradesh.

These forests are characterised by small coriaceous leaved evergreen trees, reaching up to 12 m in height, forming complete canopy, with short boles and spreading crowns. Locally the proportion of deciduous species may be large. Climbers are many and Bamboos are almost absent. Grasses are not conspicuous.

The top layer of trees is composed of *Albizia amara*, *A. lebbeck*, *Acacia leucophloea*, *Azadirachta indica*, *Buchanania angustifolia*, *Diospyros chloroxylon*, *Manilkara hexandra*, *Pterospermum canescens*, *P. suberifolium*, *Sapindus emarginatus*, *Strychnos nux vomica* and *Syzygium cumini*.

Middle layer consists of trees like *Atalantia monophylla*, *Diospyros ferrea*, *Flacourtia indica*, *Garcinia spicata* etc. The shrubs include *Catunaregam spinosa*, *Memecylon umbellatum*, *Ochna obtusata*, *Tarenna asiatica*. Climbers are abundant and the more common ones are *Derris scandens*, *Pterolobium indicum*, *Ziziphus oenoplia*, and species of *Acacia*, *Asparagus* and *Combretum*.

8. Dry savannah forest

A form of dry deciduous forests formed as a result of intensive biotic interferences, like burning, lopping and grazing, is seen scattered throughout the Eastern Ghats. These are mostly be seen in the hill-top areas with altitudinal range around 100 m. Here the trees stand far apart singly or in small groups in more or less heavy grass in which certain fire resistant plants persist. The trees have very short boles and are usually crooked and unsound or hollow. Stemless *Phoenix humilis* var. *pedunculata* is particularly characteristic of these forests.

Rao *et al.* (1982) based on their intense field studies are of the opinion that climatic factors, particularly high wind velocity, coupled with heavy rainfall produce considerable damage to the soil cover on hill tops, causing high erosion of soils. The Bauxite cover which is immediatey below the surface soil may be responsible for this type of vegetation.

Common trees of these forests are *Phyllanthus emblica*, *Pterocarpus marsupium* and *Terminalia chebula* intermixed with *Phoenix humilis* var. *pedunculata*. Common grasses seen in these forests are *Arundinella setosa*, *Chrysopogon aciculatus*, *Cymbopogon flexuosus*, *Imperata cylindrica* and *Themeda triandra*.

9. Scrub forests

This type of forest is usually confined to the bases of hills, bordering villages and generally in the much disturbed and degraded dry deciduous forests. These scrubs are considered to be the result of intensive biotic interferences and may be considered as the degraded stages of dry deciduous forests. In these forests the soil cover is shallow. Bamboos may be present. The shrubs are often thorny or not liked by the cattle. Thin layer of grass occurs. This type is quite common all along the Eastern Ghats and are formed due to the denudation of the original deciduous forests. Thorny thickets hardly 4-6 m high, predominate in this area, and due to recurrence forest fires during summer season, grasses grow abundantly.

Afterwards, where the soil is highly eroded with opening up of rocks and boulders, thorny *Euphorbia* species to grow prominently. Included in these forests are Southern Tropical thorn forests and Southern *Euphorbia* scrub forests.

Some of the prominent trees of this forests are : *Acacia catechu, A. catechu* var. *chundra, A. leucophloea, Balanitis aegyptiaca, Cassia fistula, Catunaregam spinosa, Chloroxylon swietenia, Diospyros melanoxylon, Erythroxylon monogynum, Euphorbia antiquorum, E. tirucalli, Manilkara hexandra, Strychnos nux vomica, S. potatorum, Ziziphus mauritiana* and *Z. xylopyra*. Some of the shrubs associated with the above are: *Capparis brevispina, Carissa spinarum, Dichrostachys cinerea, Dodonaea viscosa,* and *Maytenus emarginata.* Some of the common climbers of this vegetation are: *Abrus precatorius, Aristolochia indica, Asparagus racemosus, Cissampelos pareira* var. *hirsuta, Cocculus hirsutus, Gymnema sylvestre, Hugonia mystax, Pterolobium hexapetalum* and *Toddalia asiatica.* The ground floor is composed of herbs like *Andrographis paniculata, Dipteracanthus patulus, D. prostratus, G. obtusa, Hibiscus micrantha, Pavonia zeylanica, Peristrophe paniculata* and *Vernonia cinerea.*

Apart from the above types of vegetation some plant species are prominent in certain pockets of Eastern Ghats, i.e. *Vanilla wightiana* (Orchidaceae) growing luxuriantly in Eastern Ghats in villages like Labarthi, Munjasam in East Godavari District of Andhra Pradesh (Rao *et al.* 1982) and possibly one of the richest "Vanilla Sanctuary" may be established in this region.

Similarly, *Santalum album* is seen in large numbers at Javadi Hills of Tamil Nadu. *Cycas beddomei* an endemic species is seen commonly in forests of Tirupathi, Cuddapah District, Andhra Pradesh.

While discussing in detail the various types of vegetation in Peninsular India specially in Eastern Ghats, Legris & Meher-Homji (1982) are of the opinion that most of the forests of Peninsular India are relegated to the hills. Most of the forests of hill ranges between 700 to 1200 m are of deciduous type. A change in flora occurs conspicuously above 700-800 m in northern latitudes, above 900 m in northern section of Eastern Ghats and above 1200 m in the hills of Southern India. According to them the vegetational types of Eastern Ghats can be grouped under the following categories:

1. *Albizia amara* series (A thorn forest community)

This type of forests occurs in plains of Coromandel and Circars, up to Balasore in the north, up to an altitude of 600 m. These regions receive rains during the retreading monsoon period (October-December) due to depressions and cyclones.

2. *Cochlospermum-Gyrocarpus-Givotia-altitudinal* ecotone

From the basal region of the hills of the Eastern Ghats in Coromandel-Circar, to the summits a change in climate and vegetation is noted. After about 500 m in skeletal slopes are seen *Cochlospermum religiosum, Gyrocarpus jacquinii, Givotia moluccana* and occasionally *Commiphora caudata* marking an ecotone zone with deciduous forest at higher elevations.

3. *Hardwickia* binata series:

This type occurs in the middle and southern sections of Eastern Ghats as in the Nallamalais, Kalrayan and the Mysore plateau. In Andhra Pradesh part of Eastern Ghats *Pterocarpus santalinus* is an important associate of *Hardwickia binata.* These regions receive an annual rainfall of about 1000 mm spread over 5-6 months.

4. Dry deciduous Teak type: Terminalia-*Anogeissus latifolia-Tectona* grandis series:

This series extends up to Kanyakumari from Jhansi and Guna district of North India, extend along the slopes of Eastern Ghats and eastern side of the Northern Ghats. At Javadi Hills this type occurs above 900 m at Mysore plateau between 600 m to 1200 m and in Nallamalais above 500 m. These forests receive annual rainfall from 800 to 1800 mm and the dry season lasts for about 6 months. Three subtypes are dealt with in this series as follows:

They place these subtypes under fire as destructive agent and with grazing factors, the main reasons for the degradation of the forest.

a) *Savanna-woodland:*

This is an open type of forest formation in which the crowns do not touch. The tree and shrub species are almost same as the forest stage but also some fire-resistant trees are seen more commonly, viz. *Phyllanthus emblica, Diospyros melanoxylon* and *Bridelia retusa. Bombax ceiba* often infiltrates into these forests.

b) *Tree-savanna:*

This physiognomy differs from the savanna-woodland only in the greater number of species of trees the density does not exceeding 0.3. The forests are reserved in recent times after the shifting cultivation and the trees are smaller in size and the height being less than 9 m.

c) *Shrub-savanna:*

Here the trees occur much scattered but are stunted and shrubby. This is due to recurrent fires, grazing and excessive hacking.

d) *Scrub-woodland :*

Here the tree stratum may reach a height of 10-12 m and the crowns of trees do not meet. This type carries groups of trees separated by thickets. Some of the trees of this type are *Tectona grandis, Terminalia tomentosa, Boswellia serrata, Sterculia urens, Butea monosperma, Anogeissus latifolia, Lagerstromia parviflora,* and *Dalbergia paniculata.* The undergrowth consists of species like *Acacia catechu, Ziziphus mauritiana, Z. oenoplia, Maytenus emarginata, Carissa congesta* and *Xeromphis spinosa* which belong to thorny/spiny group. Also unarmed elements like *Vitex negundo, Holarrhena antidysenterica, Ixora arborea, Annona squamosa, Clerodendrum viscosum* are commonly seen along with the armed ones. In Zangareddigudem-Vijayawada area the forests consist of typical dry deciduous species mixed with those of dry evergreen (viz. Terminalia-Angeissus-Tectona series mixed with Albizia amara series).

e) *Closed thicket:*

This type is often met with near the cultivated areas, where the density of the villages is high. Here thorny shrubs and coppice shoots of unarmed trees occur in thickets reaching an height up to 5 m, above the general level of which a few tree species scattered between 15 to 35 m apart, rise to a height of 8-10 m. Some of the thorny species met within this type are : *Acacia catechu, A. leucophloea, Ziziphus mauritiana, Z. xylopyra, Xeromphis spinosa, Flacourtia indica, Capparis zeylanica* and *Euphorbia nivulia.* Stunted trees like *Anogeissus latifolia, Tectona grandis, Terminalia tomentosa, Boswellia serrata, Pterocarpus marsupium, Cassia fistula, Buchanania lanzan* and also *Dendrocalamus strictus* are found. Unarmed shrubs and trees like *Holarrhena antidysenterica, Wrightia tinctoria, Annona squamosa, Calycopteris floribunda* (scandent shrub) and *Clerodendrum viscosum* are commonly seen.

f) *Discontinuous thorny thicket:*

This is also like the previous type met with near cultivated areas. Apart from heavy illicit felling, these are subject to excessive grazing. The discontinuous thicket is made up of i) thorny and unpalatable species, and ii) coppice shoots of other species, the first group predominating. Grasses are very low and discontinuous. Some of the common species encountered here are: *A. catechu, Acacia nilotica, Capparis sepiaria, Dichrostachys cinerea, Dodonaea viscosa* and *Xeromphis spinosa*

g) *Scattered shrubs*

This is the most degraded stage on exposed parent rock on areas littered with boulders and pebbles or yet in unreserved areas. The grass cover is completely grazed. The shrubs rarely exceed 1.5 m in height and spacing varies from 3 to 6 m or even more. Cactiform Euphorbias along with *Cassia auriculata, Dodonaea viscosa* and *Maytenus emarginata* are among the species met with in this type.

5. The Sal forest types

According to Legris & Meher-Homji (1982) the northern section of the Eastern Ghats is characterised by the presence and the prominence of the Sal (*Shorea robusta*). The general floristic composition remains the same as that of the deciduous forests containing Teak, the major difference being the total absence of Teak the marked dominance of the Sal. The western most limit of the Sal is in the Pachmarhi hills of the Mahadeo range, the Southern most limit is Parlakimedi and its immediate neighbourhood. They further classify the Sal forests based as climatic conditions as follows: **Dry** : *Shorea-Buchanania-Cleistanthus* series; *Shorea-Cleistanthus* series; *Shorea-Terminalia-Adina* series. **Moist**: *Shorea-Dillenia-Pterospermum* series; *Shorea-Syzygium operculatum-Toona-Symplocos* series.

PREVIOUS WORKS

Eastern Ghats as a whole are not fully explored by the botanists to assess the plant wealth ; collections in some districts, some hills, some regions have been made by different botanists. Among the older collectors mention may be made of : Ch. Th. Walther, J. G. Koenig, W. Roxburgh, B. Heyne, James Shuter, and Robert Wight, H. F. C. Cleghorn, R.H. Beddome, W. Elliot, Lushington, C.A. Barber, J. S. Gamble, C. E. C. Fischer, I. H. Burkill, V. Narayanaswamy and K. C. Jacob. H. H. Haines collected plants from Simplipal Hills, Puri and Angul Orissa. Clarke, Wood and Rev. Fr. Cardon collected plants from Surguja, and Jashpur ; Mooney collected from Kalahandi, Bailadila. Recently the collection made by the following contributed to the flora of Eastern Ghats : N.P. Balakrishnan, (Araku valley, Cuddapah hills and Tirupati Hills), E. Barnes, (Biligirirangan Hills), M. Brahmam, (Orissa), C.S. Dani, (Orissa), W. Elliot, (N. Circar), J.L. Ellis, (Nallamalais, and part of Seshachalam range), N.S. Ghate, (Godavari District), R.V. Kammathy, *et al.* (Biligirirangan Hills), S.L. Kapoor, (Mahendragiri Hills), K.M. Matthew, (Pachamalais, Carnatic), D.B. Mukerjee (Mahendragiri), K. Narayana Rao, (Tirumala), G. Panigrahi, *et al.* (Orissa), D.C.S. Raju, (Godavari, Balimela Project area, Papi Hills, Polavaram Agency tracts, Simhachalam), R.S. Rao, (Rampa and Gudem Agency tract), R.S. Rao, and S. Sudhakar, (E. Godavari District) R.S. Rao, and H. Sreeramulu (Srikakulam District) R.S. Rao, *et al.* (West Godavari District), S.P. Rath, *et al.* (Orissa Cyperaceae), A. Sanyal, (Orissa), H.O. Saxena, (Mahendragiri Hills, Orissa), K.M. Sebastine, and A.N. Henry, (Pachamalais), K.A. Shankaranarayan, (Salem District), K. Srinivasan, and G. V., Subba Rao, (Parlakimedi), G. V., Subba Rao, (Visakhapatnam District), T.V. Subba Rao, (Forest types of Andhra Pradesh), K. Subramanyam, and A.N. Henry, (Javadi Hills), K.N. Subramanyam, and K.B. Kalyani, (Javadi Hills), B. Suryanarayana, and D.R.K. Murthy, (Venkatagiri Hills), Vanamala Naidu *et al.* (Cuddapah, Tirupathi Hills) E. Vajravelu, and N.C. Rathakrishnan, (Dharmapuri District) and J. Venkateswarlu, *et al.* (Visakhapatnam).

PHYTOGEOGRAPHIC SIGNIFICANCE

The Eastern Ghats occupy an important position in the Indian Peninsula, and it acts as a migratory tract from north to south and vice-versa. The presence of a number of plants of the Himalayas, Assam, Meghalaya and Western Ghats in the Eastern Ghats regions, especially in Mahendragiri Hills of Orissa, and Visakhapatnam district, goes to prove the same.

Different theories are put forward for the presence of the above plants in the Eastern Ghats. Haines (1921-25) while dealing with the plants of Bihar and Orissa is of the view that the presence of Himalayan, Meghalaya and Assam plants as relicts of the time when the hills of Orissa were much higher and served as stepping stones for the migration of species from the high lands of the Deccan Peninsula to the newer Himalayas and vice-versa. Seshagiri Rao & Narayanaswamy (1960) state "the occurrence of Himalayan plants like *Thalictrum*, *Chirita*, *Ceropegia*, *Remusatia* and several others, though quite interesting, does not signify anything sensational". They are of the opinion that these are instances of either discontinuous distribution, or remnants of vegetation of by-gone days, got isolated on account of ancient geological disturbances.

According to Kapoor (1964) the presence of northern plant species in Mahendragiri hills is in the ratio of nearly 1: 1.5. This preponderance of the South Indian Flora is obviously due to the geographical position of the Eastern Ghats." Biswas & Sampathkumaran (1949) feel they are relicts from the time when there was a land connection between the Deccan Peninsula and Indo-Malayan region. Srivastava (1955) while discussing the flora of Parasnath has observed that they are not relicts but an exchange of floras taking place by the agencies of wind, migratory birds and human beings. Mukherjee (1935) while giving the list of plants collected from Mahendragiri Hills, also mentions the distribution of the plants. He gives a statistical account and concludes that among the sub-tropical plants collected from the Mahendragiri Hills there is a preponderance of South Indian hill flora over the other hill floras.

Razi (1955) also feels that hills of Bihar and Orissa played an important role in migration of plants. Meher-Homji (1980) noting the presence of many fossils, interprets it as an indication of cool climate in the region prior to the uplift of the Himalayas. Rao. *et al.* (1982) while analysing the new and noteworthy plant records, remark that such findings throwing light on the line of distribution of selected species would create further opening to look for them during further studies.

The following are some of the examples of presence of Himalayan, Assam, Meghalaya, Western Ghats etc. plants in Eastern Ghats : *Anaphalis adnata*, *Bulbophyllum densiflorum*, *Beilschmiedia sikkimensis*, *Callicarpa macrophylla*, *Chirita hamosa*, *Delphinium roylei*, *Ensete glaucum*, *Eulophia explanata*, *Forrestia mollissima* var. *glabrata*, *Lysimachia alternifolia*, *L. decurrens*, *Mucuna nigricans*, *Parabaena sagittata*, *Prunus jenkinsii*, *Raphidophora decursiva*, and *Sapium eugeniaefolium*. Subba Rao & Kumari (1968, 1972, 1973) mention the following as new records to E. Ghats of Visakhapatnam District: *Dillenia aurea*, *Enhydra fluctuans*, *Eriocaulon luzulifolium*, *Melasma arvense*, *Ranunculus laetus*, *Saussurea heteromalla*, *Sloanea sterculiacea*, *Thalictrum foliolosum* and *Tinospora malabarica*.

Also nearly 40 species which are hitherto believed to be present only in Western Ghats are seen in wild state in Eastern Ghats (Rao *et al.* 1982). Some of the noteworthy among them are : *Debregeasia malabarica*, *Dicliptera zeylanica*, *Didymoplexis pallens*, *Glochidion ellipticum*, *Knoxia mollis*, *Lobelia zeylanica*, *Mallotus rhamnifolius*, *Microstylis versicolor*, *Nothopegia racemosa*, *Platystoma flaccidum*, *Pilea trinervia*, *Plectranthus mollis*, *Pouzolzia bennettiana*, *Syzygium malabaricum*, *Xenacanthus pulneyensis*, *Vanilla wightiana* and *Ziziphus glabrata*.

The great Ice Age called the glaciation during the Pleistocene period, about a million years ago, when most of Europe, N. Asia and N. America were covered by ice caps for several thousands of years seems to have influenced the migration of Himalayan and N E Indian species southwards to south Indian hill tops. To quote Wulff (1950 : p. 154): "The advance and retreat of ice occupied a period of thousands of years, during which, as a result of changes in climatic conditions, plants and animals migrated, as the ice advanced from the north to south and from upper additional zones to the valleys and plains, and, as the ice retreated, returned, in part to the north and higher elevations". Turrill (1958) states : "The southern drive of the flora must have had a telescoping effect, crowding the alpine to subalpine, the subalpine to the temperate and so forth" This seems to explain the reason for the occurrence of many northern species of Himalayas and N E India and the southern species of Western Ghats in Eastern Ghats.

ENDEMICS

Nayar *et al* (1984), Ahmedullah & Nayar (1987) deal in detail about the endemic plants of the Eastern Ghats. According to them the E. Ghats which have about 2000 species of flowering plants, constituting 13 per cent of the Indian elements and among these, 77 taxa (68 species and 9 varieties) belonging to 60 genera and 27 families are endemic to the Eastern Ghats. These 77 endemic taxa include 67 dicots, 9 monocots and one gymnosperm. There is no endemic genus strictly confined to the Eastern Ghats.

The distribution pattern of the endemic plants of the Eastern Ghats is quite different from that of the Western Ghats. The species-rich zones are isolated mainly because the Eastern Ghats do not form a continuous range, but form rather broken hill ranges with plains in between. Thus the isolation and restricted distribution of the narrow endemic plants due to geographical, ecological, edaphic and climatic barriers is much more pronounced in Eastern Ghats, in comparison with the Western Ghats where there is a continuity of mountain system and an almost same humid climatic regime throughout, for which reason the endemic plants of Western Ghats have a relatively wider distributional range (Ahmedullah & Nayar, 1987).

The Eastern Ghats depending on the vegetation may be broadly divided into 2 regions for endemism purposes: 1. The northern part of the Easten Ghats covering Mahendragiri hills of Ganjam, Koraput and Madgol hills of Visakhapatnam, 2. The southern part from Seshachalam hills down up to Madurai with Nallamalais, Cuddapah, Tirupathi, Javadi, Shevaroys hill ranges prominent among them.

In the Northern Eastern Ghats region, most of the forest is of moist deciduous type with *Shorea robusta* prominent among them. The hills of Ganjam-Koraput range have many narrow endemic species like *Acacia donaldii, Aglaia haslettiana, Mucuna minima, Oryza jeyporensis, Themeda mooneyi, Tragia gagei* and *Uvaria enucincta.* The hills of Visakhapatnam district including Araku Valley contain many endemics and some of them are *Argyreia arakuensis, Kalanchoe cherukondensis, Memecylon madgolense, Niligirianthus circarensis* and *Toxocarpus roxburghii.* Also *Cajanus cajanifolius, Bupleurum andhricum, Leucas mukerjiana, Maytenus bailadillana, Phlebophyllum jeyporense* are local endemics, and they are not very narrow in the strict sense, but are confined to the northern part of Eastern Ghats.

The Southern Eastern Ghats exhibits many endemics, prominent among them are : dry type of "Sal" i.e. *Shorea tumbuggaia, Pterocarpus santalinus,* (the Red Sanders), *Cycas beddomei, Argyreia choisyana, Boswellia ovalifoliolata, Crotalaria sandoorensis, Euphorbia longistyla, Euphorbia senguptae, Pimpinella tirupatiensis, etc.*

According to Ahemedullah & Nayar (1987), the Eastern Ghats have some ecological islands that harbour the endemic plants of Eastern Ghats, viz. Ganjam, Koraput range, Visakhapatnam hills including Araku valley and Madgol hills, Nallamalai-Cuddapah range, the Tirupathi hills, Shevaroy hills and hills in north and south Arcot districts. Most of the areas in the above regions are under commercial exploitation of land by way of quarrying and mining, dam building, monoculture forest plantations and hydroelectric projects, resulting in the heavy destruction of virgin forest areas in some pockets. For preservation of the interesting and endemic taxa as well as the virgin forests of the Eastern Ghats, the above mentioned regions may be considered for Biosphere Reserves. Rao *et al.* (1982) have also proposed a few more pockets in northern Andhra Pradesh, including Vanilla Orchid groves for consideration as Biosphere Reserves. However Subba Rao *et al.* (1982) point out that a major portion of Orissa and Andhra-Pradesh remains unexplored or underexplored, hence the correct position of endemism of Eastern Ghats may not be assessible. Also they propose six regions which may be considered for Biosphere Reserves, *viz.*,

1. Simlipal and Jeypore Hill forests stretch of Orissa.
2. Relatively undisturbed Dandakaranya in Koraput & Bastar.
3. Tanjavanam, Lumbasingi, Tajangi areas in Visakhapatnam District.
4. Rampa, Gudem, Sapparla, Dharakonda agency area in Visakhapatnam District.
5. Papi Hills, Bhadrachalam area in West Godavari & Khamman Districts.
6. Nallamalai and Seshachalam hills in Kurnool & Cuddapah Districts.

A complete list of endemics of E. Ghats as reported by Ahmedullah & Nayar (1987) is given below.

Acacia donaldii Haines	Mimosaceae
Actinodaphne madraspatana Bedd.	Lauraceae
Aglaia haslettiana Haines	Meliaceae
Albizia orissensis Sahni & Bennet	Mimosaceae
A. sikharamensis Sahni & Bennet	Mimosaceae
Alphonsea madraspatana Bedd.	Annonaceae
Andrographis beddomei C. B. Clarke	Acanthaceae
A. nallamalayana Ellis	Acanthaceae
Argyreia arakuensis Balakr.	Convolvulaceae
Arundinella setosa Trin. var. *lanifera* C.E.C. Fischer	Poaceae
Aspidopteris hutchinsonii Haines	Malpighiaceae
Barleria morrisiana Barnes & Fisch.	Acanthaceae
Boswellia ovalifoliolata Balakr. & Henry	Burseraceae
Brachystelma glabrum Hook. f.	Asclepiadaceae
B. volubile Hook. f.	Asclepiadaceae
Bridelia cinerascens Gehram.	Euphorbiaceae

Bupleurum andhricum Nayar & Banerjee	Apiaceae
Cajanus cajanifolius (Haines) van de Maesen	Fabaceae
Caralluma indica N. E. Br.	Asclepiadaceae
C. lasiantha N. E. Br.	Asclepiadaceae
Chrysopogon velutinus (Hook. f.) Bor	Poaceae
Cordia domestica Roth	Boraginaceae
C. evolutior Gamble	Boraginaceae
Crotalaria madurensis Wight var. *kurnoolica* Ellis & Swamin.	Fabaceae
C. paniculata Willd. var. *nagarjunakondensis* Thothathri	Fabaceae
C. sandoorensis Bedd.	Fabaceae
Croton scabiosus Bedd.	Euphorbiaceae
Cycas beddomei Dyer	Cycadaceae
Decaschistia cuddapahensis T. K. Paul & Nayar	Malvaceae
Dicliptera beddomei C. B. Clarke	Acanthaceae
Dimeria orissae Bor	Poaceae
Euphorbia deccanensis V. S. Raju var. *nallamalayana* (Ellis) V. S. Raju	Euphorbiaceae
E. longistyla Boiss.	Euphorbiaceae
E. senguptae Balakr. & Subram.	Euphorbiaceae
Habenaria panigrahiana Misra	Orchidaceae
H. panigrahiana Misra var. *parviloba* Misra	Orchidaceae
Indigofera barberi Gamble	Fabaceae
Iseilema venkateswarlui Satyavathi	Poaceae
Kalanchoe cherukondensis Subba Rao & Kumari	Crassulaceae

Lasianthus truncatus Bedd.	Rubiaceae
Lasiococca comberi Haines	Euphorbiaceae
Leucas diffusa Benth.	Lamiaceae
L. lavandulifolia Rees. var. *nagalapuramiana* Chand.	Lamiaceae
L. mollissima Wall. var. *sebastiana* Subba Rao & Kumari	Lamiaceae
L. mollissima Wall. var. *silvestriana* Subba Rao & Kumari	Lamiaceae
L. mukerjiana Subba Rao & Kumari	Lamiaceae
L. nepetaefolia Benth.	Lamiaceae
Maytenus bailladillana (Swamy & Mooney) Raju & Biswas	Celastraceae
Memecylon madgolense Gamble	Melastomataceae
Mucuna minima Haines	Fabaceae
Neuracanthus neesianus C. B. Clarke	Acanthaceae
Nilgirianthus circarensis (Gamble) Bremek.	Acanthaceae
Notonia shevaroyensis Fyson	Asteraceae
Ophiorrhiza chandrasekharanii Subba Rao & Kumari	Rubiaceae
Oryza jeyporensis Govind. & Krish.	Poaceae
Pavetta madrassica Brem.	Rubiaceae
Phlebophyllum jeyporensis (Bedd.) Bremek.	Acanthaceae
Phyllanthus narayanaswamii Gamble	Euphorbiaceae
Pimpinella tirupatiensis Balakr. & Subram.	Apiaceae
Premna hamiltonii (Buch.-Ham.) Ellis	Verbenaceae
Pterocarpus santalinus L.f.	Fabaceae

Rhynchosia beddomei Baker	Fabaceae
Rostellularia vahlii (Roth) Nees var. *rupicola* Ellis	Acanthaceae
Santapaua madurensis Balakr. & Subram.	Acanthaceae
Shorea tumbuggaia Roxb.	Dipterocarpaceae
Sophora interrupta Bedd.	Fabaceae
Tephrosia roxburghiana Drumm.	Fabaceae
Themeda mooneyi Bor	Poaceae
T. saxicola Bor	Poaceae
Toxocarpus roxburghii Wight & Arn.	Asclepiadaceae
Tragia gagei Haines	Euphorbiaceae
Triphasia reticulata Smith. var. *parviflora* Santapau	Rutaceae
Uvaria encincta Bedd.	Annonaceae
Vernonia shevaroyensis Gamble	Asteraceae
Wedlandia gamblei Cowan	Rubiaceae

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5.10b. COROMANDEL COAST

(M. S. Swaminathan)

India has a coast line of approximately 5700 km covering the coast of Bay of Bengal (East coast), Arabian Sea (west coast) and Indian ocean (the southern Kanniyakumari). The east coast is approximately 1500 km long with an average of about 100 to 130 km, running in wide curves. The east coast which is often called Coromandel coast mostly covers the area between the Mahanadi river in Orissa to Kanniyakumari in Tamil Nadu. The seabourds are wider along the east coast than on the west coast. Unlike, the west coast, the east coast is deficient in rain fall, but plains of east coast are much wider and drier. The Coromandel coast borders major part of Bay of Bengal, to Palk strait and to Gulf of Mannar of Indian ocean. It consists of bays, gulfs, straits, channels, lagoons, estuaries, salt water lakes, back waters etc.

There are a number of lagoons and backwaters in Coromandel coast, some of which are linked up by the Buckingham canal, an inland network of water way system running parallel to Bay of Bengal. The Buckingham canal was used for transportation during the last century, now this canal system remains almost unused and heavily silted.

The Pulicat lake near Nellore in Andhra Pradesh is a typical lagoon and the second largest salt water lake on Coromandel coast which existed at various levels in the past and is now separated from the sea by the Sriharikota Island and an old beach ridge. The seaward fringe of the coast is in general, swampy and sandy, that make it uninhabitable. Generally the gradation of salinity is more throughout the seaward side and gradually decreasing towards leeward side and even becomes absent in distant areas of extensive lake system.

The Coromandel coast covers the states of Orissa, Andhra Pradesh and Tamil Nadu. The Orissa coast which otherwise may be called Utkal coast, is slightly curved, conforms to more or less Orissa boundary covering a length of about 400 km. This lies approximately between the rivers Subarnarekha and Rushikulya including the Mahanadi delta and the coastal lagoon Chilka. Here the hills come almost to the coast. The Mahanadi delta along the seaward margin is more straight and is fringed with sand dunes because of stronger wave action. The marshy terrain along the coast is forest-covered which is much less conspicuous than in the Sunderbans. The most important physiographic unit of the area is the Chilka Lake situated south of Mahanadi delta. It's origin is due to formation of bay-mouth bar, and in places it is more than 200 m wide. The lake as it spreads out into a pear-shaped expanse of water, 70 km long, widens in the north-east and tapers in the south-west. Two rivers Bhargavi and Daya drain into the lake, making the water sweet in the rainy season. Hills bind the shores on the south-west. There are a number of rocky islands. The coastal plain of the Chilka Lake is dotted with low hills and is drained by the Rushikulya river.

In Andhra Pradesh and Tamil Nadu the East coast is called Payan Ghat. The Andhra Pradesh part of Coromandel Coast extends from the southern limits of Utkal plains to the Pulicat Lake and conform more or less to the State boundary. The coast line exhibits both rocky and sandy types. The Andhra Pradesh coast line is fringed with many back waters, estuaries and lagoons.

Kakinada and Nizampatnam bays are deep and usually exhibit high waves. Two of the biggest rivers of Deccan, i.e., the Godavari and the Krishna, flow through Andhra plains and form deltas in their lower reaches. The Kolleru lake near Eluru town is situated between these deltas. It receives the drainage from adjoining hills and is connected with the sea by a single channel. The present position of this lake is taken as evidence of the advance of the coastal plains towards the sea. Some of the important back waters and estuaries of Andhra Pradesh are near Bhiminipatnam, Coringa, Nizampatnam, Bapatla, Chinnaganjam, Tummalapenta, Gunnamola, Utukuru, Krishnapatnam etc. Pulicat Lake and Buckingham Canal are situated partly in Andhra coast.

The Tamil Nadu coast extends from south of Pulicat Lake up to Kanniyakumari. The Tamil Nadu part of Coromandel coast is about 675 km long with an average width of about 100 km. Cauvery delta is its most important physiographic unit. The river divides into 2 channels at the island of Srirangam. There is a marshy area along the southern fringe of the delta to the east of Point Calimere. A number of small islands lie in the Gulf of Mannar. Some of the leading islands of the region are Rameswaram, Krusadi, Shingle, Hare and Church. The major lagoons of Tamil Nadu coast are Muthupettai in Tanjore District and Pichavaram in South Arcot District. Some of the important back waters and estuaries in this region are in Ennore, Muttukadu, Palar, Marakkanam, Velar, Pazhaiyar, Chunnambar and Punnakayal. Palk Bay which is in Tamil Nadu coast is shallow and almostly waveless. The entire seaboard of Tamil Nadu coast is mainly sandy with an outcrop of rocky headlands at Mahabalipuram, Mandapam, Cape Comorin and also exhibits tidal creeks and flats at the riverine mouths, of which the Vellar and the Cauvery (Coleroon) are note-worthy. At the mouth of these rivers numerous creeks, extensive mud and saline flats with the formation of proestuarine vegetation is noticable particularly at Pichavaram, Tuticorin and adjoining regions. Besides the above habitats there are coral reefs in the Gulf of Mannar from Mandapam to Tuticorin environs giving rise to hard substratum with high percentage of calcium carbonate making it a specialised habitat.

Gulf of Mannar situated in Tamil Nadu may be termed as Marine Province, containing about 26 islands. Krusadi is one of the biggest island here. The flow of water during tidal action from the Gulf of Mannar to Palk Bay is through Pamban Channel. The islands here are characterised by the presence of coral reefs. The substratum is with coral rubbles, broken shells, calcareous deposits, sand stones and coarse to fine sands.

Phytogeographically most of the scientists treat Coromandel coast and Eastern Ghats as one unit. Hooker & Thomson (1855) in the Introductory chapter of Flora Indica places Coromandel coast under Hindustan-Orissa, Carnatic. Clarke (1898) while dividing India based on the distribution of Cyperaceae, treats coromandel alongwith Eastern Ghats on one region under Coromandelia from Orissa to Cape Comorin. Prain (1905) in his introductory chapter on Bengal Plants includes Eastern Ghats and Coromandel coast as a subregion of Deccan and states 'the area which suddenly descend from the Eastern Ghats to the low coast land is called Coromandel". Takhtajan, (1988) places Coromandel coast under Deccan Province and states. "the flora of the Coromandel subprovince (Hooker, 1904) or the Carnatic Province Hooker & Thomson, 1855) differs somewhat from that of the rest of the Deccan Province. This subprovince occupies the strip of low land between the Eastern Ghats and the sea and stretches from Orissa to Tirunelveli".

Recently, Meher-Homji (1991) while dividing the vegetational types of India into 11 phytoclimatic zones, places Coromandel coast under, *Albizia amara* zone with *Albizia amara - Acacia* type & *Manilkara-Chloroxylon* type. Also the coastal belt of Orissa under *Sal* zone with *Shorea Dillenia Pterospermum* type.

Champion & Seth (1968) in their revised survey of forest types of India, classifies the coastal vegetaion of India under Moist Tropical forests and subdivided into Littoral and Tidal swamp forests taking into consideration the situations under which they were growing. But according to Rao & Sastry (1972) the word 'littoral' sensu Champion and Seth is dubious as it incorporates sandy beaches all round the coast whereas this word in the geomorphic sense covers an area falling directly under the tidal ebb and flow influence which cannot be considered equivalent to consistently vegetated sandy beaches situated beyond the drift line reognised as supra-littoral region. Hence they suggest the word' 'Strand Vegetation' for the above. Rao & Sastry (1971, 1972 & 1974) after many years of critical study of coastal vegetation of India proposes a new classification, which seems to be ideal for coastal vegetation and is followed here.

The coastal region which comprises diverse ecosystems presents very interesting aspects for ecological, physiological and phytogeographical studies. Only certain physiologically specialised and ecologically adapted plants which had evolved remarkable adaptations to survive in the salt water milieu grow in this sensitive ecosystem.

The coastal vegetation is broadly classified as 1. Strand Vegetation 2. Eastuarine Vegetation.

1. STRAND VEGETATION

The term strand vegetation is explicit and indicates habitat relationship of plants and the strand. This vegetation is characterised by open mat forming pioneers in varying proportions closely followed by scattered herbs, shrubs and trees dispersed on a relief beyond the high tide limit designated as "Supra littoral zone or Backshore". This is further divided into 3 subtypes namely sand, rock and coral strands which correspond to the underlying substratum and show marked differences in the vegetation pattern and floristic composition. In each subtype there are zonations which exhibit characteristic plant groupings like open pioneer zone, the closed herbaceous zone, the middle mixed or bushy zone and the inner woodland zone.

a) *Strand Sand :*

This is a vegetational subtype along a sandy relief beyond the mean high tide limit and it occurs along the coast on sandy backshore of variable width. In the open pioneer zone of this vegetaion which lies away from the drift line, the following species are quite common : *Canavalia maritima, Cyperus arenarius, Ipomea pes-caprae, Launaea sarmentosa, Rothia indica, Sesuvium portulacastrum, Spinifix littoreus, Sporobolus virginicus, Trachys muricata,* and *Zoysia matrella.* In the herbaceous zone which succeeds the above, the following herbs are quite characteristic: *Aristida setacea, Aristolochia bracteata, Atriplex repens, Blumea obliqua, Croton bonplandianus, Enicostemma axillare, Euphorbia rosea, Geniosporum tenuiflorum, Giseckia pharnaceoides, Gloriosa superba, Halopyrum mucronatum, Heliotropium curassavicum, Indigofera aspalathoides, Ipomoea pes-caprae, Launaea sarmentosa, Mollugo nudicaulis, Peplidium maritimum, Perotis indica, Phyla nodiflora, Phyllanthus rotundifolius, Polycarpaea corymbosa, Polycarpon prostratum, Portulaca oleracea, P. pilosa, P. quadrifida, Sesamum prostratum, Spinifex littoreus* and *Trachys muricata.* In the bushy zone the following strand shrubs, undershrubs and herbs form the chief components: *Allmania nodiflora, Boerhavia diffusa, Calotropis gigantea, C. procera, Carissa spinarum, Cassia auriculata, Cissus quadrangularis, Clerodendrum inerme, Coldenia procumbens, Crotalaria linifolia, C. verrucosa, Dononaea viscosa, Euphorbia rosea, Hedyotis puberula, Indigofera oblongifolia, Jatropha glandulifera, J. gossypifolia, Perotis indica, Phyllanthus maderaspatensis, Sauropus bacciformis, Spermacoce hispida, Tephrosia lanceolata, T. purpurea, T. villosa, Vitex negundo* and *Zornia gibbosa.* The above zone which is an admixture of shrubs, herbs and creepers gradually merges to form the open inner woodland zone, where some species attain tree stature. Common trees and plants with arborescent habit of this zone are : *Acacia planifrons, Borassus flabellifer, Calophyllum inophyllum,* *Hibiscus tiliaceus, Jatropha glandulifera, Manilkara hexandra, Morinda citrifolia, Pandanus fascicularis, Phoenix pusilla, Pongamia pinnata, Prosopis cineraria, Reissantia indica, Thespesia populnea, Toddalia asiatica, Vitex negundo* and *Ziziphus mauritiana.* The common climbers are : *Gloriosa superba, Hemidesmus indicus, Leptadenia reticulata, Pergularia daemia* and *Tiliocora acuminta.* The common cultivated trees of this zone are : *Anacardium occidentale, Casuarina equisetifolia, Cocos nucifera, Pithecellobium dulce* and *Prosopis·chinensis.*

B. Strand Rock :

This rocky relief which is distributed along the West coast is less prominent in the East coast; the reason being that the east coast is primarily a deltaic type and is intercepted by rocky promontories only at certain pockets. The flora of this region is invariably a mixture of coastal and local inland plants and characteristically devoid of any true strand rock taxa. The extension of rocky promontory or headland into the sea which is subjected to consant wave action is devoid of any angiosperm flora and only marine algae make their appearance. The rocky relief sloping towards inland with thin mantle of sand in the Crannies, pot-holes and crevices without much clay and organic matter support only a sparse growth of herbaceous plants (Rao & Sastry, 1974). The following herbs are sparsely seen here : *Blepharis repens, Euphorbia thymifolia, Goniogyna hirta, Portulaca pilosa* and *Vernonia cinerea.* In the rocky relief *Atriplex repens, Boerhavia diffusa, Cenchrus ciliaris, Cyperus pachyrrhizus, Fimbristylis cymosa, Hybanthus enneaspermus, Ipomoea asarifolia, Phyllanthus maderaspatensis, Scilla hyacinthina* and *Tridax procumbens* could be seen. Further towards he inland side where the gravelly substratum is more and rocks are less, low scrub vegetation occurs where spiny thickets of *Barleria prionitis, Carissa spinarum* and *Toddalia asiatica* are common. Along with them the following herbs and shrubs can often be seen : *Acalypha indica, Acanthospermum hispidum, Caralluma adscendens* var. *attenuata, Dichrostachys cinerea, Diospyros ferrea* var. *buxifolia, Echinops echinatus, Euphorbia tirucalli, Indoneesiella longipedunculata, Jatropha gossypifolia, Lantana camara* var. *aculeata, Mollugo pentaphylla, Pavonia zeylanica* and *Polygala arvensis. Cissus quadrangularis* and *Tylophora indica* are the common climbers here. In less rocky to more gravelly or sandy situations the following can be commonly seen : *Aristolochia bracteata, Cassia nigricans, Ipomoea pes-caprae, Kleinia grandiflora, Launaea sarmentosa, Polycarpaea corymbosa, Portulaca pilosa, P. quadrifida* and *Urginea congesta.*

C. Strand Coral

A subtype vegetation is seen along the coral relief beyond the mean high tide limit, which has a restricted distribution and seen in the islands and reefs situated in the Gulf of Mannar, Mandapam vicinity and Krusadi group of islands.

There are at least nine well-known islands situated in the Gulf of Mannar of Tuticorin coast which lie at 8^0 48' N latitude and 78^0 11' E. longitude. They are locally known as Upputhannitheevu, Nallathannitheevu, Shulitheevu, Kariashulitheevu, Vilangushulitheevu, Koswaritheevu, Cronjeetheevu, Vantheevu (Church Island) and Panidyantheevu (Hare Island). Hare and Church islands are situated 4.5 and 6.5 km respectively from Tuticorin port. Hare Island has about 58.85 hectares of land while Church island has about 22 hectares of land.

Rameswaram Island is siuated between 9^0 10' 9^0 19.5' N and 79^0 12.5' - 79^0 25.5' E. The island is about 20 km long and about 9 sq. km wide at the widest part and covers an area of 85 sq. km.

Krusadi group of islands is situated in Gulf of Mannar approximately between 9^0 14'N-9^0 15' N and 79^0 10.5'-79^0-14.5'E and consists of 5 islands i.e. Pumurichan, Wadu, Periyakanda, Krusadi and Shingle islands. The first 4 are separated from one another by short distance, while Shingle Island is about 2.5 km east of Krusadi island.

The terrain in the above islands is composed of coral reef, forameniferal sand, clays and shell deposits. These deposits occur as beach rocks, coral debris and coral sand or shingles in assorted sizes. An interesting feature is the distribution of plants and their fidelity to this habitat. The vegetation in this habitat also exhibits zonations into open pioneer, closed herbaceous and inner woodland zone.

In the open pioneer zone which is constantly under sea water inundation the following are quite common. *Atriplex stocksii, Avicennia officinalis, Cordia subcordata, Pemphis acidula, Salicornia brachiata* and *Suriana maritima.* In the raised coral rocks with crevices *Halopyrum mucronatum, Polycarpaea spicata* and *Sporobolus tremulus* are common. In the raised ridges zone with coral debris and coral sand, lying between the open pioneer zone and closed herbaceous zone, shows characteristic flora by the growth of seedlings of *Pemphis acidula* and *Cyperus pachyrrhizus.* In the closed herbaceous zone *Eragrostis riparia, Fimbristylis cymosa, Scaevola plumieri, Sporobolus spicatus, S. tremulus* and *S. virginicus* are common. In the herbaceous zone the following are commonly seen : *Cymbopogon caesius, Eragrostis riparia, E. tenella, E. viscosa, Excoecaria agallocha, Halopyrum mucronatum, Launaea sarmentosa, Lumnitzera racemosa, Pemphis acidula, Scaevola plumieri, Sporobolus tremulus* and *Suriana maritima.* The inner woodland zone which lies in proximity to the hinterland region harbours small trees and bushes like *Dodonaea viscosa, Guettarda speciosa, Messereschimidia argentea* and *Thespesia populnea.*

In the Sriharikota Island and Irakkam Island in the Pulicat lake of Andhra coast a very interesting aspect of the existing natural vegetation along the Andhra coast is noticeable. Not very far from the coast line of Sriharikota in some undisturbed areas the vegetation is composed of trees like *Albizia amara,* *Sapindus emarginatus, Strychnos nux-vomica, Tamarindus indica* and *Terminalia cuneata.* The common shrubs are *Dodonaea viscosa* and *Memecylon umbellatum* with common climbers of the region i.e. *Abrus precatorius, Hemidesmus indicus* and *Ichnocarpus frutescens.*

SEA GRASSES

The following sea grasses are reported from Coromandel coast (Ramamurthy *et al*, 1992) : *Enhalus acoroides, Halophila beccarii, H. decipiens, H. ovalis, H. ovalis* subsp. *ramamurthiana, H. ovata, H. stipulacea, Thalassia hemprichii, Cymodocea rotundata, C. serrulata, Halodule pinifolia, H. univervis, H. wrightii,* and *Syringodium isoetifolium.*

II. ESTUARINE VEGETATION

The estuarine bordeland vegetation is characterised by dense and gregarious growth of woody plants, shrubs and succulent herbs in varying proportions dispersed on a relief lying under constant influence of tidal and fresh water resources. In India this type of vegetation is predominant in the deltaic regions and riverine mouths along the east coast. The term 'Mangroves' is derived from the word "mangal" and the Portuguese word for mangroves is "mangue". According to Macnae (1968) "Mangal" is the most appropriate term to describe the mangrove formations. The same has been adopted by Walsh (1974) in his review on Mangroves and by Chapman (1975) in his book on Mangrove vegetation. Mangroves are a group of salt tolerant plant species which occur in the tropical and subtropical intertidal estuarine regions, sheltered coast lines and creeks and are dominated by partly submerged sclerophyllous plant species which are taxonomically unrelated. According to Rao (1982) the term Mangrove has to be treated as a kind of growth and not as a tree or shrub. In fact the term should be applicable primarily to such taxa which have arched stilt roots, devoid of metaphores and show viviparous habit and also tolerate saline water to considerable depth around the stem bole. Typical mangroves are plants which have partly reached the sea estuarine interphase on stilts or props with adaptations like viviparous germination and pneumatophores for survival in the partly saline and partly submerged coastal ecosystems.

The seven basic features of maritime environment of mangroves, as given by Subba Reddi (1982) are : Air temperature, Shores free of strong wave and tidal actions, shallow shores, currents, salt water, tidal range and substratum containing fine-grained alluvium. The best mangrove formations are seen where the tidal regime is normal with a constant mixing of sea water and fresh water and where the temperature does not optimally go below 20° C. According to Mathauda (1957) the mangrove vegetation is fundamentally of a transitional nature. Conditions of growth change with the progress of situation and elevation of the land from sea level.

The four major roles of mangroves are (Banerjee *et al*, 1989) : mangroves help in soil formation in trapping debris; they serve as seive for rich organic soil washed down through river systems into the sea; provide appropriate ecosystems and refuge for fish, marine invertebrates, mollusc and birds and they contribue detritus enhancing the productivity of the ecosystems. Mangroves besides acting as stabilizers of wind and sea wave action along the coastal belts, also help to dissipate the wave energy. Mangroves produce one of the richest ecosystems, by regulating flow of water laden with rich organic minerals, stabilize the alluvial soil brought from the river systems, fix the sediments of the sea with the detritus. Mangroves also function as a buffer against the oil slicks washed down from the sea. They are of economic importance being a source of timber, fuel etc. and also provding good breeding ground for fishes and hospitable environment for marsh crocodiles.

The mangroves in the east coast not only attain a good sociability, density and stature but also are composed of a relatively good number of species. The west coast mangroves are poor in quality and quantity. The major estuaries on the Coromandel coast are Mahanadi estuarine complex (About 30,000 acres); Godavari (about 33,260 acres); Krishna (about 12,800 acres) and the shallow Cauvery estuarine (about 6,660 acres) systems.

The Mahanadi estuarine delta of Utkal coast lies approximaely between 86^{0} 40' to 87^{0} E and 20^{0} 15' to 20^{0} 25' N within the Cuttack district of Orissa state. The area is bounded on the North by the Baitarini river and Dhamara estuary which separate it from Balasore district on the west, by the Bay of Bengal on the east and on the south by Puri.

The mangrove forests of Godavari estuary are situated between 16^{0} 13'-16^{0} 15' N latitude and 82^{0} 20' E longitude, covering an area of approximately 6000 hectares. At Dhowlaishwaram the Godavari branches into two main streams, the East Godavari or Gautami Godavari and West Godavari or Vasishta Godavari. The mangrove forests at Coringa, Yanam, Kandikuppa, Kakinada and Sacramento are in the East Godavari delta. Coringa river is an important distributory of the river Gauthami Godavari. Coringa river and the Gaderu rivers which originate from Gauthami Godavari at its mouth and form part of Godavari estuarine system.

Pichavaram is situated in the south eastern coast of S. Arcot District of Tamil Nadu, at 11^{0} 26' N & 79^{0} 48' E between Vellar and Coleroon estuaries. It consists of many isolated stripes of sand bars throughout the entire area protected from the direct wave action of the sea. The tidal rhythm here is quite noticeable throughout the mangrove area.

Point Calimere lies between 70^{0} 31' 80^{0}E and 10^{0} - 1' N on the Coromandel coast of Peninsular India in Thanjavur District of Tamil Nadu occupies an area of about 5700 hectares as a triangular cape projecting into the Bay of Bengal.

It is a sanctuary for Water Birds and migrant Flamingos. Black buck, spotted deer and wild boars are present in the wooded portion of the forests. The Vedharanyam R.F. which is mostly of Tropical dry evergreen type occupies an area of about 5663 hectares, whereas Talaignayar, which has estuarine vegetation, occupies an area of about 1236 hectares. Mangrove vegetation is seen in low lying areas at various localities in Vedharanyam where partial inundation takes place during the high tides. A luxuriant growth of mangroves is seen at Muniappaneri.

Champion (1936) proposed a preliminary classification for coastal vegetation under moist tropical seral types divided into Beach forests and Tidal forests purely based on the edaphic conditions under which they grow. They were reclassified by Champion and Seth (1968) under moist tropical forests divided into Littoral and Swamp forests taking into account the situations under which they were growing. Under the tidal swamp forests the following subtypes are included i.e. mangrove scrub, mangrove forest, salt and water mixed forest, brackish water mixed forest and palm swamp. The Estuarine vegetation is characterised by dense woody plants, shrubs and succulent herbs in varying proportions dispersed on a relief under the constant influence of tidal and fresh water resources. Rao and Sastry (1974) after many years of study of the coastaaal vegetation including the estuarine vegetation, proposes a new classification adhering to the original framework of Champion and Seth. Broadly the Estuarine vegetation is categorised under two soil-vegetational types : Euestuarine and Proestuarine.

1. EUESTUARINE

According to Rao & Sastry (1974) the nomenclature of the above may be termed as plants closest to the area bordering the estuarine water and land. A relief under the constant influence of the tides composed of a few taxa showing high degree of fidelity and good sociability within a shallow area under tidal influx or elevated dry areas bordering the estuarine vicinity. The following plants are some of the indicator plants of the above : *Aegialitis rotundifolia, Nypa fructicans, Phoenix paludosa, Porteresia coarctata,* and *Urochondra setulosa. Aegialitis rotundifolia,* an erect shrub is confined only to tidal bank of Sunderbans and Mahanadi delta. *Nypa fruticans* constitutes a gregarious group wherever it is found in the estuarine and brackish swamps of the Gangetic Sunderbans. The primary need of the plant is shallow area under tidal water influence. This does not seem to occur further south of Sunderbans and is yet to be discovered in the Coromandel coast. *Phoenix paludosa,* a gregarious slender palm with annular stem is found confined to the elevated estuarine borders of the Gangetic Sunderbans and Mahanadi tidal rivers in Orissa. *Porteresia coarctata* is a saline grass and is one of the first plant to come up on a newly built up estuarine bank. It has extensive distribution along the tidal rivers of the Gangetic Sunderbans, the Mahanadi estuarine complex, and the Godavari delta.

2. Proestuarine

A vegetational mosaic representing three distinct categories often mix up responding to nature of the relief and the ebb and flow of tides. The recognised three distinct soil-vegetational types are Tidal Mangrove, Euhaline and Prohaline forms. Their sequential occurrence in regular zonation depends on the nature of the relief and tidal influence. The component taxa show fidelity to the gradient exhibited by the relief.

a. Tidal Mangrove

This subtype is characterised by the abundantly and luxuriantly growing scrubs and tree species of the mangroves, in other words taxa on muddy relief under tidal influence. The components of the tidal mangrove often exhibit two growth forms namely scrubs and trees. Along the outward fringes if the estuary is nearer to the sea under less sheltered conditions, extensive development of *Avicennia alba* and *A. marina* stretching long areas in the form of scrub forests are seen. Under protective cover from the shore banks, the tree *Rhizophora mucronata* forms a layer quite unlike the scrub layar. As long as swampy conditions prevail they form a dense growth and attain considerable growth size with compactly packed pneumatophores and stilt roots all over.

The common plants of this subtype are *Avicennia alba, A. marina, A. officinalis, Aegiceras corniculatum, Bruguiera gymnorrhiza, Ceriops decandra, Kandelia candel, Rhizophora apiculata* and *R. mucronata*. A notworthy feature is the association of the fern *Acrostichum aureum* in the mangrove habitat. But studies prove (Rao *et al.* 1973) that it is a fresh water salt tolerant fern growing gregariously over a clayey substratum rich in organic matter and pH of acidic value. A change from the alkaline to acidic habitat due to biotic or other causes could be the primary cause for the invasion of this fern into the Mangrove belt.

b. Prohaline

In this subtype, there is a mixing of salt water from the sea and the fresh water from the rivers resulting in conditions favourable for the growth of salt tolerant fresh water plants. Some of the indicator plants of this subtype vegetation are *Barringtonia racemosa, Bruguiera gymnorrhiza, Caesalpinia bonduc, C. crista, Cerbera manghas, Dalbergia spinosa, Excoecaria agallocha, Heritiera fomes, H. littoralis, Hibiscus tiliaceus, Ipomoea macrantha, Lumnitzera racemosa, Pongamia pinnata* and *Sonneratia apetala*. Also the grass *Myriostachya wightiana* and the sedge *Cyperus rotundus* grow abundantly in this regions.

c. Euhaline

This sub-type is characterised by the presence of highly salt tolerent plants which grow under conditions of apparent alternating wetness or dryness. The component taxa are halophytes and accordingly their various parts show good degree of adaptive modifications. Common indicator plants of this region are : *Acanthus ilicifolius, Aleuropus lagopoides, Arthrocnemum indicum, Atriplex stocksii, Fimbristylis cymosa, Salicornia brachiata, Suaeda maritima* and *S. nudiflora.*

Plants of important estuaries

The major estuaries in Orissa are in between the rivers Devi and the Dhamra rivers along the Utkal Coast and the Burhabalanga tidal estuary. *Aegialitis rotundifolia, Phoenix paludosa* and *Porteresia coarctata* form pure or mixed stands in the former, while in Buurhabalanga tidal estuary *Rhizophora mucronata* grows along with seaward fringes while *Phoenix paludosa* grows well in the elevated border lands. Some of the common species of tidal mangrove zone here are *Avicennia officinalis, Bruguiera cylindrica, Ceriops tagal, Kandelia candel, Rhizophora mucronata* and *Xylocarpus granatum.* In the prophaline zone the following salt tolerant fresh water taxa like *Amoora cucullata, Cynometra iripa Derris trifoliata, Excoecaria agallocha, Flagellaria indica, Hibiscus tiliaceus, Lumnitzera racemosa, Pandanus odoratissimum, Premna integrifolia, Sonneratia apetala* and *Tamarix gallica* are common. *Acrostichum aureum* grows in open forest clearings. The most recorded plants that grow in the euhaline zone are *Acanthus ilicifolius, Clerodendrum inerme, Salicornia brachiata, Suaeda nudiflora, Sporobolus virginicus* and *Zoysia matrella.*

In the Coringa tidal estuary of the Godavari estuarine complex in Andhra Pradesh, the grass *Porteresia coarctata* occupies the newly formed silt deposits in the intertidal region. *Avicennia alba, Rhizophora apiculata* and *R. mucronata* are the chief tidal mangrove species of this region. Along with climbers like *Caesalpinia crista, Dalbergia spinosa* and *Derris trifoliata* the following are commonly seen growing : *Avicennia officinalis, Bruguiera gymnorrhiza, Excoecaria agallocha, Hibiscus tiliaceus, Sonneratia apetala* and *Xylocarpus granatum.* Along the water margins *Clerodendrum inerme, Cyperus rotundus* and *Myriostachya wightiana* grow luxuriantly.

In the Vellar estuary the euestuarine taxa are absent. In the tidal mangrove zone, plants like *Aegiceras corniculatum, Avicennia officinalis, Ceriops decandra, Rhizophora apiculata* and *R. mucronata* usually form the vegetation, whereas in the prohaline zone *Bruguiera cylindrica, Dalbergia spinosa, Derris trifoliata, Lumnitzera racemosa, Sonneratia apetala* and *Xylocarpus granatum* are the most prominent taxa. On the dry elevated euhaline alkaline banks *Aleuropus* *lagopoides*, *Arthrocnemum indicum*, *Cressa cretica*, *Salicornia brachiata*, *Sesuvium potulacastrum* and *Suaeda nudiflora* grow along with shrubs like *Acanthus ilicifolius* and *Clerodendrum inerme*.

In Kodaikkadu (Point Calimere) the vegetation of the area comes under the Tropical Dry Evergreen Forests. The reserve forest is surrounded on two sides by the Bay of Bengal and on two other sides by Saline swamps where the littoral vegetation is prominent. *Spinifex littoreus* is a very distinct plant acting as a soil binder in many places. The carpet vegetation consists of *Aeluropus lagopoides*, *Aristida setacea*, *Launaea sarmentosa*, *Phyla nodiflora* and *Zoysia matrella*. *Arthrocnemum indicum*, *Suaeda monoica*, *S. maritima* are found in abundance. *Peplidium maritima* occurs abundantly near the sea shore. The mangrove vegetation near Muniappaneri area is disturbed. The plants like *Aegiceras corniculatum*, *Avicennia officinalis*, *Excoecaria agallocha* and *Tamarix troupii* are found in scattered populations here.

NEW TAXA

Along with many new records, the recent discovery of the following new taxa from the Coromandel coast proves the rich botanical wealth of this region : *Dichrostachys santapaui*, *Geniosporum prostratum* var. *longiracemosum*, *Halophila ovalis* subsp. *ramamurthiana*, *Jatropha maheshwarii*, *J. tanjorensis*, *J. villosa* var. *ramnadensis*, *Melhania balakrishnanii*, *Polygala raoi*, and *Theriophonum sivaganganum*.

PHYTOGEOGRAPHY

Rao & Sastry (1974) while analysing the coastal vegetation of India point out that Indian strand vegetation is a mixture of Afro-Perso-Arabian/Western and Indo-Malayan/Eastern elements or Polynesian and Australian affinity. In short it can be safely called Indo-Pacific, bordering Indian Ocean and W. Pacific ocean. Besides a few rare or endemic elements of localised or regional distribution also occur. Also the terrestrial estuarine flora distributed in the Euestuarine and Tidal mangrove zones is derived chiefly from Malesian and Polynesian islands.

The eastern element, the distributional range of which covers Burma, Malay Peninsula, Australia and Polynesia is represented by the plants like *Allmania nodiflora*, *Bauhinia anguina*, *Calophyllum inophyllum*, *Calotropis gigantea*, *Cordia subcordata*, *Clerodendrum inerme*, *Cyperus pendunculatus*, *Ipomoea macrantha*, *I. pes-caprae*, *Heritiera littoralis*, *Morinda citrifolia*, *Oldenlandia diffusa*, *Pemphis acidula*, *Scaevola plumieri*, *S. taccada*, *Scyphiphora hydrophyllacea*, *Spinifex littoreus* and *Xyris indica*. Many of the above mentioned plants extend up to South Western Indian Peninsula from Malesian Islands through Malacca, Tenasserim, Sunderbans and Coromandel Coast [illegible] elements are noticeable in Coromandel coast which may extend into Sri Lanka. *Eulophia epidendraea, Heterostemma tanjorense, Oldenlandia shuteri* and *Sesamum prostratum* are plants strictly of the Coromandel coast. The disjunct occurence of *Psilostachys sericea* from Saurashtra and Bombay and at Nellore in Coromandel Coast is of considerable interest. The strand flora of Sri Lanka is well represented along the southern shores of Tamil Nadu including the islands in the Gulf of Mannar.

According to Rao & Sastry (1974) the floristic elements of the estuarine borderland vegetation which constitutes a subtype of the Indian coastal flora are akin to the near and far of shores and lack endemic and native elements. Their density, frequency, floristic composition, species number and gregarious habit, change from Gangetic Sunderbans to Kanyakumari. This change is mainly due to the disjunction of dominant individual species. They conclude, in the Indian estuarine conditions the euestuarine zone possesses a few disjunct taxa of wide distribution. Further the floristic components of the proestuarine complex are chiefly representative taxa of Indo-Malayan alliance of which, a few are circumtropical halophytes mixed with few salt tolerant local plants.

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5.11. ANDAMAN AND NICOBAR ISLANDS

(N.P. Balakrishnan and J.L. Ellis)

The flora of the Andaman and Nicobar group of islands is very rich with about 3000 taxa of angiosperms, pteridophytes, bryophtes, lichens, etc. Among the angiosperms 10 per-cent are endemic to these islands. The proximity of the islands to the equator and the influence of both south-west and north-east monsoons with annual rainfall of about 3180 mm, have greatly contribute to the occurence of dense humid tropical forests, occupying about 86 per cent of the total land area of 8249 sq km of these islands. The distributional pattern of several types of forests depends mainly on the geographical orientiation of the islands from the Arrankkan-Yoma hill range of Myanmar to the Sumatran range of Indonesia, resulting in northern ones having Myanmarese (Burmese) elements andd the southern ones, the Indonesian elements.

The flora of these islands still remains rather insufficiently known. Earlier explorations were confined only to a few inhabited islands, leaving many which were unapproachable. Only recently with the intensive explorations of Botanical Survey of India parties, the virgin forests of most of the islands are becoming botanically better known. The earliest botanical studies in these islands date back to the year 1791, when Colonel Kyd, founder of the Calcutta Botanic Garden, visited these islands, made collections and introduced many species to the Calcutta garden. During the subsequent years Helfer, Kurz, Prain, King, Rogers and Parkinson made extensive collections during the 19th and early part of 20th centuries. Among recent collectors, mention may be made of B. S. Chengappa and K. C. Sahni of the Indian Forest Service and K. Srinivasan, K. Thothathri, P. K. Hajra, P. K. Muherjee, S. P. Banerjee, K. Ramamurhy, J. L. Ellis, N. P. Balakrishnan, N. Bhargava, M. K. Vasudeva Rao, N. G. Nair, P. Chakraborty, D. K. Hore, R. P. Dwivedi, M. Sanjappa, U. Chatterjee, T. Chakrabarty, etc. of Botanical Survey of India. With their intensive and extensive explorations and botanical studies, now we have better knowledge about the flora.

VEGETATION

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 everwet conditions. These forests are floristically the richest, potently complicated, 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 N. Andamans, and mount Thuiller in Great Nicobar Island.

Kurz (1876) working on the Nicobar group of islands has grouped the vegetation as follows:

(i) Mangrove forests ; (ii) Beach forests; (iii) Tropical forests, including (a) Coral Reef and (b) True Tropical forests; (iv) Grass-heaths of Car Nicobar and Kamorta islands; (v) Marine vegetation with some sea *Halophia ovalis* and *Enhalus acoroides*.

Champion & Seth (1968) have treated the forests of Andaman and Nicobar 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.

The configuration and composition of some of the above major types of forests can be summarised as follows:

The giant evergreen forests are typically of climatic climax of these islands, where optimum conditions are prevalént. Characteristically the top canopy though irregular is almost covered. The soil is composed of deep allluvial and is able to retain the water content of the abundant rainfall of about 300 cm for long periods. Many species of *Dipterocarpus alatus, D. gracilis, D. incanus, D. turbinatus* var. *andamanica* and *Hopea odorata* are found here. The second storey comprises of *Baccaurea sapida, Sideroxylon longipetiolatus, Endospermum malaccense, Artocarpus gomezianus, Myristica glaucescens, Buchanania platyneura,* etc.

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, Planchonia andamanica, Hopea odorata, Sideroxylon longipetiolatum,* associated with *Garcinia andamanica, Myristica andamanica, M. glaucescens, Baccaurea sapida,* etc. The climbers include *Gnetum scandens, Ancistrocladus tectorius,* the climbing bamboo *Dinochloa andamanica, Artabotrys speciosus, Calamus longisetus, C. palustris, C. pseudorivalis,* etc., the last three making cane-brakes at disturbed places with exposed canopy.

The *Andaman semi evergreen forests* are either with decidulous or evergreen species, mixed or pure. They 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, Artocarpus lakoocha, A. chaplasha* and *Pterocarpus dalbergioides* intermixed with *Dillenia* *pentagyna, Pometia pinnata, Litsea panamonja, Xanthophyllum andamanicum, Magnolia andamanica, Garcinia andamanica, Caryota mitis* and *Parishia insignis.* Climbers include *Dinochloa andamanica, Combretum latifolium, Thunbergia fragrans* and *Calamus* spp. Because of the 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 secondary 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 congalomerate. The soil is rather shallow and sandy loamy. The characteristic species include : *Pterocarpus dalbergioides, Largerstroemia hypoleuca, Chukrasia tabularis, Sterculia alata, Petrocymbium tinctorium, Terminalia bialata, T. procera etc.* The second storey comprises *Adenanthera pavonina, Dillenia pentagyna, Lannea coromandelica, Disopyros marmorata,* etc., followed by smaller trees like *Murraya paniculata, Pterospermum alatum, Ixora grandifolia, Atalantia 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 the preceeding forest, and they are essentially composed of two canopies, the upper one comprising *Salmalia malabarica, Pterocymbium tinctorium, Terminalia bialata, Tetrameles nudiflora, Parishia insignis,* etc. and the lower canopy comprising *Pterocarpus dalbergiodes, Lagerstroemia hypoleuca, Albizia lebbeck, Adenanthera pavonina, Planchonia andamanica, Diploknema butyracea,* etc. This type is more of 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 N. Andamans and Mount Thuiller of Great Nicobar Island at altitudes above 600 m from msl. 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 of inferior quality surrounded by wet evergreen forests at lower levels of the hill slopes. The common trees include *Dipterocarpus costatus, Phyllanthus andamanica, Memecylon collinum, M. caeruleum, Psychotria balakrishnanii, Grewia indandamanica, Canarium manii, Mesua ferrea, Hopea andamanica, Cratoxylum formosum, Euphorbia epiphylloides, Chionanthus sumatranus, Cryptocarya ferrarsi, Phoenix* sp. and the climbing bamboo *Dinochloa andamanica* making impenetrable thickets with entangled and matted stems. Interestingly the ground layer has commonly the grasses *Oryza indandamanica, Imperata cylindrica, Heteropogon contortus, Chrysopogon aciculatus,* associated by 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 N.E. Indian orchids *Porpax meirax* and *Ascocentrum ampullaceum*.

Parkinson (1923) 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 Andamans and Mt. Ford on Rutland Island.

Thothathri (1960 & 1962) treats the Andaman forests under 7 types including vegetation of the cleared lands and open areas and marine vegetation.

Saldanha (1989) demarcates 6 forest types in the Andamans : (i) Giant Andaman Evergreen, (ii) Andaman Tropical Evergree (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.

Balakrishnan *et al*. (1989) working on the Great Nicobar Island in the proposal for establishment of a Biosphere Reserve give the following types :

(i) Sandy beach formation consisting of (a) Herbaceous beach, (b) Shrubby beach, (c) Woodland beach, (d) Casuarina beach, (e) Pandanus beach, and (f) Mixed Littoral forests.

(ii) Mangrove vegetation consisting of (a) Mangrove shrubs, (b) Mangrove forests, and (c) Nypa palm swamp.

(iii) Lowland swamp consisting of (a) Pandanus swamp and (b) Areca swamp.

(iv) Evergreen forests consisting of (a) Pure evergreen and (b) Mixed evergreen types.

(v) Man-made vegetation consisting of (a) Coconut plantations and (b) Secondary formations, including farmlands.

Further dealing with the natural vegetation of the entire Andaman and Nicobar Islands, Balakrishnan (1977 & 1989) broadly classifies the vegetation into 2 major groups consisting of 8 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 of 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) Sumberged vegetation, (ii) Mangrove vegvetation (iii) Strand vegetation, (iv) Tidal or swamp forests. B. Inland: (i) Evergreen Forests, (ii) Decidous forests, (iii) Grasslands, (iv) Aquatic vegetation.

A. LITTORAL

(i) *Submerged vegetation* : This includes the sea weeds (marine algae) and sea grasses (marine angiosperms). The sandy beaches with shallow waters, strewn with rocks and boulders and coral reefs, facilitate luxuriant growth of marine algae. The most common one are *Enteromorpha, Ulva, Acetabularia. Codium, Halimeda, Caulerpa* and *Dictyosphaeria* of the green algae (Chlorophyceae), *Padina, Turbinaria* and *Sargassum* of brown algae (Phaeophyceae) and *Ceramium* of red algae (Rhodophyceae) (Srinivasan 1960). The sea grasses of the genera *Cymodocea, Enhalus, Halophila* and *Thalassia* are especially common on sandy soils in quite waters, up to a metre beneath the ebb level.

(ii) *Mangrove vegetation* : The mangrove forests of Andaman and Nicobar Islands are one of the best in the world, having high floristic richness, complexity index and biomass production (Singh *et al.* 1990). About 15% of the area of Andaman and Nicobar Islands (about 250,000 acres) are covered by mangrove vegetation. They are better formed in the Andaman Islands than in the Nicobar Islands. The Andaman mangroves are perhaps the best developed ones in India. Many workers have done intensive studies on the mangroves of these islands. Among them Parkinson (1926), Sahni (1958), Thothathri (1962), Balachandra (1988), Mall *et al.* (1985) and Dagar *et al.* (1991) are noteworthy. Mall *et al.* (1991) have analysed the composition of the vegetation, standing crop biomass, litter production, litter decomposition and soil respiration in monogeneric mangrove forests and mixed mangrove forests of Andaman Islands and found that the mangroves of these islands posses more biomass than any other mangroves. Litter composition rate in these forests was influenced by litter quality, dissolved oxygen and substrate salinity being greater in the substrate having high amount of dissolved oxygen and higher salinity. Dagar *et al.* (1991) give a detailed ecological study including factors for distribution and growth, floristics, vegetation, phytosociology, succession, productivity, litter production, associated fauna, utilization, human impacts and suggestions for an ecologically compatible management of the mangrove forests of these islands.

The most common trees in these mangrove forests and *Rhizophora mucronata, R. apiculata, R. stylosa, R. conjugata, Bruguiera gymnorrhiza, B. parviflora, Carallia brachiata* and *Zylocarpus granatus*. Climbers and epithytes common in these forests are *Hoya parasitica, Dischaidia bengalensis, Derris trifoliata* and several ferns and a few orchids. The mangrove palm, *Nypa fruticans* is also common especially in tidal creeks where fresh and salt water mix. Very often it forms pure stands with a closed canopy without any undergrowth.

In degraded mangroves, caused by cutting of trees, a sort of swampy vegetation, seldom inundated by sea water, can be seen with the fern *Acrostichum aureum* growing in clumps on raised mounds. This is often associated by *Acanthus ilicifolius,* a shrub with spinescent margined leaves and blue flowers.

(iii) *Strand vegetation* : The vegetation occupying the coastal sandy belt include herbaceous dune formations and wood beach forests. The most common sand dune plant is *Ipomoea pes-caprae*, which may occur as pure formation or in association with other herbaceous plants like *Vigna marina, Phyla nodiflora* and the grass *Ischaemum muiticum.* The other grasses of sand dune formations are *Spinifex littoreus* and *Thuarea involuta.* Behind this zone or often adjacent to it, one can see the dense shrubby growth of *Sacaevola sericea.* The other shrubby plants behind the dune zone are *Dononaea viscosa. Clerodendrum inerme, Desmodium umbellatum, Morinda citrifolia, Breynia racemosa, Leea indica, Pluchea indica* and *Allophylus cobbea.* Often climers like *Wedelia biflora, Caesalpinia crista* and *Cyclea peltata* are associated with them.

Along retreating coasts, one can find 'Barringtonia formation', the dominant tree being *Barringtonia asiatica,* often associated with *Guettarda speciosa, Calophyllum inophyllum* and *Pongamia pinnata.* In several places shrubs like *Pemphis acidula, Messerschmidtia argentea, Vitex trifolia* and *Pandanus* spp. can be seen.

The beach forests which occur behind the sand dune and/or Barringtonia formations are dominated by the trees of *Hernandia peltata, Thespesia populnea, Mimusops littoralis, Syzgium samarangense, Sophora tomentosa, Glochidion calcocarpum, Intsia bijuga, Cycas rumphii, Pandanus* spp. etc. The herbaceous species commonly found in these forests are *Acalypha indica, Euphorbia hirta, Centotheca latifolia, Ophiorrhiza mungos, Aerva lanata, Ischaemum muticum, Cyperus kyllinga,* etc. The common climbers are *Dischidia bengalensis, D. nummularia, Pothos scandens* and *Hoya spp.* The epiphytic species commonly met with are orchids like *Dendrobium crumenatum, Luisia teretifolia, Bulbophyllum lepidum, Cymbidium aloifolium* and *amanica* and *Eria* ferns like *Polypodium phymatodes* and *Drynaria quercifolia.*

Along some beaches, particularly on the west coast of Great Nicobar and Little Andaman Islands, one can find pure stands of *Casuarina equisetifolia,* sometimes associated with *Pandanus tectorius.*

(iv) *Tidal and swamp forests* : In coastal areas where the soil is slightly saline and wet or marshy, but not flooded by sea water except during very high tide or storms, a particular type of tidal or swamp forests can be seen. The trees in these forests exhibit certain peculiarities as adaptations to the habitat, like buttress roots, stilt roots and conically thickened stem bases. These adaptations are responses to meet the low air supply to the root system and to support and protect the trees from strong wind, as the root system is usually shallow in the soil.

The common trees found in these forests are *Heritiera littoralis, Barringtonia racemosa, Ficus retusa*, etc. associated with *Brownlowia lanceloata, Cyanometra ramiflora, Scyphiphora hydrophyllacea, Excoecaria agallocha, Lumnitzera racemosa, Xylocarpus granatum, Dolichandrone rheedii* and *Sonneratia acida*. At certain localities *Phoenix paludosa* can be seen in such areas. In Great Nicobar Island, in such forests one can find large wild populations of *Areca catechu*, growing naturally, called *Areca* swamps, often associated with *Syzygium samarangense, Ficus rumphii, Mangifera camptosperma* and *Terminalia bialata*. Among the woody climbers and stragglers, the common ones are *Caesalpinia crista, Derris scandens, D. heterophylla* and *Flagellaria indica*. On many trees in such forests of Andaman Islands, the peculiar epiphytic myrmecophilous plant, *Hydnophytum formicarium* can be seen, with swollen irregular-shaped stems in which ants dwell. Epiphytic orchids normaly seen are *Dendrobium, Bulbophyllum, Eria*, etc. Epiphytic ferns commonly noticed are species of *Drymoglossum, Lepisorus* and *Asplenium*. Along open marshy areas adjacent to mangrove forests, large populations of *Acrostichum aureum* and *Acanthus ilicifolius* associated with *Cyperus* sp. grow in dense clumps on raised mounds.

B. INLAND

(i) *Evergreen forests* : These forests are the most dominant and magnificient in these islands, representing the climax vegetatiion with a closed compact balanced community of diverse tropical plants. The canopy is closed consisting of three or more strata of storeys. There is little sunlight reaching the floor of these forests. Humus content is rather poor and soil is mainly composed by clayey loam with micaceous sandstones below. Bhargave (1958) has made detailed analysis of their forests in Andaman Islands and Kurz (1976) and Balakrishnan *et al.* (1989) in Nicobar Islands.

The evergreen forests of Andamans and Nicobars are distinct in floristic composition, though ecologicaly similar.

(a) In *Andaman Islands* : These forests are mainly composed of various species of *Dipterocarpus*, reaching 40-50 metres high with almost straight boles. The associated common trees are *Sideroxylon longipetiolatum, Planchonia andamanica, Xanthophyllum andamanicum* etc. The second storey is made up of smaller trees like *Baccaurea sapida, Myristica glaucescens, M. andamanensis, Buchanania platyneura, Randia pulcherrima, Pometia pinnata, Fagraea racemosa, Micromelum mintum, Duabanga sonneratioides*, etc. These forests dominated by large trees exhibit rather poor shrubby flora. However the few common shrudby ones seen are *Leea indica, L. aurantiaca, Clerodendrum viscosum, Maesa andamanica, Morinda umbellata, Breynia rhamnoides, Jasminum subglobosum* and *Grewia disperma*. Among the woody climbers the commonest ones are the canes represented by *Calamus longisetus, Daemonorops manii* and *D. kurzianus*.

Lianas and woody climbers like *Entada rheedei*, *Mezoneuron cucullatum*, *Illigera appendiculata* and *Thunbergia laurifolia* are common in these forests. The herbaceous flora is rather negligible, except in open places near streams and clearings, where the dominant species are *Phragmites karka* and *Saccharum spontaneum*. The most common epiphytic plants are the large leaved fern, *Asplenium nidum* and orchids like *Dendrobium aphyllum* and *D. secundum*. Among the epiphytic ferns the common ones are *Drymoglossum piloselloides*, *Drynaria quercifolia* and *Lycopodium phlegmaria*.

(b) In *Nicobar Islands* : The main dominant trees of these forests are *Calophyllum soulattri*, *Sterculia macrophylla*, *Planchonella longipetiolata*, *Amoora wallichii*, *Horsfieldia irya*, *Dacryodes rugosa*, *Actephila excelsa*, *Fagraea auriculata*, *Aglaia gangoo*, *Chydenanthus excelsus*, *Litsea glutinosa*, *Elaeocarpus serratus*, *Nephelium lappaceum*, *Nothaphoebe panduriformis*, *Kibara coriacea*, etc. These are often associated with climbers like *Freycinetia insignis*, *Phanera nicobarica*, *Fibruarea chloroleuca*, *Tinomiscium petiolare*, *Aristolochia tagala*, *Pothos* spp. etc. Different shrubs like *Randia longifolia*, *Saurauia bracteosa*, *Crytadromoea nicobarica*, *Melastoma affine*, *Uncaria sp.*, *Astronia macrophylla*, *Gynotroches axillaris*, etc. and lianas like *Indoroucheria griffithiana*, *Rourea minor*, *Tetrastigma lanceolarium*, etc. are also seen. Two species of tree ferns, *Cyathea albo-setacea* and *C. nicobarica* are also frequently seen in these forests.

(ii) *Deciduous forests* : These forests occupy the undulating hills and slopes where the capacity of the soil to hold water is considerably low. The are characterised by trees which shed their leaves during the major part of the dry season. They are found mainly in North Andamans, Middle Andamans and some parts of South Andamans.

The most common trees are *Pterocarpus dalbergioides*, a valuable timber tree often buttresed at base and growing up to 40 50 metres, *Canarium euphyllum*, *Ailanthes kurzii*, *Parishia insignis*, *Terminalia* spp., *Albizia lebbeck*, *Diploknema butyracea*, *Tetrameles nudiflora*, *Pterocymbium tinctorium*, etc. The second storey is composed of *Semecarpus kurzii*, *Miliusa tectona*, *Sterculia villosa*, *Diospyros pyrrhocarpa*, *Cratoxylon formosum*, *Pterospermum aceroides*, *Sageraea elliptica*, *Lannea coromandelica*, etc. The third storey consists of smaller trees and large shrubs like *Vitex glabrata*, *Streblus asper*, *Grewia disperma*, *Cordia grandis* and *Linociera terniflora*. The shrubby growth in these forests are richer than in evergreen forests due to greater amount of sunlight reaching the forest floor, and the common ones are *Actephila excelsa*, *Ixora grandifolia*, *Licuala peltata*, *Bridelia griffithii*, *Mallotus acuminatus* and *Rinorea bengalensis*. Canes are sparsely distributed, the commonest one being *Calamus viminalis*. The other common climbers are *Ventilago madraspatana*, *Sphenodesma unguiculata*, *Pothos scandens*, *Delima sarmentosa* and *Dinochloa andamanica*. The herbaceous vegetation in these forests are represented by many grasses like *Paspalum conjugatum*, *Echinochloa crus-galli*, *Dichanthuim annulatum*, the fern *Pteris* *quadriaurita*, and other herbs like *Alysicarpus vaginalis, Peperomia pellucida* and *Nelsonia campestris*. The epiphytic elements consist of *Drynaria quercifolia, Dendrobium aphyllum, Cymbidium aloifolium* and *Pholidota imbricata*.

Such deciduous forests are absent in Nicobar Islands, where it is replaced by mixed evergreen forests, which exhibit along with evergreen elements, partially deciduous trees like *Pterocymbium tectorium, Artocarpus chaplasha, Terminalia catappa, T. bialata, T. citrina, Anthocephalus chinensis, Dehaasia triandra, Lagerstroemia ovalifolia*, etc. A characteristic gymnospermous tree, *Gnetum gnemon* occurs in these forests. Species of *Agalaonema, Piper, Hetaeria*, etc. occupy the ground layer, whereas epiphytes like *Asplenium, Pholidota, Luisia, Pteroceras*, etc. are seen on several trees. Rare palms like *Rhopaloblaste augusta, Pinanga manii*, etc. are also found in these forests.

(iii) *Grasslands* : Several disturbed and degraded hillocks in Andaman Islands show rich grasslands dominated by the most common *Imperata cylindrica*, associated with *Themeda triandra* and *Saccharum spontaneum*. These species are usually associated with *Heteropogon contortus, Chloris barbata, Charysopogon aciculatus, Eragrostis zeylanica* and *E. unioloides*. The sedge, *Scleria cochinchinensis* and ferns *Dicranopteris linearis* and *Lygodium flexuosum* are also found frequently. Among the other herbs and undershrubs mention may be made of *Uraria lagopodioides, Desmodium heterocarpon, Triumfetta rhomboidea* and *Urena lobata*. At certain places the large shrubby *Melastoma malabathricum* and *Erycibe paniculata* can be seen. Sometimes these grasslands are invaded by *Eupatorium odoratum*, which dominates and destroys most of the grass species.

The curious occurrence of grass heaths in Kamorta Island and some parts of Car Nicobar Island, which by all accounts seem to be a permanent feature, is still perplexing. Mostly it is occupied by *Saccharum spontaneum, Eragrostis zeylanica, Heteropogon contortus*, and several species of *Fimbristylis, Imperata cylindrica, Ischaemum muticum, Paspalum scrobiculatum, Arundo roxburghii*, etc. One opinion is that these grasslands were created over a century ago by clearing of the forests by the Danish settlement for goat grazing. Kurz (1876) confesses his inability to solve the mystery. N.G. Nair (1979) assigns the occurrence to natural causes and partly to man's activities, calling it 'Semianthropogenic Grasslands'. It is necessary to conduct a detailed study of this peculiar ecological climax, to find out the real cause and to know why they have not reverted to tropical evergreen forests over the long lapse of years.

(iv) *Hydrophytic Vegetation* : The scarcity of natural stagnant water bodies in these islands resulted in a rather poor fresh water flora. However, the few man-made and natural ponds and the paddy fields exhibit plants like *Ipomoea aquatica, Lemna perpusilla, Najas indica, Hydrilla verticilata, Nymphea nouchali* and algae like *Chara* and *Nitella*. The fresh water marshy areas accommodate species like *Ludwigia perennis, Blyxa roxburghii, Monochoria vaginalis, Polygonum barbatum*, *Fuirena glamerata, Hygrophila erecta* and the water fern *Ceratopteris thalictroides*, along with several species of sedges.

ENDEMIC AND RARE PLANTS

According to Vasudeva Rao (1986) there are 1454 species of angiosperms recorded from Andaman & Nicobar Islands and among them 3 genera and 187 species are endemic to these islands. The present state of knowledge on the flora of these islands indicates that there are about 2100 species of angiosperms in these islands and among them 3 genera and about 216 species, representing about 11% of the total flora, are endemic to these islands. Among these, 144 species are endemic to Andaman Islands and 72 species are endemic to Nicobar Islands (Balakrishnan *et al.* 1989). Further intensive and extensive explorations in unexplored and underexplored islands will definitely add more new species to the list.

As in most tropical island floras, the most peculiar feature of the endemic plants of these islands is their restricted distributioin. Most of the endemics in these islands are rare and many are being threatened with extinction. The extreme competition for space and sunlight in a tropical evergreen insular ecosystem limits the distribution of most species, resulting in their confinement to very small limited areas. This is the reason why most of the endemics have been collected only once, many only from the type localities and several never since the type collections, as listed by Balakrishnan & Vasudeva Rao (1983). Hence destruction of even a small area of forests in these islands may render the endemics of that area extinct.

It is also interesting to note that about 40% of the flora of these islands are South-east Asian from Myanmar to Malesia and are absent in the mainland India. Being located in these small islands with a total land area of only about 8300 sq. km, as big as a district in mainland India, these extra-Indian elements can also be considered rare and endangered as far as India is concerned. In view of this considerable aspect, two Biosphere Reserves, one at Great Nicobar Island, which has been declared, and another at North Andaman Island including Saddle Peak has been proposed to protect the flora. However, there is need to have more such Biosphere Reserves in these islands.

PHYTOGEORAPHY

Ridley (1930) expressed that the Andaman and Nicobar Islands are undoubtedly continental, formerly connected with Myanmar (Burma) in the south, retaining the remnants of a more widely extended flora. Hooker (1906) in his phytogeographic division of India included Myanmar and Andaman Islands together in the eighth and Malay Peninsula from Kedah to Singapore, together with Nicobar Islands in the nineth positions.

Under the Indo-Malesian subkingdom within Paleotropical kingdom, Thakhtajan (1986) phytogeoraphically classifies Andaman Islands as a province under Indo-Chinese Region and Nicobar Islands under Malesian Region, both distinct from the Indian Region, indicating the affinities exemplified by the flora of these islands. Melville (1973) states that the land masses surrounding the Indian Ocean were formerly parts of the Gondwana continent during the Palaeozoic and Mesozoic times.

An analysis of the flora of different islands shows very interesting features. The Andaman group of islands have more species common to north-east India, Myanmar, Thailand and Malaysia, the Nicobar group have more species common with Indonesia in the south and Malaysia, in the east.

The disjunct distributioin of various species of plants found in these islands makes it all the more interesting and intriguing. *Pterocarpus dalbergioides* and the various species of *Dipterocarpus* which form the pride of the Andaman forests (except Little Andaman Island) are curiously absent from the Nicobar group. Moreover, *Pometia pinnata, Scyphiphora hydrophyllacea, Pemphis acidula, Ancistrocladus tectorius, Crypteronia paniculata, Tetrameles nudiflora* and *Pandanus andamanensium,* which are common in Andaman group are totally absent in Nicobar group. Very interestingly, *Areca triandra,* which is common in Andaman Islands is absent in Nicobar group, where one finds wild populations of *Areca catechu,* particularly along the west coast of Great Nicobar Island, which is totally absent in Andamans as discussed by Balakrishnan & Nair (1979). Similarly, wild populations of *Piper betle* and its six wild relatives have been discovered from Great Nicobar Island (Ellis & Vishnoi 1989, Sreekumar & Ellis 1990). Wild populations of *Piper betle* or any of its relatives are absent in Andaman Islands. *Podocarpus wallichianus,* present in Nicobars, is absent in Andamsns, where it is replaced by *Podocarpus neriifolia.* Other interesting plants occurring only in Nicobars and not found in Andamans are *Kibara coriacea, Burmannia championii, Pandanus leram, Phanera nicobarica, Cyrtandra burttii, C. occidentalis, Rhopaloblaste augusta,* etc. Among the pteridophytes there are several species which are confined to either Andamans or Nicobars. The tree ferns are totally absent in Andamans but the genus *Cyathea* is represented by 2 species in Nicobar group. *Lycopodium nummulariaefolium, Helminthostachys zeylanica* and *Ophioglossum pendulum* are found in Nicobars but not in Andamans.

Many of the plants of Andaman Islands extend their distribution to the north towards Thailand, Myanmar, Bangladesh and N.E. India. Some obscure orchids of N.E. India, such as *Ascocentrum ampullaceum* and *Porpax meirax* find place on 700 m high Saddle Peak of N. Andamans. *Coelogyne trinervia, C. thailandica, Thunia alba, Hopea helferi,* also share their distribution with the northern land masses.

Sahni (1953) and Thothathri *et al.* (1973) have made detailed floristic studies on the flora of Great Nicobar Islands.

More recently, Balakrishnan *et al.* (1989) have summarised their findings on Great Nicobar flora as follows :

— Great Nicobar Island shows no endemism at family level ; the families Dipterocarpaceae, Simaroubaceae and Polygalaceae are not represented in Great Nicobar, but are found in Andamans.

— Great Nicobar and Indonesia share more common families and genera, than with N.E. India, Myanmar, Thailand and Malaysia.

— The presence of those species wich are common between Andamans and Nicobars are signs of recent migrations and exchanges.

— Out of about 700 species occurring in Great Nicobar Island, 74 are endemics, 210 are species strictly Malesian and not found in any other part of India and only the remaining 416 are having widespread distribution.

The speculation of Renovize (1979) that the islands possess about 700 species mostly related to the flora of Malaya and Jacob's (1978) remarks that the flora is closely related to the Sumatran flora, are found to be true.

These findings suggest that land connection bnetween N. Andaman and Myanmar and between Great Nicobar and Sumatra were for longer periods than between Andaman and Nicobar groups. Perhaps, there never was any land connection between Andaman group of islands and Nicobar group of islands. The deep Ten Degree channel separating these two groups of islands could vouch for it. A long period of land connection with Myanmar in the north and with Sumatra in the south must have facilitated the occurrence of more floristic elements common with both those landmasses. Later isolation should have given rise to many endemic elements in these islands.

Balakrishnan (1989) again stresses similarity of climatic conditions of the Western Ghats and West Coast of Peninsular India and Sri Lanka with those of Andaman & Nicobar Islands. He says (p. 60) : "............At the specific level we find several rare plants especially orchids common to these two areas. Examples are *Porpax reticulata, Thrixspermum album, Geodorum densiflorum, Calanthe triplicata, Corymborchis veratrifolia, Eulophia graminifolia* and *Nervilia aragoana.* Other species which are common to these two areas are *Floscopa scandens, Phylochlamys spinosa, Burmannia championii, Osbeckia tenera, Myxopyrum smilacifolium, Christisonia alba* ....At generic level, the number of common genera amount to several hundreds............"An interesting distribution pattern is shown by the palm genus *Bentinckia* which has only two species in the world and one of them, *B. condapanna* is found in the southern W. Ghats and the other

B. nicobarica in Nicobar Islands. One cannot think of reasons for these similarities with peninsular India, except through Gondwana land connections.

T. A. Rao & Chakraborti (1987) working on the coastal plants in the Andaman & Nicobar Islands highlight on the Pantropical, Indo-Pacific, Indo-Malesian, Indo-African, and Neotropical floristic elements present in the coastal flora of these islands. They give examples as follows :

Indo-Pacific : *Aegiceras corniculatum, Asplenium nidus, Cyperus pedunculatus, Dodonaea viscosa, Euphorbia atoto, hernandia peltata, heritiera littoralis, Ipomoea macrantha, I. pes-caprae, Lumnitzera littorea, Messerschmidtia argentea, Morinda citrifolia, Pemphis acidula, Scaevola sericea, Rhizophora stylosa,* etc.

Indo-Malesian : *Cynometra iripa, Guettarda speciosa, Heritiera fomes, Lumnitzera racemosa, Ochrosia oppositifolia, Sonneratia caseolaris, S. griffithii,* etc.

Indo-African : *Calophyllum inophyllum, Launaea coromandelica, Ximenia americana,* etc.

Neotropical : *Cordia subcordata, Suriana maritima,* etc.

These findings can be summarised as follows :

— While Andaman flora shows closer affinities with Indo-Myanmar-Thailand flora, the Nicobar flora shows closer affinities with Malaya-Sumatra flora. At the same time both these groups possess considerable number of both Indian and Malesian elements.

— The presence of several species common between Andaman and Nicobar is probably the result of past land connections or recent long distance dispersal. Probably both these factors have influenced the present distribution.

— The presence of a significant number of endemic species in both these groups indicates long period of isolation of these islands from neighbouring continental areas.

— The floristic differences between these two groups of islands are the result of isolation, separated as they are by the deep and wide Ten Degree Channel and remained isolated for a longer period of time than they were with their adjacent continental land masses, i.e., Myanmar in the north Sumatra in the south.

— The flora of Andaman & Nicobar Islands show a connecting link or a trasition zone between floras of Indian subcontinent and Malesian subcontinent.

— The flora also shows close affinities with the flora of Peninsular India and Sri Lanka, probably due to the ancient Gondwana land connections.

To put it in a nutshell, it may be safely assumed that in the distant past these islands were connected to Indo-Malesia through which the migration of species up and down from Indian mainland to Malesia occurred leaving remnants on these islands. The original flora got enriched by the evolution of endemic species and also by long distance migration of species from both the subcontinents.

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