Pt. Govind Ballabh Pant

Memorial Lecture: XXVII

Dr. R. Raghavendra Rao

G.B. Pant National Institute of Himalayan Environment
(An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Govt. of India)
Kosi-Katarmal, Almora, 263 643, Uttarakhand, India

Dr. R. Raghavendra Rao

- Fellow, Indian National Science Academy, New Delhi
- Fellow, National Academy of Sciences, Allahabad
- Fellow, Indian Academy of Sciences, Bangalore
- Fellow, Linnean Society of London, United Kingdom
- Fellow, Society of Ethnobotanists, Lucknow
- Fellow, Indian Botanical Society
- Fellow, Indian Association of Angiosperm Taxonomy, Calicut
- Fellow, Association for Plant Taxonomy, Calcutta
- Indian National Science Academy Honorary Scientist
- Chairman, Karnataka State Environmental Appraisal Committee

Specialization:

- Plant Taxonomy and Ethnobotany
- Phytogeography, Medicinal & Aromatic Plants
- Biodiversity and Conservation

Awards & Recognitions:

2013 Prof. V. Puri Memorial Medal, Indian Science Congress Association Calcutta, India
2008 Prof. Y. D. Tyagi Gold Medal of the Indian Association for Angiosperm Taxonomy, Calicut, India
2006 Elected President, Indian Botanical Society
2001 Scientist of the Year, National Environmental Science Academy, New Delhi, India
1999 Prof. B. A. Razi Medal of the Association of Plant Taxonomy, Calcutta, India
1999 Pitambar Pant National Environment Fellowship Award by Ministry of Environment and Forest, GoI
1994 William Harshberger Medal by Society of Ethnobotanists, Lucknow, India
1988-91 Elected President of Society of Ethnobotanist, Lucknow, India

Research and Development Experience:

- Dr. Rao did his B. Sc. in 1967 and M. Sc. (Botany) in 1969 from Mysore University, and Ph.D. in Systematic Botany from Mysore University, Manasa Gangotri, during 1974. He has spent almost 40 years in basic research, and around 34 years on surveying of natural resources. He has guided more than 30 candidates on basic research and produced 14 Ph.D. Dr. Rao has published around 240 research articles and 14 scientific books.
- Dr. Rao has carried out research on various aspects of plant biology in North-East Hill University as Associate Professor, Botanical Survey of India at Kolkata & Dehra Dun as a Joint Director, and in NBRI and CSIR-CIMAP, Bengaluru, as Director-Grade Scientist.
- Dr. Rao has served as the Editor of the International Journal of Ethnobotany (published by the Society of Ethnobotanists) and published 7 volumes of the journal during 1989-96. In addition, 3 volumes of Flora of India were also edited and published by him while working in Botanical Survey of India. Dr. Rao edited the departmental Journal, 'Magnolia' and brought out 5 volumes during 1975-79 during his stay at the North-East Hill University. He is currently serving as Member of Editorial Board of International Journal Herba Polonica, Poland.
- Considering the immense contributions of Dr. Rao in plant Taxonomy, eight new taxa are named after him, and currently, Dr. Rao is engaged in teaching, research, research supervision, and serving various national level scientific committees of DST, DBT, DoEN of GoI.

Pt. Govind Ballabh Pant

Memorial Lecture: XXVII

Dr. R. Raghavendra Rao

September 10, 2021

at

Kosi-Katarmal, Almora

G.B. Pant National Institute of Himalayan Environment

(An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Govt. of India)

Kosi-Katarmal, Almora, 263 643, Uttarakhand, India

The Himalaya - Biogeography, Biodiversity & Bio-resources: Concerns & Strategies

Dr. R.R. Rao

Indian National Science Academy Honorary Scientist
No. 328, B-4, Kendriya Vihar, Yelahanka, Bengaluru- 560064
Email.: raocimap@gmail.com

Extended Summary

Honorable dignitaries, Director and faculty of the Institute, ladies and gentlemen,

It is indeed a great honour for me to deliver this memorial lecture named after Pandit Govind Ballabh Pant, *a true son of the mountains* is always remembered as one of the country's most prominent freedom fighters and an administrator who played a key role in shaping modern India, actively took part in the Non-cooperation movement, the Civil Disobedience movement and the Satyagraha movement. He was the First Chief Minister of Uttar Pradesh (1946 -1954) and Union Home Minister (1955 - 1961) and was a recipient of the highest civilian award, the Bharat Ratna in 1957. He was a great Parliamentarian, a great thinker, and above all a great human being always struggled for the welfare of the people of Himalayan region. The Nation has given rich tributes to him by establishing the G.B. Pant University of Agriculture & Technology, Pant Nagar, G.B. Pant Institute of Engineering & Technology, Pauri, and our G.B. Pant National Institute of Himalayan Environment, Kosi, Katarmal, Almora. I feel proud to be associated with this unique Memorial lecture named after Pandit G.B. Pant. I thank the Director and staff of the Institute for giving me this great opportunity.

G. B. Pant National Institute of Himalayan Environment (Formerly known as G.B. Pant Institute of Himalayan Environment & Development) was established during 1988-89 as an Autonomous Institute of the Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India. I have been in close association with this Institute since the time of land selection for this Institute. During the last three decades, the Institute has made commendable progress and achievements in evolving integrated management strategies for conservation of natural resources, and to ensure environmentally sound development in the entire Indian Himalayan Region (IHR). All the Directors and the faculty have greatly contributed to the Institute that is what is today. While remembering the contributions of all Directors of the Institute, I also wish to express my condolences for the recently demised Directors, Dr. R.S. Rawal and Dr. U. Dhar.

The Himalayas are the world's loftiest but youngest mountain ranges extending for over 2500 km from south of the Indus

Valley beyond Nanga Parbat (height 8114 m) in the west to Namcha Barwa (height 7755 m) in the east between 72^0 and 91^0 E and 36^0 N. The width of the Himalayas from south to north varies between 200 and 350 km. The altitude ranges from 300 m to 8849 m. Of the more than 110 peaks rising to elevations of 24,000 feet (7,300 m.), Mt. Everest is the world's highest, with an elevation of 8,849 m. The Himalayas evolved some 70 million years ago, during Upper cretaceous period due to Indo-Australian plate colliding with Eurasian plate (plate tectonics theory). It is presumed that the Indo-Australian plate is still moving at 67 mm/year resulting the Himalayas rising by about 5 mm/year, making them geologically active experiencing a high number of earthquakes and tremors. With the hitting of Indo-Australian Plate with Eurasian Plate, the Himalayas erupted by a gradual process of "Corrugation" from the hypothetical Tethys sea bed, the residue of which is Mediterranean Sea. Occurrence of sea fossils even on Mt. Everest is supportive of this view. Such weaker areas in continental landmass are geologically termed "faults"- sensitive areas for Earthquakes. The Himalayas are bordered to the northwest by the mountain ranges of the Hindu Kush and the Karakorum and to the north by the high and vast Plateau of Tibet. The Himalayan ranges are formed of four parallel longitudinal mountain belts. They are designated, from south to north, as the Outer or sub Himalayas (also called the Siwalik Range); the Lesser Himalayas; the Great Himalayas and the Tibetan Himalayas. Farther north lie the Trans-Himalayas or the Cold Deserts.

The climatic conditions and the floristic composition in the Himalaya are so varied that different bio-geographers have divided the Himalayan systems into three to four of five divisions (Clarke, 1889; Hooker, 1906; Chatterjee, 1940, 1962; Mani, 1974; Rodgers & Panwar, 1988). For the present discussion, I consider 3 regions namely, the West Himalaya (J & K; H. P.; Garhwal & Kumaon region), the East Himalaya (Arunachal Pradesh, Bhutan, Sikkim, Darjeeling district of West Bengal) and the Central Himalaya (Nepal). West Himalaya covers areas west of western Kumaon and differs from East Himalaya in greater breadth and length, higher altitude, scanty rainfall, heavy snowfall, cool and dry climate. The tree line in West Himalaya ca. 3600 m whereas in East Himalaya it is at 4600 m (beyond tree line is alpine zone). Above 5400 m is permanent snow.

The Phyto-geographical affinities of the Himalayan flora have been discussed by several workers (Meher-Homji, 1965; Gupta, 1962, 1964, 1982; Kanai, 1963; Hajra & Rao, 1990). It is well established that the European and Central Asian elements are frequent in areas west of the river Sutlej, while the Chinese elements extend from Yunnan in the east right through the East Himalayan ranges. In fact, the Himalayas have drawn floral elements from Mediterranean, Irano-Turanian, north African, Siberian and in the east Chinese and Malaysian elements. The present day Himalayan flora is related to the flora of northwestern and western China in the eastern sector while the Mediterranean elements become more numerous westward from Sikkim to Kashmir through Nepal, Kumaon and Garhwal region including Nanda Devi Biosphere Reserve. Temperate floristic elements are too many in Himalayas. Some of the conspicuous temperate elements in the Flora are *Anemone, Clematis, Thalictrum, Ranunculus, Caltha, Callianthemum, Sambucus, Trollius, Isopyrum, Aquilegia, Delphinium,*

Aconitum, Spiraea, Sedum, Cimicifuga, Paeonia, Berberis, Viola, Epimedium, Corydalis, Erigeron, Aster, Fumaria, Silene, Thermopsis, Trifolium, Oxytropis, Fragaria, Senecio, Saussurea, Lespedeza, Galium, Asperula, Valeriana, Brachyaster, Achillea, Tanacetum, Leontopodium, Anaphalis, Crepis, Taraxacum, Androsace, Lysimachia, Cichorium, Picris, Lithospermum, Arnebia, Pedicularis, Mentha, Thymus, Geum, Myosotis, Calamintha, Dracocephalum, Teucrium, Cheiranthus, Arabis, Parrya, Cardamine, Draba, Cochlearia, Eutrema, Braya, Saxifraga, Dianthus, Gypsophila, Cerastium, Arenaria, Parnassia, Stellaria, Agrimonia, Potentilla, Pleurospermum, Circaea and *Epilobium*. Similarly, the dominant Mediterranean floristic elements in the Himalaya are *Fagonia, Argyrolobium, Ononis, Eruca, Trifolium, Moricandia, Nerium, Ziziphus, Capsella, Chorispora, Trigonella, Eryngium, Celtis, Malcomia, Melilotus, Medicago, Colutea, Quercus, Viburnum, Cotinus, Alhagi, Hypecoum, Prosopis, Fraxinus, Prunus, Papaver, Cedrus, Diplotaxis, Rosa, Punica, Farsetia, Alyssum* and *Pyracantha*.

The Steppe Elements like *Megacarpaea, Eurotia, Axyris, Tauschia, Kochia, Euclidium, Morina, Cnicus, Perula, Hippophae, Guldenstaedtia, Myricaria, Astragalus, Juniperus, Scabiosa, Artemisia, Triplostegia, Eremurus, Dipsacus, Prangos* and *Hyoscyamus* are dominant in W. Himalaya. The Tropical Asiatic Elements like *Pittosporum, Phoebe, Saraca, Terminalia, Decaspermum, Oxyspora, Machilus, Litsea, Haldina, Uncaria, Hedyotis, Lasianthus, Eriobotrya, Kalanchoe, Willughbeia, Medinilla, Trachelospermum, Photinia, Gymnopetalum, Daphne, Pentanura, Pygeum, Myristica, Diospyros, Cinnamomum, Beilschmiedia* and *Jasminum* are dominant in East Himalaya at comparatively lower altitudes. There are also some genera of African origin and the occurrence of such plant genera in both Africa and India may be explained in one of two different ways - The genus may have a Gondwana origin; that is, it may have arisen before Africa and India got separated into distinct continents. What was once a contiguous range was broken into a widely disjunct distribution by continental drift; or the genus may be much younger, having arisen on one continent and subsequently established populations on the other by long-distance seed dispersal may be by migratory birds.

The Chinese mountains being much older in age (300 million years) compared to Himalaya have contributed significantly to the Himalayan flora. It is believed that during Tertiary period a common flora covered the whole of East Asia including Himalaya, China and Japan. The successive changes in climate and topography during Pleistocene period resulted in the separation of floras as well as resulting in bringing new elements and pushing some existing elements causing isolation and disjunct distribution of several taxa such as *Olea ferruginea, Berberis, Saxifraga, Monotropa, Polygala abyssinica, Micromeria biflora* and the Cedars. Some taxa having discontinuous or disjunct distribution in Himalaya are listed.

The Biogeography of Himalaya (distribution of floristic elements between West and East Himalaya) is quite fascinating but needs extensive and critical analysis of flora. The East Himalayan flora is more related to the Tropical humid Sino-Himalayan and Malayan flora while the West Himalayan flora has affinities with Eurasian flora. Several species of Western

Himalaya penetrate up to Kumaon or western border of Nepal but absent in E. Himalaya, i.e. *Pinus gerardiana, Juniperus macropoda and Picea smithiana.* The Steppe elements like Artemisia, Chenopodiaceae members, *Juniperus semiglobosa* and *J. turkestanica* are recorded from Nanga Parbat region. The species like occur in E. Himalaya but absent beyond E. Nepal. Again, Cedrus deodara distributed from Afghanistan to W. Himalaya extends to western Nepal and absent beyond this limit. *Primula sikkimensis, Magnolia campbelli,* many orchids, Rhododendrons and some palms of Eastern Himalaya extend their westward distribution as far as Kumaon. Therefore, the area east of Kumaon and west of Nepal between 830 and 840 E is a transition zone between the West and East Himalayan phytogeographic regions (Stearn, 1960), and still needs intensive and critical phytogeographic analysis. Regarding Gymnosperms as far as the number of species are concerned although Eastern Himalaya are far richer, there exist vast coniferous forests in the western Himalaya. *Pinus gerardiana, Juniperus macropoda* and *Picea smithiana* are some gymnosperms distributed in the northwest Himalaya but are absent in the eastern Himalaya. Similarly, the genus *Ephedra* is well represented in Western Himalaya with six species while only one species, *Ephedra gerardiana (somalata ?)* occurs in East Himalaya. On the other side, several species like *Larix griffithiana, Picea spinulosa, Cephalotaxus griffithii, Gnetum montanum, Cycas pectinata* and a few others found in east Himalaya are absent beyond east Nepal.

The forest types in Himalaya are so numerous and diverse that only some broad vegetation types can be outlined. The forests of the Himalaya are broadly classified as (1) the Montane tropical and subtropical forests up to elevation of 1200 m, (2) the Montane temperate vegetation from about 1700 to 2000-2500 m, and (3) the alpine vegetation stretching from 3000 to 4500 m. Depending upon the local climate, numerous subtypes of these forests have also developed. At the basal region of extreme western end, the vegetation is semi-arid with bushes of *Capparis, Calotropis* and *Stipa.* Subtropical conifer forests mostly of *Pinus roxburghii* (chir pine) often in pure formation occur in West Himalaya and *P. khasiana* in East Himalaya (often mixed with some broad leaved trees) are noticed at lower altitudes while the temperate conifer forests of *Abies, Cedrus, Picea* and *Taxus* at higher altitudes stretching from 3000 to 3500 m in West Himalaya are common. The wet temperate broad leaved forest around 2500–3000 m includes several typical temperate species like *Quercus, Rhododendron, Engelhardtia, Castanopsis,* etc., in moist areas. In the semi arid cold desert region of Ladakh and Lahaul-Spiti many stunted, cushion forming and gnarled shrubs of J*uniperus, Stachys tibetica, Caragana versicolor, Acantholimon lycopodioides, Thylacospermum caespitosum* and *Hippophae rhamnoides* are common.

The alpine zone in the Himalaya, particularly west Himalaya is the most fascinating feature of vegetation with enormous floral diversity. The alpine zone begins above the tree line, between elevations of 3,200 and 3,600 m. extending up to about 4,200 m in the west Himalaya and up to 4,500 m or more in the eastern Himalaya. The alpine vegetation of *Aconitum, Aquilegia, Astragalus, Cotoneaster, Rhododendron, Potentilla, Primula, Saxifraga* and several genera of Asteraceae are remarkable. Juniper (genus *Juniperus*) is widespread, especially on sunny sites, steep and rocky

slopes, and drier areas. The Rhododendron occurs scattered but is more abundant and conspicuous in the wetter parts of the eastern Himalaya. The mosses and lichens grow in shaded areas at lower levels in the alpine zone where humidity is high.

The alpine region is covered by heavy snow for almost 7-8 months in a year. The flora is mostly of herbaceous plants scattered in the meadows locally called Bugyals. Almost all the species are ephemerals - complete their life cycles in a week's time or 10 days. The flowers are highly brightly coloured to attract the scarce insect population in the region. A kind of floral rhythm can be observed in the alpine flora. Different species comes to bloom at different times in succession at regular intervals. This adaptation is again to use the services of scarce pollinators. Almost all plants of a given species come to bloom (gregariously) simultaneously forming a carpet of different colours. Compared to the overall size of the plant the flowers are much larger and conspicuous, another adaptation of alpine plants to attract the pollinators. **'The Valley of Flowers'** in Garhwal Himalaya is a typical Alpine flora and is considered as the botanical paradise in India.

The sub-alpine zone in W. Himalaya is also of high altitude type and support a large number of floral and faunal communities. Many of the species of the alpine zone are also found here. The dominant species of the zone are the Himalayan maple *Acer caesium,* west Himalayan fir *Abies pindrow,* Himalayan white birch *Betula utilis* and *Rhododendron campanulatum* with Himalayan yew *Taxus wallichiana, Syringa emodi* and *Sorbus lanata.* Some of the common herbs are *Arisaema jacquemontii, Boschniakia himalaica, Corydalis cashmeriana, Polemonium caerulium, Polygonum polystachyum, Impatiens sulcata, Geranium wallichianum, Galium aparine, Morina longifolia, Inula grandiflora, Anemone rivularis, Pedicularis pectinata, P. bicornuta, Primula denticulata* and *Trillidium govanianum.* Both alpine and sub alpine zones are sensitive to disturbance (fragile ecosystems).

Floristic diversity: Thanks to numerous plant taxonomists, the flora and vegetation of the Himalayas are fairly well known. Yet, the botanical surveys in this region are inadequate or incomplete. This is evident by the fact that hundreds of new taxa in all groups of plants are being discovered and described almost every year. The floristic diversity in the Himalaya is so rich and diverse that it is not possible to discuss in its entirety here nor it is required too. The Himalayas support a very rich biodiversity mainly due to the Strategic position having connection with adjacent rich floristic regions, vast stretch of geographic area, diverse habitats – dry deserts, cold deserts, alpine, temperate, tropical habitats, wetland areas, diverse ecological conditions (High rainfall area, coldest place on earth etc.), altitude varying from sea level to the highest mountain ranges of the world, Gondwana connection in the geologic past and the entire Himalaya forming an active speciation zone, where new species are being added regularly. The Himalayan bio-geographic zone is the richest and unique botanical region in India and encompasses a broad range of ecological habitats varying from grassy meadows to dense humid evergreen forests; disturbed secondary formations to almost virgin and relict types as in `Sacred Forests'. We find in this region a mixture of tropical, temperate and alpine forests each type depicting its own characteristic biodiversity. About 50% of total number of vascular plant species of India occur in this region which

includes nearly 30% of endemic taxa. This region being the `Sanctuary of Primitive Angiosperms' is considered as the 'Cradle of Flowering Plants' where many groups of angiosperms have originated and diversified (Takhtajan, 1969; Rao, 1994). Regarding the diversity in terms of number of taxa a total of 8765 taxa comprising 1912 genera and 210 families are reported from Himalayas (although bio-diversity is not just the game of numbers). Among this, the J&K region has 1649 species, Himachal Pradesh 2558, Uttarakhand 3846, Arunachal Pradesh 4079 (5500?) species. Asteraceae, Orchidaceae, Poaceae and Fabaceae are the most dominant families each having 1390, 1370, 1060, 960 taxa, respectively. However, no infra specific diversity is assessed, although a high number of ecotypes or populations are expected in the different altitudinal ranges of Himalaya. Such infra specific diversity is most needed for medicinal plants for their sustainable utilization.

Several families in the Himalaya show great floristic diversity both at species and infra specific level and are represented by more than 100 species. Some plants e.g. species of *Christolea, Arenaria, Thylacospermum, Acantholimon, Festuca* and *Juniperus* that occur especially in the high alpine meadows in cold desert regions of Trans-Himalaya survive the extreme adverse ecological conditions by special adaptations. Cushion forming plants include species of *Androsace* (Primulaceae), *Saxifraga* (Saxifragaceae), Rhodiola (Crassulaceae), *Thylacospermum* and *Arenaria* (Caryophyllaceae). Several hundred plants aggregate together to form a dense, spherical or globose cushion-like habit. Certainly this is an adaptation against severe cold and heavy snowfall during winters. One cushion of *Arenaria* or *Thylacospermum* measuring ca 30cm diam. takes as much as 100-150 years. Among the insectivorous plants *Nepenthes khasiana, Drosera burmannii, D. peltata, Utricularia* spp. are of significant interest. *Christolea himalayensis* is reported to be growing at 6300 m, which is the highest altitude known for a flowering plant in the world. On the other end of the spectrum there are some plants with unusual forms in the high alpine areas. These may be 'cushion forming' or 'snow ball' plants or the 'hot house' plants. The 'snow ball' plants, *Saussurea gossypiphora* and *S. graminifolia* (Asteraceae) look like a snow ball due to the dense, white woolly hairs which cover the entire plant and protect from cold wind and snow and keeps warm in day time even if outside temperature suddenly falls. Bees or flies take shelter in the warmth and at the same time pollinate the flowers. The dense woolly hairs that cover the apical meristem act as a sort of thermal insulation. There is yet, another interesting group of 'hot house' plants like the Rheum nobile and *Saussurea obvallata* which have their inflorescence sheltered by leafy bracts that can be compared to glasses of a 'hot house'. The flowers open inside the bracts, where the insects also take shelter for warmth and at the same time pollinate the flowers.

Endemism in the Himalayan Flora

The Himalayan flora is an admixture of floras drawn from the adjacent countries and mountains. Still, a large number, in fact ca 30% of the Himalayan flora is more or less endemic. A vast majority of the endemics are neo-endemics having originated in the Himalayas in the recent past. According to Chatterjee (1940) the endemic dicots in the Himalayan flora (including Nepal & Bhutan) are 3169 and about 1000 monocots. This is certainly a high number for a continental

area. The lofty Himalayan ranges not only act as a barrier against free migration of flora from surrounding countries/regions but also restrict the movement of Himalayan plants to the other regions in India. Eastern and Western Himalayas are two mega biodiversity regions of the World (Singh et al. 2015). Trans- Himalayas including Ladakh and Garhwal and Kumaon are the two micro endemic centres of Western Himalayas. The Sikkim Himalaya and Arunachal Pradesh are the two micro endemic centres in Eastern Himalaya. A total of 3160 endemic species recorded from entire Himalayas. About 71 genera are endemic to Himalayas. Five families - Tetracentraceae, Hamamelidaceae, Circaesteraceae, Butomaceae and Stachyuraceae are endemic to the Himalayas. Some families like Berberidaceae (77), Saxifragaceae (108), Ranunculaceae (131), Roasaceae (176), Apiaceae (144), Caryophyllaceae (79), Gentianaceae (84), Primulaceae (80), Lauraceae (78) in Himalaya show high percentage of endemics.

The Trans-Himalaya or the cold deserts of Himalaya: The cold deserts of Himalaya are arid areas not affected by the Indian monsoons as they lie in the rain-shadow of the Himalayan mountain systems. These hills experience snow. The mean annual rainfall is less than 50 mm only in the form of snowfall. Spread over an area of 74,809 sq. km, the cold desert of Himalaya covers Leh and Kargil districts of Ladakh in J&K; Lahaul and Spiti along with some parts of Chamba and Kinnaur districts of Himachal Pradesh. Some of the unique features of the cold desert flora are the (1) Cushion-forming habit: Perennial, short and study woody stem, deep root system, penetrating rock crevices and fissures. Stem heavily lignified, repeatedly branched, densely packed with leaves and flowers forming dense hemispheric cushion. This protects from strong wind action, strong thermal radiation, desiccating effect of air pressure and heavy snow layer (which may be of several feet thick). Characteristic species are *Thylacospermum caespitosum, Saxifraga* spp., *Androsace* spp., *Corydalis crassissima*, *Acantholimon lycopodioides,* and *Arenaria* spp. (2) The other typical habit is the diminutive or miniature habit which shows the miniature plants, highly reduced in size with a solitary but conspicuous flower. The underground tap root system is well developed, as long as 30 cm or more with a perennial rootstock. Some characteristic species: *Lancea tibetica, Pleurogyne brachyanthera, Gentiana thomsonii, Taraxacum bicolor, Corydalis boweri, C. crasissima, Saxifraga parva, Anemone imbricata, Brya sinensis, Microula tibetica, Saussurea* spp. (3) The bushy habit: Under this category the plants attain 30-50 cm or even more and form dense bushy habit with woody branches, e.g., *Caragana pygmaea, Ephedra gerardiana, Hippophae rhamnoides, Myricaria prostrata* and *Lonicera hispida.*

The Cold Desert flora of Himalaya show close affinities with the flora of Mediterranean region. The distribution of many species of Himalayan cold desert extends to surrounding regions like Tibet (Karakorum), Russia (Siberia) and other Mediterranean countries revealing perhaps their migration to Himalaya in the geologic past. The migration of species through long distance travelling birds cannot be over ruled. At the same time, through active speciation many endemics are also evolved. A high concentration of endemics is noticed in the cold desert region.

In the West Himalaya Tropical & Sub-tropical vegetation (1000-1800 m) consists of Moist mixed deciduous Shorea robusta (sal) forest up to an altitude of 1000m. Anogeissus latifolia is also common. The moist Deciduous forests: up to 1500 m. *Albizia procera, Haldinia cordifolia, Terminalia alata, Dalbergia sissoo, Bombax ceiba, Mallotus philippensis, Ougenia oojeinensis, Bauhinia vahlii, Dendrocalamus strictus* and *Holoptelia integrifolia* are the dominant species. Swamp vegetation: *Bischofia javanica, Salix tetrasperma, Carallia brachiata, Diospyros malabarica, Alstonia scholaris* and *Litsea monopetala.* The Sub-tropical pine forests are abundant between 1000-1800 m, predominantly of *Pinus roxburghii* (chir pine), often mixed with *Rhododendron arboreum.*

The Temperate forests occur between 1800-3000 m. Depending upon the species these could be broad leaved or conifer forests. The broad leaved temperate forests are mostly composed of *Quercus leucotrichophora, Q. semecarpifolia, Rhododendron arboreum, Lyonia ovalifolia,* and *Myrica sapida.* The broad leaved deciduous forests at comparatively drier regions are composed of *Aesculus indica, Acer cappadocicum, Carpinus viminea, Fraxinus micrantha, Ulmus villosa, Taxus wallichiana, Rosa webbiana, R. macrophylla, Berberis jaeschkeana,* and *B. pseudumbellata.* The Temperate conifer forests: (Between 2000-3000 m) *Cedrus deodara, Picea smithiana, Pinus wallichiana, Cupressus torulosa,* often conifer,-oak-rhododendron association. *Betula utilis - Abies spectabilis* association around 4000m marks the tree limit in W. Himalaya. Between 3500-5500 m we find in this region predominant Alpine vegetation mainly composed of *Cremanthodium arnicoides, Geranium himalayense, G. pratense, Heracleum candicans, Impatiens sulcata, Primula denticulata, Rumex nepalensis, Selinum wallichianum, Senecio laetus, Synotis kunthiana, Anaphalis nepalensis, A. royleana, Aconitum heterophyllum, A. balfourii, Aster diplostephioides, Bistorta affinis, B. vivipara, Corydalis spp., Potentilla microphylla, Arenaria kumaonensis, Saxifraga* spp., *Campanula aristata, Thalictrum alpinum, Oxytropis lapponica, Arenaria festucoides, Waldheimia tomentosa, Caragana versicolor, Stellaria decumbens, Viola biflora* and *Gentiana* spp. all scattered in the grasslands. **The Valley of Flowers**, a botanical paradise in Garhwal, Uttarakhand is a typical alpine zone.

Based on the dominance of species, the following vegetation types are also recognized in W. Himalaya. Deodar forests (1500-3200 m), mainly comprising of Cedrus deodara. Blue pine forests (2600-3600 m) of *Pinus wallichiana;* Mixed Coniferous forests (2800-3200 m) with species like *Cedrus deodara, Pinus wallichiana* and *Picea smithiana;* Birch forests (3000-4300 m) with *Betula utilis* (Bhoj patra), *Rhodendron campanulatum, Sorbus aucuparia;* Rhododendron scrubs, (3800-5000 m) comprising of *R. anthopogon, R. lepidotum and R. nivale;* Juniper scrubs (3400 – 5000 m) *Juniperus communis, J. indica, J. squamata;* Alpine scrubs (3400-5000 m) with *Rosa macrophylla, R. sericea, Spiraea canescens, Cotoneaster* sp., *Lonicera obovata, Ephedra gerardiana, Hippophae* sp., *Myrtama elegans;* Alpine meadows (bugyals) 3500-5500 m, *Geranium* sp., *Heracleum candicans, Impatiens sulcata, Primula macrophylla, Silene* sp., *Oxytropis* sp., *Corydalis* sp., and *Aconitum* sp., *Sausssurea* sp., *Kobresia* sp. and numerous others. Arctic Cold Desert vegetation

(4000-5500 m) predominantly of Lichens, Arenaria spp., *Anaphalis nepalensis, Carex nivalis, Corydalis violacea, Thylacospermum caespitosum, Stracheya tibetica, Lancea tibetica, Saxifraga* spp., *Rhodiola* spp., *Melica persica, Eriophyton rhomboideum, Hyssopus officinalis* and *Saussurea* sp.

The Himalayas are an abode of many life saving medicinal plants. The medicinal virtues of Himalayan plants was highlighted even in the great Indian Epic Ramayana – when Lord Hanuman was sent to Himalaya for collecting the life saving "Sanjeevani" plant for treating Lord Lakshman, the brother of Lord Rama who was fatally ill in the war between Lord Ram and demon king Ravana at present day Sri Lanka. Even today, the alpine meadows in the Himalaya hold innumerable "Sanjeevani – like" plants having miraculous effects for various ailments, which need to be properly identified, scientifically evaluated and global level products developed for human welfare. *Rhodiola* sp., a cold desert plant inhabiting very difficult and high altitudes is recently reported as the modern Sanjeevani plant by Leh based Defence Institute of High Altitude Research (DIHAR). *Rhodiola* (local name- Solo, ladakhi name) is a wonder plant that has immuno- modulatory, adaptogenic (adapted to difficult environment condition) and radio-protecting abilities due to presence of secondary metabolites and phytoactive compounds. The plant has also been found to have anti-depressant and appetizer properties. The herb can mitigate the effect of gamma radiation used in bombs in biochemical war fares. The adaptogenic qualities of the plant can help the soldiers in adjusting to the low pressure and low oxygen environment. Recently, this species was also mentioned in one of his talks by the Honorable Prime Minister of the Country suggesting that we should bring to light the use of the plant for human welfare. There are many such miraculous Sanjeevani-like plants awaiting our attention. If we are successful in identifying one species of that type the entire economy of the country gets boosted.

East Himalaya & North-East India

The East Himalaya & North-East Indian bio-geographic zone is the richest botanical province in the country with an enormous biodiversity of ancient lineage. The botanical highlights of East Himalaya and North-east India are (1) The highest rainfall zone located here. (2) Diverse habitats- Alpine, Temperate, Tropical, Cold desert, Wetlands, Fallows, etc. broadly under wet humid tropics. (3) Gateway for migration of floras from Tibet, China, Malaysia, Myanmar, Japan, etc. (4) A mega diversity region in India; ca 50% (i.e. 8,500 species) of total Indian angiosperm flora. (5) High rate of endemism (ca 4000 species of flowering plants). (6) Sanctuary of ancient and primitive angiosperms. (7) High diversity in orchids, rhododendrons, primulas, canes and bamboos, hedychiums, medicinal plants, ferns and fern-allies. (8) Genetic diversity in Musa, Citrus, Pyrus, Prunus, Curcuma, Oryza, grain legumes, etc. (9) Maximum ethnic diversity, local indigenous people intimately connected with and have influenced the flora. (10) Maximum habitat disturbance by way of shifting agriculture and developmental activities. (11) One of the three 'hot spot' zones in India as listed by IUCN. (12) Home of several botanical curiosities: *Nepenthes khasiana, Sapria himalayana, Mitrastemon yamamotoi* and *Rhopalocnemis phalloides.*

The East Himalaya & North East India also exhibit remarkable altitudinal

zonation of vegetaion. Here the Alpine zone occurs between 4000 – 5500 m with species of *Androsace, Saussurea, Sedum, Myricaria, Arenaria, Rhododendron, Corydalis, Primula, Lagotis, Pedicularis, Ephedra, Thylacospermum, Leontopodium* and *Saxifraga*. The Subalpine zone between 3000 – 4000 m with taxa like *Abies, Tsuga, Juniperus, Rhododendron, Gentiana, Rheum, Polygonum, Swertia, Potentilla* and *Carex*. The Temperate Zone lies between1800 – 3000 m with dominant taxa like *Quercus, Lithocarpus, Rubus, Castanopsis, Alnus, Michelia, Acer, Symplocos, Tsuga, Pyrus, Magnolia, Rhododendron, Populus, Prunus, Picea, Betula, Juniperus, Cassiope* and *Salix*. The subtropical zone 1000 – 1800 m with *Ficus, Pinus, Schima, Prunus, Engelhardtia, Wendlandia, Rubus, Osbeckia* and Tropical vegetation with *Dipterocarpus, Acrocarpus, Shorea, Mesua, Altingia, Tetrameles, Gynocardia, Knema, Duabanga, Oroxylum, Terminalia, Bombax, Bischofia, Albizia, Dysoxylum, Phoebe, Bauhinia* and *Syzygium*. However the floristic composition varies from place to place. The sacred groves in North-East India deserve a special mention. Most of these forests are temperate types and are today critically endangered. Sacred groves are a patch of forest left untouched/ undisturbed by the local inhabitants on religious myths or beliefs. Usually dedicated to a local deity, or a mother-Goddess who is supposed to preside over the grove and protect the people. The sacred groves in E. Himalaya provide shelter for a number of botanically curious species like *Taxus wallichiana* (solitary seed; highly medicinal), *Botrychium lanuginosum* (Grape-like globose sori - a fern), Helicia nilagirica (The only wild species of family Proteaceae in India), *Gnetum scandens* (Climbing gymnosperm with broad leaves and pendent fruits), *Paphiopedilum insigne* (Lady slipper orchid), *Anoectochilus sikkimensis* (Ground orchid with variegated leaves), *Exbucklandia populnea* (With heart shaped leaves & 4 ovate hood-like stipules- primitive plant), *Corylopsis himalayana* (With golden yellow drooping catkin-like spikes, primitive flowering plant), *Manglietia insignis* (With large white flowers, primitive flowering plant), *Epipogium roseum* (Pinkish white flowered orchid, a Saprophyte), *Balanophora dioica* (with cone-like inflorescence, Parasitic), *Monotropa uniflora* (With bluish white solitary nodding flowers, parasitic) and *Mitrastemon yamamotoi* (Cup-shaped capsules, parasitic).

The floristic diversity in some groups/ genera in East Himalaya is discussed. Of the ca.18500 species of flowering plants in India, East Himalayan region alone harbours roughly 50% of the total flora. Some 7500 plant species are estimated of which, roughly 2,000 (i.e. 36 per cent) are endemic. Out of about 315 flowering plant families in India more than 200 families are represented in this region. Many families, represented in India by a solitary genus with 1 or 2 species are represented in this region, e.g. Nepenthaceae, Turneraceae, Illiciaceae, Ruppiaceae, Siphonodontaceae, Tetracentraceae, and a few others (Rao and Murthy, 1990). Out of 3 genera and 36 species of Elaeocarpaceae in India 2 genera and 23 species are found in this region. The family Elaeagnaceae with 15 species in India is represented by 13 species in Eastern Himalaya. There are other interesting features of the flora worth mentioning. *Cycas pectinata,* a rare species occurs scattered in Kamrup. *Gnetum gnemon* is recorded from the Khasi, Jaintia and Naga hills. *Podocarpus nerifolius* also occurs in the Khasi hills. *Euryale ferox* with giant floating leaves has its distribution in several districts of Assam.

East Himalaya and North-east India share the maximum number of endemic species and other rare plants showing discontinuous distribution. Some such phytogeographically interesting species are *Uvaria lurida* (endemic), *Magnolia gustavi* (endemic), *Distylium indicum* (endemic), *Merrilliopanax cordifolia* (endemic), *Ardisia quinquangularis* (endemic), *A. rhynchophylla* (endemic), *Aphyllorchis vaginata* (endemic), *Hoya manipurensis* (endemic), *Eria barbata* (endemic), *Gastrodia exilis* (endemic), *Paphiopedilum insigne* (endemic), *Hedychium calcaratum* (endemic), *H. dekianum* (endemic), *Nepenthes khasiana* (endemic), *Nymphaea pygmaea* (Siberia, north China), *Magnolia lanuginosa* (Nepal) etc.

Discussing the orchid diversity, it is said that currently 1350 species of orchids are known from India, of which 960 species are known from E. Himalaya & NE India alone. While a majority of orchids are ornamentals, a few such as *Vanda tessellata* (Rasna) and *Flickingeria macraei* (Sanjeevani, Jeevanti), *Orchis latifolia* (Munjatak) which are mentioned in epic Rigveda, Atharveda, and Charaka Samhita as reputed medicinal plants. Orchids have cultural and religious significance too – *Rhynchostylis retusa* popularly known as kopoh phool is traditionally worn by women dancers during Bihu festival in Assam. The stems and pseudo bulbs of several species of orchids are used in Chinese traditional medicines. Orchids are well known for their showy and long lasting flowers and therefore highly priced.

Bamboo plays an important role in the economy of the region and is associated with the mankind since ancient times. Out of 18 genera and 130 species so far known in India 15 genera and 64 species are represented in eastern Himalaya. East Himalaya forms the centre of genetic diversity for the genera *Bambusa, Dendrocalamus, Arundinaria* and *Cephalostachyum.* However, the bamboo forest in the E. Himalaya are not a climax type but only a seral community coming up in jhum fallows of 40-50 years old after the original forests are felled.

Rhododendrons are also well known for their showy flowers, have great horticultural potential. (European nurseries are harvesting enormous profit). According to a recent report Mao et. al., 2017) there are 129 taxa (80 spp, 25 subsp & 27 vars.) of rhododendrons of which 119 taxa are recorded from Arunachal Pradesh only. Both shrubs and arborescent forms are reported. *Rhododendron nivale* is the smallest species (hardly 10 cm). All efforts should be made to multiply and bring them to some of our temperate botanic gardens.

Diversity in the genus Hedychium: The *genus Hedychium of the family Zingiberaceae* is another group of ornamental plants that can be directly introduced into our gardens. The fragrant flowers on terminal spikes have attractive white, yellow, orange, and red colours. There are ca 40 species in India. Of these 35 species occur in east Himalaya alone. From Arunachal Pradesh itself 18 species are reported.

Botanical Curiosities

Botanical curiosities in the Himalaya are many. There are some root parasites like *Sapria himalayana* of the family Rafflesiaceae. This recently discovered largest root parasite has attractive crimson flowers measures 35 cm across. Another root parasite of the family *Mitrastemon*

yamamotoi recently collected from Mawsmai forests is a polyendemic. There are many such interesting species.

The East Himalaya & North-East region is considered a 'cradle of flowering plants', which represents some of the primitive angiosperm families like Magnoliaceae, Degeneriaceae, Himantandraceae, Eupomatiaceae, Winteraceae, Trochodendraceae, Tetracentraceae and Lardizabalaceae. Some of the specific primitive genera include *Alnus, Aspidocarya, Betula, Decaisnea, Exbucklandia, Haematocarpus, Holboellia, Houttuynia, Magnolia, Pycnarrhena* and *Tetracentron.* Some important primitive flowering plants of E. Himalaya are listed in the Table below. Campbell's magnolia grows in the forests of the Himalaya from Nepal to SW China and Burma at altitudes of 2400-3000 m. Flowers are 13-20 cm across, with12-15 large white petals. *Magnolia cathcartii,* one of the most primitive species found in Eastern Himalayas, Bhutan, Assam, Sikkim, Myanmar, Vietnam, at altitudes of 1800-2700 m. This being a highly ornamental species is worthy of introduction to botanic gardens.

Endemics in the East Himalaya are also very high. Families like Orchidaceae, Ericaceae, Lauraceae, Balsaminaceae, Apiaceae, Rosaceae, Asteraceae,

Primitive Angiosperms of E. Himalaya & N. E. India

Name of species	Family	Distribution
Alcimandra cathcartii	Magnoliaceae	E. Himalaya, Assam
Magnolia campbellii	-do-	E. Himalaya, Manipur
M. gustavii	-do-	Assam
M. pealiana	-do-	Assam
Manglietia insignis	-do-	E. Himalaya, Meghalaya
Michelia champaca	-do-	E. Himalaya, Assam
Pachylarnax pleiocarpa	-do-	Assam, Nagaland
Paramichelia baillonii	-do-	Assam
Talauma hodgsonii	-do-	Sikkim, Assam
T. rabaniana	-do-	Assam
Illicium griffithii	Illiciaceae	Meghalaya
Kadsura heteroclita	Schisandraceae	E. Himalaya, Assam
Schisandra axillaris	-do-	Meghalaya

Tetracentron sinense var. himalense	Tetracentraceae	E. Himalaya
Euptelea pleiosperma	Eupteleaceae	Assam
Brasenia schreberi	Cabombaceae	Meghalaya
Aspidocarya uvifera	Menispermaceae	E. Himalaya
Haematocarpus thomsonii	-do-	Sikkim, Meghalaya
Pycnarrhena pleniflora	-do-	Assam
Decaisnea insignis	Lardizabalaceae	E. Himalaya, Assam
Holboellia latifolia	-do-	Meghalaya
Parvatia brunoniana	-do-	Assam
Stauntonia brunoniana	-do-	Assam
Altingia excelsa	Altingiaceae	Assam
Corylopsis himalayana	Hamamelidaceae	Meghalaya
Distylium indicum	-do-	Meghalaya
Exbucklandia populnea	-do-	E. Himalaya, Meghalaya
Houttuynia cordata	Piperaceae	Meghalaya
Myrica esculenta	Myricaceae	Assam
Alnus nepalensis	Betulaceae	Assam

Gentianaceae, each have 77, 29, 27, 22, 21, 20, 17, 16 endemic taxa, respectively. The East Himalaya is also known as a major genetic estate of several wild relatives of crop plants. The taxonomical and cytogenetic studies have revealed Assam-Burma-Siam-Indo-China region as the center of origin of Musa where enormous diversity is observed. Among the several endemics of the genus Musa in E. Hiamalaya many are recently described. Banana in north east India grows wild along the hilly slopes of Arunachal Pradesh, Meghalaya and Assam. The region is also rich in *Citrus* wealth with nearly 64 taxa of *Citrus* growing wild. Also, it is regarded as the center of origin for 5 species of palms of commerce – coconut, areca nut, palmyra palm, sugar palm and wild date palm. Diversity of wild relatives in cereals and millets, legumes, fruits, oil seeds,

vegetables, fibers, spices and condiments in West and East Himalaya are discussed.

However, what we know of the diversity in Himalaya is far less than what we do not know. In spite of hectic botanical explorations by Botanical Survey of India, and other National Institutes during the last 100 years, the diversity of Himalayan flora is yet to be fully assessed. Every year near about 200 species are being added by way of new discoveries in the country including Himalaya. The East Himalaya, particularly Arunachal Pradesh and other North-Eastern States need to be fully explored.

Himalayan bio-resources:

The biological resources in the Himalaya are so numerous and diverse that it is not possible to list all of them here in an article like this. Only a brief reference to some important ones can be made. In spite of the fact that Himalayas hold enormous diversity of highly potential species for economic development and possess high expertise of bio-technology coupled with excellent laboratory facilities, yet no global level products have emerged. Unless the bottlenecks in this direction are removed India cannot compete with other biodiversity rich nations in the region. The Himalayan region is well known as a major genetic estate for a number of economically important bio-resources. Some major ones are apart from the valuable timber, medicinal and aromatic plants, numerous wild edible plants, wild genetic resources of several cultivated plants like mango, apple, lime, banana, many pulses and hundreds of wild vegetables. However, some of these resources are fast dwindling in the region mainly due to anthropogenic disturbances. After the Rio Convention, all countries have realized that biodiversity rich nations are going to be the rich and powerful nations in the world in coming decades. But holding the rich biodiversity under lock and key alone will not make a country strong. We need to convert the biological wealth into economic wealth. This is only possible through intense bio-prospection and product development. Medicinal plants are one such group which can be directly utilized for product development. Some high value medicinal plants in the Himalayan region are *Saussurea costus* (kuth root), *Inula racemosa* (Poshkar root), *Aconitum heterophyllum* (Atees root), *Picrorhiza kurrooa* (kutkai root), *Dactylorhiza hatagirea* (Salam panja root), *Valeriana jatamansi* (Sugandhbala root), *Ephedra gerardiana* (Aasmani booti, Somlata stem), *Taxus wallichiana* (Birmi leaf), *Angelica glauca* (Chora root), *Juniperus communis* (Hauber hindi), *Artemisia maritima* (Seski herb), *Mucuna pruriens* (Kaunch beej), *Carum carvi* (Kalazira, Vilayatizira), *Bunium persicum* (Shingoo zira), *Cinnamomum tamala* (Tejpat leaf), *Celastrus paniculatus* (Malkangani seeds), *Bergenia ciliata* (Pakhanbhed rhizome), *Rheum emodi* (Revand chindi rhizome), *Dioscorea deltoidea* (Singli mingli tubers), *Podophyllum hexandrum* (Meda/Mahameda rhizome), *Berberis* spp. (Daruhaldi root), *Viola* spp. (Banfsha whole herb), and *Hedychium spicatum* (Kapur kachri rhizome). Botanically the genus Ginseng refers to a species of *Panax* of Araliaceae (Pan meaning all; akos meaning cure). This is considered as a tonic herb that helps to improve overall health and used for centuries to boost energy, sharpen mind, reduce stress, treat impotency and extend life. The true Ginseng refers to *Panax ginseng* that occurs in China and Korea; also known as Korean Ginseng. The Himalayan Ginseng or the Indian Ginseng refers to the *P. pseudoginseng* subsp. *himalaicus*. The medicinal potency lesser than the

true *Panax ginseng* and is believed to be a conglomerate of 5 different taxa. *Panax pseudo-ginseng* – a species of northeast India has great potential for development; highly invigorating and energy giving plant (Indian viagara). There is an urgent need to evaluate all the species of Ginseng in Himalaya and go for bio-prospection and product development. Some of the important ethnic medicinal plants of the East Himalayan region having great economic potential are *Aconitum ferox, A. heterophyllum* (Ranunculaceae), *Aquilaria khasiana, A. malaccensis* (Thymelaeaceae), *Bergenia ciliata* (Saxifragaceae), *Coptis teeta* (Ranunculaceae), *Cordyceps sinensis (Clavicipitaceae), Dendrobium nobile* (Orchidaceae), *Nardostachys jatamansi* (Valerianaceae), *Panax assamicus* (Araliaceae), *Paris polyphylla* (Liliaceae) and *Rubia manjith* (Rubiaceae). Among the wild cereals and millets *Avena barbata, A. fatua, Elymus dahuricus, E. nutans, Hordeum brevisubulatum* subsp. *nevskianum* and *Pennisetum orientale* are significant. Edible fruits like Berberis petiolaris, *Capparis spinosa, Cotoneaster falconeri, Ephedra gerardiana, Hippophae rhamnoides* subsp. *turkestanica, Malus baccata, Ribes alpestre, R. orientale, Myrica nagi, Rosa webbiana* and *Rubus saxatilis* are important. Other wild edible species of Himalaya include *Allium carolinianum, A. humile, A. jacquemontii, A. stoliczki, A. tuberosum, A. victorialis, Amaranthus cruentus, Bunium cylindricum, B. persicum, Carum carvi, Chaerophyllum acuminatum, C. villosum, Chenopodium album, C. botrys, C. foliosum, Cicer microphyllum, Elsholtzia densa, Eremurus himalaicus, Heracleum lanatum, Lactuca dolichophylla, Mentha longifolia, Milula spicata, Nepeta longibracteata, Oxyria digyna, Polygonum alpinum, P. polystachyum, P. viviparum, Rumex acetosa* and *R. nepalensis.*

There are a number of potential taxa for bio-prospection in Himalaya. *Thylacospermum, Acantholimon, Christolea, Eremurus, Caragana, Cicer jacquemontii, C. microphyllum* (wild Cicer) of trans-Himalaya have cold resistant genes for breeding purpose. *Aconitum, Berberis, Hyoscyamus, Alangium, Podophyllum, Taxus* have alkaloids of high value for drug development. Several species of *Chrysanthemum, Tagetes* and *Artemisia* have insecticidal properties.

There are innumerable wild ornamental plants of horticultural value. Several species of Orchids, Rhododendron, Primula, Lilies, etc. can be directly introduced to man-made settings and botanic gardens. The horticulturists and nurserymen have to play a great role in popularizing these species for our Indian gardens. For example, *Lilium mackliniae* (Sirohi lily) a very beautiful lily producing pale pink attractive, pendant bell- shaped flowers is critically endangered in Manipur. The plant is multiplied and sold in European nurseries. Why should we not encourage entrepreneurship in North-East India to multiply and distribute ornamental plants to all our Botanic Gardens as well as for export purpose?

Although Himalayan region is well established as a mega diversity region in the entire Indian sub-continent, the severe population pressure and changes in the socio-economic life styles of the peoples, and the so called economic development of the region have all posed a serious threat to the unique biodiversity of the region. Several hundred species are critically endangered and several unique habitats are severely threatened with extinction.

Threatened habitats are those areas which support unique species/ecosystems but have come on road to destruction or alteration due to human activities. Wetland systems, arid zone regions, cold desert areas, high altitude alpine areas, fresh water swamps, unique habitats of Nepenthes, Sapria, Sirhoi lily, etc are some examples. The Motharonwala swamp forest is a localized vegetation complex where water logging is a perennial feature. Tropical fresh water swamp forests represent the seral stages from open water to close forest canopy and lead to the development of tropical rain forest (Richards, 1966). Once formed a continuous chain from west to east the swamp vegetation is now represented by one patch in Kaziranga in the east and other patch in Doon valley in the west (hence living fossil community ?). Due to this indiscriminate and unscientific exploitation of swamp by the local people, the swamp has degraded in its unique biodiversity and aesthetic value. Major threats to these swamps are - unscientifically lopping of trees for fodder, illegal harvest of medicinal plants like *Centella asiatica, Bacopa monnieri,* bulk collection of edible plants like *Rorippa nasturtium-aquaticum,* and *Diplazium esculentum* and diverting the water source for agricultre purpose and above all the problem of pollution in recent times have posed serious threat to the unique swamps of Doon valley. The vegetation structure of this swamp is also changing resulting in more hardy, exotic and invasive species such as *Eupatorium adenophorum, Lantana camara* and *Parthenium hysterophorus.* Similarly, the sacred groves in the E. Himalaya are also much disturbed in recent years. Fast changing attitude of the local people towards sacred groves is a matter of grave concern. Their existence is a matter of time and doubt. Kanjilal and Das (1934) comment "It is a great pity that the black foot of destruction is already visible in some parts; the ultimate disappearance of these charming groves is therefore only a question of time". As the sacred groves act as "islands" of dense vegetation amidst disturbed ecology, the flora and fauna have no escape routes during disturbance. Hence the sacred forests can be termed as "Death Traps". Such sacred groves represent the remnants of past climax vegetation, they help in tracing the vegetation history and phytogeography of the area. They act as refuge of certain rare endangered and biologically interesting species. As beliefs attached to these sacred forests by the local people are fast dwindling, conservation of these sacred groves should be put on high priority. Where local beliefs have dwindled, the forest departments and state governments should come forward to protect these patches by enforcement of law. Educating local tribes about significance of such sacred groves for conservation may also greatly aid in the effective protection of these ancient 'Botanical treasures'. Since the evolution of biota within sacred groves is more or less hampered (due to island nature of these groves) a methodology may be thought of to get the different sacred groves connected by creating some biological corridors. All sacred forests must be treated as "Hot Spot areas" for immediate protection as they also act as 'death traps'. Therefore conservation of sacred groves must find high priority in conservation programmes.

Conserving and safeguarding of the rich biodiversity and their habitats therefore is not only essential but urgent. Discussing the major threats to biodiversity in the Himalayan region, it is said that (1) Ever increasing population growth, (2) Selective removal of specific groups of plants, (3) Extensive practice of shifting agriculture

by local people, particularly in East Himalaya, (4) Extension of townships, road construction on hills creating accessibility of remote areas, (5) 'Modernisation' leading to change of life style and cultural values of local people, (6) Free access and unregulated exploitation of bio-resources in the region (7) Tourists influx and their greed for collection of specific groups of ornamental plants (orchids, rhododendrons etc.), (8) Dependence of plant based industries solely on wild resources of biodiversity, (9) Unplanned economic up development of the people, (10) Spread of certain alien weeds such as *Ageratum conyzoides, Mikania micrantha, Parthenium hysterophorus, Eupatorium odoratum, E. adenophorum, E. riparium, Erigeron karvinskianaus, Galinsoga parviflora, G. ciliata and Lantana camara* and others endangering the native flora are said to be the major threats to the biodiversity sink of the region. The extinction of local populations due to the spread of alien weeds was recognized as early as 1872 by Darwin and Wallace (Darwin, 1872; Wallace, 1902). Although clear-cut assessments on biodiversity erosion in native taxa due to weed infestation are not available, it is quite logical to think that the very presence of these weeds over extensive areas, often in pure stands, indicates the elimination of substantial areas of native species. Although the spread of alien weeds depends to a large extent on disturbance of the native habitat, there are many instances that indicate that invasion of weeds like *Eupatorium, Mikania* and *Parthenium* can proceed even without continuing disturbance. Nevertheless, disturbed habitats are being created at a much faster pace than ever before in the Himalaya. Botanists should now assess the species that have become extinct or rare in different bio-geographic regions due to the spread of exotic weeds. Whether any species has become extinct or not, certainly several native species have been fragmented with extinction of populations leading to the loss of genetic diversity.

Loss of species from an area often attracts attention by botanists, but loss of genetic variability within a species (due to population extinction) often goes unnoticed as has occurred for the majority of native flora. The species fragmentation followed by decrease in population size has a deleterious effect on their survival. The loss of genetic diversity in a species reduces the ability of populations to adapt to changing environments and increase their susceptibility to pests and diseases and thus causes local extinction of the species. Some priority actions suggested for conservation of biodiversity are: completing inventories of the biodiversity, developing comprehensive databases that help in framing strategies for conservation, identifying priority sites or 'Hot Spots' for conservation, declaring 'sacred groves' as 'Death Traps' and provide protection, protecting the habitats of unique species like *Nepenthes khasiana, Sapria himalayana, Drosera* spp. etc., establishing gene-banks/ seed-banks of wild plants for long term preservation, and encouraging large scale cultivation of medicinal plants. Publishing the 'Red Bata Book' on Himalayan plants is also necessary. The reproductive biology study on critically endangered species is essential for identifying and for overcoming the 'bottleneck' in the life cycle, if any of the threatened species. Other priority areas suggested for documenting the entire biodiversity of Himalaya include developing coordinated programmes on all major groups for stock taking and identifying gaps, strengthening biodiversity collection centers (Herbaria), identifying areas needing further exploration following

coordinated multidisciplinary programmes, attempting infra-specific diversity in at least a few selected economic groups, developing distribution maps for all species, and finally developing consolidated Biodiversity Database.

In conclusion, it is emphasized that the Himalayas with their enormous natural resources are a real boon to the country. With such a vast flora having great potential for economic development and growing expertise in biotechnology and molecular biology, certainly India will emerge as a strong and powerful nation in the years to come. To realize this goal our priority agenda in the 21st century should be to identify the right bio-resource and convert the biological wealth into economic wealth following intense bio-prospection and global level product development.

Thank You all & Jai Hind

The author thanks Director, G.B. Pant Institute for the opportunity given to him to deliver the Pandit Govind Ballabh Pant Memorial lecture. Here and there some information is freely sourced for this article from the internet for which he is thankful to all the authors of such sources.

G.B. Pant Memorial Lectures

I	Dr. M.S. Swaminathan, Director, CRSARD, Madras - 1991
II	Dr. T.N. Khoshoo, Jawaharlal Nehru Fellow, TERI, New Delhi – 1992
III	Mr. V. Rajagopalan, Vice President, World Bank, Washington – 1993
IV	Prof. U.R. Rao, Member, Space Commission, New Delhi – 1994
V	Dr. S.Z. Qasim, Member, Planning Commission, New Delhi – 1995
VI	Prof. S.K. Joshi, Vikram Sarabhai Professor, JNCASR, Bangalore – 1996
VII	Prof. K.S. Valdiya, Bhatnagar Research Professor, JNCASR, Bangalore - 1997
VIII	Prof. V.K. Gaur, Distinguished Professor, IIA, Bangalore – 1998
IX	Prof. Y.H. Mohan Ram, INSA Senior Scientist, University of Delhi, New Delhi – 2000
X	Prof. J.S. Singh, Emeritus Professor, BHU, Varanasi – 2004
XI	Prof. Madhav Gadgil, Centre for Ecological Sciences, IISc, Bangalore – 2005
XII	Dr. S.S. Handa, Ex-Director, PRL (CSIR), Jammu – 2006
XIII	Dr. Lalji Singh, Director, CCMB, Hyderabad – 2007
XIV	Prof. Roddam Narasimha, Chairman, FMU, JNCASR, Bangalore – 2008
XV	Dr. R.S. Tolia, Chief Information Commissioner, Govt. of Uttarakhand, Dehradun – 2009
XVI	Prof. Raghavendra Gadagkar, CES & CCS, IISC, Bangalore – 2010
XVII	Prof. V. Nanjundiah, JNCASR, Bangalore – 2011
XVIII	Dr. Kirit S. Parikh, IRADe, New Delhi & Former Member Planning Commission – 2012
XIX	Prof. Jayanta Bandopadhyay, Former Prof. & Head, IIM, Calcutta – 2013
XX	Prof. T.S. Papola, Institute for Studies in Industrial Development, New Delhi - 2014
XXI	Dr. David Molden, Director General, ICIMOD, Nepal - 2015
XXII	Dr. Vijay Raghavan, Secretary, Department of Biotechnology, New Delhi - 2016
XXIII	Prof. S.P. Singh, Former Vice-Chancellor, HNB Garhwal University, Uttarakhand - 2017
XXIV	Prof. P.S. Roy, Former Director, Indian Institute of Remote Sensing, Dehradun – 2018
XXV	Prof. Raman Sukumar, Professor of Ecology, Indian Institute of Science, Bangalore – 2019
XXVI	Prof. Tej Pratap, Vice Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar - 2020