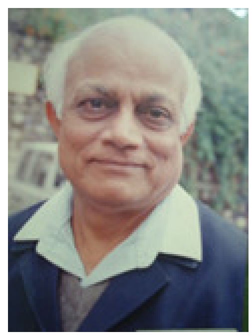
PANDIT GOVIND BALLABH PANT MEMORIAL LECTURER: IX

Plant Resources of the Indian Himalayan Region: Some Points for Action



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About Prof. H.Y. Mohan Ram

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Fellowships

Indian National Science Academy
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National Academy of Sciences (India)
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International Society of Plant Morphologists

Research Contributions

He has taught Economic Botany, Physiology and Tissue Culture at the University of Delhi for over four decades and has guided 32 research scholars in structural, developmental, reproductive and biotechnological areas of plant sciences. He has published over 220 papers and has edited four books.

One of the pioneering studies initiated by his team in the tissue culture of bamboo's, bananas and legumes has formed the basis of research work by several other groups in the country of crucial practical value are investigations of his group leading to the understanding of anatomy and enhancement of gum and gum resin yielding forest trees and their reproductive biology. The aspects are important towards efforts for employment generation, sustained yield and conservation of non timber forests products. In basic studies, the publications of Mohan Ram's group on control of flower development, post- harvest physiology of ornamental crops and control of flower sex expression, developmental biology of aquatic plans using in vitro culture (notably the Utricularia, Ceratophyllum, Limnophila, Neptunia, Trapa and Indian Podostomaceae) have been landmarks.

Professor Mohan Ram is a man of many parts. He has served the cause of science in India in a wide spectrum of roles-deucator, editor , producer of text- book and educational films, popularizer of science, promoter of talent and as a thinker and a planner. His inputs to the functioning of educational institutions, learned societies, academies and granting agencies are legion. Professor is also extremely knowledgeable about Indian classical music and cricket.

Position

INSA Senior Scientist (1996 onwards), Professor of Botany (1968-95), Reader in Botany (1961-68) and Lecturer in Botany (1953-58), University of Delhi, Delhi; Fulbright-Smith-Mundt Fellow, Cornell University, USA (1958-60), UNESCO Senior Fellow, CNRS, Gif-sur-Yvette, France (1970-71).

Pandit Govind Ballabh Pant Memorial Lecture

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I am beholden to the Chairman, Members of the Governing Body and the Director of the G.B. Pant Institute of Himalayan Environment and Development for inviting me to give this memorial lecture. Pandit Govind Ballabh Pant was a dedicated freedom fighter and a statesman, whose tireless efforts and administrative acumen in building modern India have been etched in golden letters in the history of this nation. It makes me specially happy to be delivering the lecture in the capital of this beautiful State described by the eminent Indian geologist D.N. Wadia (1957) as a "hanging valley" in his outstanding book "Geology of India".

INTRODUCTION

The prosperity of a country will depend on the judicious harnessing of its natural resources through the application of skills and value addition, keeping equity as a guiding principle. As solar energy converters and suppliers of food and a large number of useful products, plants have no equivalents. Yet the events of the past one generation have demonstrated the dangers of undoing what 65 million years of evolution has brought forth. Decimation of forests to meet the greed of the rich far above the needs of the poor, have seriously shrunk the natural areas which support, microbial, plant and animal wealth and from where all native agricultural crops have been selected. Biologists have emphasized that the long-term maintenance of the health of an ecosystem is the ultimate aim of sustainable development.

The reversal of the trend of over-exploitation calls for a proper understanding of the value of plant resources with special reference to the Himalayan region. The lofty Himalayan range, geologically one of the most recent, has had a tremendous impact on the climatic conditions of India and the neighboring countries and consequently their flora and fauna. In India all the great rivers of the north, excepting Narmada originate in the Himalaya and have provided water for navigation, fishing, drinking, sustaining forests and cultivated lands for millennia. The imposing grandeur, awe-inspiring beauty and availability of natural resources of the Himalaya have aroused great pots, artists and sages and have allured explorers from all parts of the world.

It is heart- breaking that commercial exploitation and overuse related with agricultural activities have denuded vast stretches of pristine forests causing loss of millions of tons of top soil, resulting in flash floods, silting of rivers, erosions of gullies and mountain strips. Acute shortage of water, feed for livestock, firewood for cooking and for keeping homes warm, and unavailability of minor timber and bamboo for implements have escalated unemployment, forcing the men-folk to leave their homes to seek jobs in the plains. The burden of women to care for the children and the aged compounded by the daily drudgery of gathering water and other necessities. Habitat destruction is irreversible. Restoration ecology has no easy solutions.

Among all the serious problems facing human kind today, the loss of biodiversity seems to be the most crucial. Biodiversity may be defined as the "variability among living organisms from all sources including, interalia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, and of ecosystems". India is a land of immense biodiversity in which two out of 18 got spots of the world are located (Nayar, 1996). India is one of the 12 megadiversity countries in the world with an estimated total of over 500,000 organisms, of which only a fifth have been recorded. Importantly, India is also one of the global centers of diversity of crops and domestic animals.

The total number of plant species of all groups recorded from India is ca 45,000 (the total may be closer to 60,000 as several parts of India are still to be botanically explored). Of there, seed- bearing plants accounts for nearly 17, 500 species. Nearly 81,000 species of the animals have been described. It is estimated that approximately 400,000 species of organisms may still exist in India and are yet to be described (Anonymous 1998)

The Indian Himalayan Region (IHR) (27^o 50'-30^o06' N and 72^o30'-97^o25'E) encompasses parts of Trans, North West Himalaya (Jammu and Kashmir, Himachal Pradesh), West Himalaya (Kumaun Garhwal), Central Himalaya (Sikkim, Darjeeling district of West Bengal) East Himalaya (Arunachal Pradesh) (Rodger & Panwar, 1988). In its action plan for Himalaya, the G.B. Pant Institute of Himalayan Environment and Development has included Assam, Meghalaya, Manipur, Nagaland, Mizoram and Tripura under East Himalaya. Thus IHR covers an area of 591,000km^2 and extends over 2800 km in length and 220-330 km in width with and attitudinal range of 300-8000m asl.

The 21 forest types in this region provide an enormous diversity of habitats, enabling the survival of a wide range of microbes, plants and animals (Singh & Singh, 1992).

In the second lecture delivered under this series, Dr. T.N. Khoshoo (1992) has given a comprehensive account of plant diversity in the Himalaya, emphasizing conservation and utilization. Since then several accounts dealing with the exploration, documentation and conservation of the IHR have appeared through the efforts of organizations such as the Botanical Survey of India, G.B. Pant Institute of Himalayan Environment and Development (Kosi Katarmal and its other centers), Institute of Himalayan Bioresources and Technology (Palampur) and individual scientists from the Universities.

A seminar on Plant Wealth of India, with special attention to plant human interactions in the Himalayan region was organized by the Indian National Science Academy in May, 1994, aptly at Gangtok. The papers presented have been published as a special issue of the Proceedings of the Indian National Science Academy (No.3, 63, 1997).

I would like to focus attention on certain economic plants of IHR such as bamboos and rattans, ornamental plants, and hosts of silk worms and suggests a few points for action.

DIVERSE PLANT RESOURCES

A large number of mountaineers came from various corners of the world obsessed with the spirit of adventure to scale the high peaks in the great Himalaya range and several lost their lives. Others thronged to the mountains to enjoy the floral splendor of the alpine meadows and valleys changing their hues from spring to autumn through summer (Valley of Flowers, Valley of the Gods). Some were avid collectors like Kingdon Ward (1938-56) and Ludlow and Sheriff (1939-41) (see Burkill, 1965; Vishnu Swarup, 1997).

Among the Himalayan flowering plants occurring at very high elevations, mention may be made of Stellaria decumbens (Caryophllaceae) at 6135 m. But A.F.R. Wollaston (1921) writing in *Mount Everest*, The *Reconnaissance* awards the honour to *Arenaria bryophylla* (Caryophyllaceae) at 6180 m (see Polunin & Stainton, 1984). However, the Guiness Book of Records (1984) lists *Christolea himalayensis* (Camb.) Jafri (Cruciferae) and *Ranunculus lobatus* Jacquem. (Ranunculaceae) as growing at an altitude of 6400m on Mt.Kamet (7756) as reported by N.D. Jayal.

The traditional systems of Indian medicine notable Ayurveda Siddha and Unani employ numerous herbal drugs. A very large number of Ayurvedic plants are collected from the wild in the Himalaya even from protected areas. The Regional Research Laboratory at Jammu has done commendable work on several drugs and Central Institute of Medicinal and Aromatic Plants at Lucknow and its stations are engaged in a wide range of research activities. Samant et al. (1998) have recently produced a thoroughly researched document ‘Medicinal Plants of Indian Himalaya: Diversity, Distribution and Potential Values’. This institute has also proposed to undertake a medicinal plant conservation programme with the support of DBT and in collaboration with the National Botanical Research Institute, Lucknow and the Botanical Survey of India.

The climatic conditions in several parts of the Himalaya are suitable for raising temperate commercial horticultural crops including fruits, flowers and vegetables. The various institutions of the ICAR, CSIR (notably Institute of Himalayan Bioresources & Technology, Palampur) are engaged in the cultivation, production and improvement aspects.

BAMBOOS AND RATTANS

Bamboos (giant grasses) and rattans (botanically palms and also called canes) are two prized groups of plants which have become inseparable from humans because of their wide distribution, versatility and multitudinous uses. Bamboos are an important feed for wild herbivores, provide materials for construction and articles of everyday use and of commerce.

Competing interests of the local requirements of forest dwellers, rural poor and artisans on the one hand and market forces for utility products and handicrafts on the other, have mounted an unprecedented demand on bamboos and rattans in recent times. Increasing needs are creating collection pressure on the natural stands and are posing a serious threat to their survival. Shifting cultivation, habitat destruction and over-exploitation for industrial needs at highly subsided rates have caused a large- scale elimination of their abundance and diversity. There is an urgent need to upgrade our knowledge with respect to their occurrence in the wild and under cultivation.

Considering the enormous value of bamboos and rattans for the developing countries of Asia, the International Development Research Center (IDRC), Canada has periodically organised workshops and conferences on various aspects of research and development(Lessard & Chouinard, 1980; Rao et al. 1985; Rao et al 1988; Williams & Rao, 1994;Rao & Rao, 1997). Recently Mohan Ram and Tandon (1997) have reviewed the diversity, uses and conservation aspects of Indian bamboos and rattans. Vivekanandan et al. (1998) has edited a document ' Bamboos and Rattan Genetic Resources in Certain Asian Countries'.

BAMBOO

Diversity

India has about 24 genera and 138 species of bamboos (Subramaniam, 1998) which occur naturally as understorey in many types of forests. In India 15.67% of the total forest cover including plantations is covered by bamboos yielding 4.5m tons per annum. About 58 species belonging to 16 genera are represented in Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Sikkim and Tripura in North Eastern part of India. *Dendrocalamus strictus* is the most widely distributed species and predominantly found in the dry deciduous forests all over India. *D. sikkimensis*, *D. hamiltonii* occur in Eastern India. The latter has been introduced to Himachal Pradesh. Bambusa bambos is pantropical and flourishes in moist mixed deciduous forests in several Indian states.

Bamboos show diversity in stature and form. Some are not larger than undershrubs with reed-like stems and others such as *Dinochloa andamanica* and *Schizostachyum* are slender climbers. A majority are characterised by woody stems, called culms, arising from underground rhizomes that may be monopodial(Melocanna and Phyllostachys) or sympodial (Bambusa and Dendrocalamus). These two are also classified as running and clump-forming classes of bamboos. Most bamboos have hollow internodes, although solitary stems are noted in *Thamnocalamus prainii*, *Oxytenanthera stocksii* and *Dendrocalamus strictus*.

On the basis of flowering, bamboos have been categorised into three broad groups (Brandis, 1899)- those that flower annually or nearly so (Indocalamus wightianus, Bambusa atra, Ochlandra sivagiriana); those that flower sporadically for irregualarly (*Chimonobambusa sp., Arundinaria falcata, B. tulda, Dendrocalamus giganteus, D. hamiltonii, D. longispathus*) and those that flower gregaiously at long intervals and exhibit synchronized production of seeds (Bambusa bambos, B.polymorpha, B. tulda, Ochlandra travencorica, D.stricturs). A majority of bamboos belong to the third category in which the intermast period may range from 3 to 120 years (Janzen, 1976). Bamboos of the last category generally die after gregarious flowering and production of an enormous quantity of seeds. The tribal lore and the forest records indicate a regular cycle of 48 ±2 years for *Bambusa tulda* and *Melocanna baccifera* in Mizoram (Mohan Ram & Hari Gopal, 1981).

A major handicap in the understanding of bamboo biology is lack of research on breeding systems operating in the individual species, compounded by long flowering cycles (John et al. 1995).

Non-availability of flowering material of bamboos is a serious problem for the taxonomists. Most of the new species are known by their vegetative parts like culm sheaths, juvenile shoots, microscopic and ultramicroscopic features of epidermal peels (Gaur 1987). Persistent investigations of the species that would involve recording of diversity in the morphology of the inflorescence and spikelets.

UTILITY

The strength of bamboo culms, their straightness, lightness, combined with hardness, lustrous finish, range of size, abundance, easy establishment and short-period in which they attain maturity, make them useful for numerous purposes.

The North Eastern states of India which share mountainous terrain and slopes of the extended Himalayan region are inhabited by over 60 major tribal communities. In the earlier days inaccessibility to these areas had influenced and preserved their lifestyle and creativity. Irrespective of their varied origin and language, bamboo utilization is common to all these people. Bamboos are used for construction of dwellings, bows and arrows, fish traps, baskets, food items, toys, handicrafts and musical instruments.

Bamboo finds abundant application in sericulture. It is also the raw material for the manufacture of incense sticks or ‘agarbattis’, ropes, fences mats, ladders and walk sticks. Strips of bamboos and rattans are the most common materials for wickerwork. The design, shape and size of the baskets depend upon utility and local knowledge. Carrying baskets represent excellence in aesthetics. The design and the style of the wickerwork products differ from tribe to tribe (Ranjan et al. 1986). Bamboos are in use as water conduits and piping material. People of Aunachal Pradesh and Mizoram use bamboos for collection and transporting rainwater to storage tanks. Bamboo mat boards (BMB) and bamboo composites are ecofriendly and can generate employment.

Paper is the most important bamboo product in use. Out of the 4.5m tonnes of annual output of bamboo in India, 1.8 million are utilized by pulping industries (Adkoli, 1991). In addition to paper, bamboo finds application in rayon and cellophane industries.

Young bamboo culm shoots are prized food material owing to their subtle flavor and crisp texture. Some of the bamboo delicacies include pickles and soups and vegetables made from young sprouts. Tender shoots of *Dendrocalamus strictus*, *D. hamlitonii, D.membranaceous* and *D. giganteus* are cooked as vegetables in India (Borthakur, 1996). The world’s best quality edible shoots are reported to be obtained from *Bambusa polymorpha* (Vivekanandan, 1987). Rice beer fermented in the culms of bamboos has its own appeal. Grains of bamboo are cooked as bamboo rice especially after mast seeding by the tribal in several parts of India. Fruits of *Melocanna* *bambusoides* are eaten raw or cooked. Bamboos have also enjoyed a considerable reputation in medicine.

Most bamboo species are excellent soil binders. They stabilize and enrich the soil by leaf litter. They are pioneer which colonize the jhumed (shifting cultivation) areas in Mehgalaya before secondary succession begins (Ramakrishanan, 1994). Bamboos also play a critical role in the nutrient management in shifting agriculture system of North Eastern India (Ramakrishnan, 1994). Rao and Ramakrishnan (1989) have demonstrated that N, P and K contents of species like Bambusa tulda, B. khasiana and Neohouzeana dulba are higher than those of other species in the community. Bamboos are preferred plant materials in afforestation programmes owing to easy establishment, fast growth rate and soil binding properties (Joshi et al. 1990).

RATTANS

Diversity

Rattans (family Arecaceae and sub-family Calamoideae) are palms with long, pliable and jointed stems. Rattans are most valuable for forest dwellers as they furnish raw materials of daily use, for arts and crafts and importantly livelihood.

There are over 600 species of rattans belonging to 13 genera (Williams & Roa, 1994). India is represented by 51 species of rattans belonging to 5 genera (Lakshmana, 1993). Whereas most of them belong to the genus Calamus growing wild in Assam, Sikkim, Arunachal pradesh, West Bengal, Karnataka, Kerala and Andaman and Nicobar group of Islands, two species *C. arborescence* and *C. ciliaris* have been introduced to India. Besides, Daemonorops (4spp.), Plectocomia (4 spp.), Korthalsia (2 Spp.), Hyrialepis (1 spp.) are also found in India.

Calamus species show a wide range of ecological adaptations. Morphologically, canes may be climbers, twiners or scramblers. They differ in length and thickness of the internodes. Differences in properties are observed from the base of the plant to the top. It is the intermediate portion which is more pliable and durable and finds extensive use in furniture work. It is the heterogeneity in the length and diameter of the internodes in combination with the differences in the density, moisture content, fiber length and fiber wall thickness that make rattans extremely useful material for various purposes. The final use depends upon the properties and method of processing the raw material.

Utility

At the international level export of raw rattan and rattan products are principally carried out by Indonesia, Malaysia, Philippines and Thailand. The most commonly used rattans in India are C. *rotang* and C. *latifolius*. Species such as C.*acanthospathus*, C.*guruba*, C. *latifolius*, C.*rotang, C. tenuis, C.rheedi*, C.*andamanicus* and *Plectocomia himalayana* find use in making furniture exclusively or in combination with bamboos. The latter include chairs, frames, seat mats, lamp shades, chicks and wall hangings. Cane are also employed in making basket, umbrella handles, walking sticks, batons used by army officers or conductors directing orchestras. Owing to their strength and resilience, rattans are used for making handles of hockey sticks and cricket bats. Fishing rods, polo sticks and javelin are also made from rattans.

Apart from their application in the manufacture of furniture, canes have gained importance as items of food and medicine. Tender stems *of C. rotang, C. erectus, C. floribundus and C. latifolius* are used as vegetables (Borthakur, 1996). Seeds of C. aractus and *C. extensus* are employed as substitutes for areca nut (Hajra & Chakraborty, 1981). Fresh fruits of C.latifolius, C. plygamus, C.longisetus and the fleshy mucilaginous sweet pulp of *C. rotang* are edible. Fruits of these species are often pickled.

Calamus oil extracted from the roots contains palmitic acid, is- eugenol, eraginol, calamine, calamol, etc and is uses in perfumery and for flavoring liqueurs (Anonymous 1992).

The dried root of C. rheedi is powered and applied to ulcers in Kerala. C. rotang is reported to have anti-tumour properties and is also useful in controlling biliousness and bleeding. The hard stem is often used as a vermifuge. Tender leaves of *C. travencoricus* are used in dyspepsia, biliousness and ear troubles.

Conservation of Bamboo and Rattans

Conservation methods and nursery techniques of bamboos differ markedly from those of agricultureal crops. Therefore, concerted efforts are needed to develop plantation of selected species (Williams & Rao, 1993). However, plantation should not be raised exclusively for pulp production. Species suitable for several other purposes should also be grown to sustain the small-scale industries. Improper harvesting methods, poor silvicultural practices are important factors resulting in shortages. Seedlings are often grazed and the natural seed bank is robbed by rodents after mast seedlings, leaving a negligible amount for regeneration. It is estimated that there is a potential of 2.75 million tonnes of annual production of bamboos from the natural resources, provided proper nursery techniques are employed Judicious thinning of culms is necessary for the growth and development of new culms (Sharma, 1980).

Natural regeneration of canes is very poor. Canes gatherers indiscriminately remove the immature plants along with the mature ones accounting for irreversible losses. Current local supplies are insufficient to sustain the domestic markets. This shortage has become acute at a time when the rattan industry is vastly expanding. Gross insufficiency in the supply of the raw material has affected the large manufacturing units which have closed down. The illegal drainage of raw material to the larger units has seriously threatened the smallscale industries located in the vicinity of the rattan resources.

An appropriate and integrated conservation approach is required to regenerate the natural stock of bamboos and rattans to ensure sustained availability. Both *ex situ* and *in situ* conservation strategies are needed to replenish the resources and to meet the mounting demands. Unlike bamboos which have faster rate of growth, commercial rattans required greater attention as the agro techniques are not well worked out.

The pattern of distribution of rattans in India is presently restricted to highly inaccessible areas. Concrete data on the natural distribution and affinities with the other components of the forests are not available. This information is needed for the protection of their habitat. Pollination biology, fruit set, seed storage and germination of rattans are yet to be investigated in detail.

Cultivation practices need improvisation at the nursery level. Species of *Calamus* are dioecious (Uhl & Dransfield, 1987). A continuous supply of seeds requires availability of both the male and female plants in the vicinity of plantation sites. Growth rates and appropriate harvestable age of commercial rattans are important aspects which need to be considered to assure timely extraction. Canopy management and light play an important role in the establishment of nursery seedlings (Uhl & Dransfield, 1987).

Conventional methods of propagation of bamboos include use of propagules such as rhizomes, suckers, culm cuttings and seeds (Anonymous 1988). Propagation by seed is the most convenient method because a single seed will result in a whole clump,that would yield several mature annually harvestable culms from the age of 4-7 years. However, as already explained, the availability of seeds is problematic as gregarious flowering in the commercially important bamboos occurs after long intervals of time followed by mast seeding and death of entire populations. Importantly, bulk of the seed is consumed by predators only a few seeds that escape have to restart a whole new generation of bamboos. This is dependent on the timely arrival of rains. Certain bamboos that flower sporadically may not always yield sufficient quantity of seed owing to sterility. Bamboo seeds are short- lived under natural conditions and lose viability after 6-8 months. Their viability can be substantially extended by storage at 4^{o} C in seed banks. It is therefore important to monitor the time and extent of flowering in the various states so that collection and transport of valuable seed material can be organized promptly. This requires an efficient networking of forests departments, NGO's and users. Bulk cold storage of bamboo seeds is necessary for large- scale planting in areas inside and outside forests. Ironically potatoes and several edible fruits have massive storage facilities. But tonnes of bamboos seeds so vital for the life support system of the rural poor and as sources of raw materials for industries are wasted away due to lack of storage and communication.

Propagation Through Tissue Culture

Tissue culture is advantageous over conventional methods of propagation. This ensures continuous supply of planting material, helps in conserving wild germplasm and in scaling up rare mutants for elite materials. A large number of plantlets can be raised in a short span of time. Tissue culture and shoot bud culture in bamboos would reduce the difficulty often encountered with the bulky offsets for transportation

Somatic embryogenesis and micropropagation from seeds, culm cuttings and rhizome are the most common *in vitro* methods employed (Mehta et al. 1982; Rao et al. 1988; Rout & Das, 1994; Mascarenhas et al. 1988; Saxena, 1990).

Reports on precious flowering of bamboos in aseptic cultures was a special achievement (Rao & Rao, 1990; Nadgauda et al. 1990;Chambers et al. 1991). Nadgauda and co- workers (1990) reported the induction of flowering in cultures of

Bambusa arundinacea and *Dendrocalamus brandisii* and also seed set *in vitro*. These authors had suggested that induction of flowering in bamboos would be useful for hybridization. If protocols for flowering can be standardized and repeatedly demonstrated, it would be possible to obtain flowers and seeds in off-season (Mohan Ram, 1994). There is expectation that if this work can be done using explants from selected mature plants, it could pave the way for improved breeding of bamboo stock, providing a perennial source of seeds. As most of the bamboo species are ployploid, it is yet to be examined whether test-tube flowering will fulfill the requirement on a scale that would be of commercial significance (Mohan Ram, 1994). It is pertinent to recall that bamboo hybrids have been obtained in vivo for the first time by Guangjhu and Fuiqiu (1987) through conventional procedures.

The need to raise large plantations of rattans can not be accomplished with the limited quantity of seeds. Although micropropagation offers an ideal alternative for preventing extraction form the wild and conservation of germplasm, the technique is yet to be fully exploited for rattans. Reports from India on micropropagation of rattans are scanty. Pioneering work on cane micropopagation has been done in the Philippines and Malaysia. Complete plantlet reported for *C. manillensis* (Patena et al. 1984) and *C. manan* (Yusoff, 1989). Initial attempts have been made to develop micropropagation protocols in *C. manan* (Gunawan & Yani, 1986; Gunawan 1989). There are problems in selecting suitable explants for the micropropagation of rattans. When the main shoot tip of the palm is used as an explant, it results in the total destruction of the mother plant. Juvenile shoots (internodes), and tender stems from selected canes must be tested for their performance. Therefore, research in this direction should be given high priority. *In vitro* studies on commercially important rattans should be taken up on priority basis.

Strategies for Augmenting Production

On the basis of the state of the art prepared by consulting various published accounts of experts, the following measures are suggested for increasing the productivity of bamboos and rattans in India (modified from Mohan Ram & Tandon, 1997; Mohan Ram 1998)

- To meet the needs of the tribals and rural poor and the requirements for the cottage level industries, cultivation of economically important bamboos must be taken up through programmes involving local communities, using indigenous technologies as well as improved and simple methods in suitable areas.
- Extraction of bamboos and rattans from the wild should be stopped.

- A National Centre for research on all aspects of bamboos and rattans should be set up. *
- With the availability of seeds after gregarious flowering, large quantities must be collected and kept in cold storage (4°C) and distributed to users for waste land development, agroforestry, social forestry, joint forest management programmes and for individual users and NGO's. Seeds of rare species and those that flower at long intervals need be stored in gene banks.

- For sustained supply at the local level, measured distribution of the raw material to the traders and firms must be organised. Co-ordination is required between the suppliers and manufacturing units so that irregularities created due to unexpected shortages of the supply do not create obstacles in the smooth running of export-oriented firms.
- Farmers should be kept aware through local language pamphlets about the recent techniques and species – dependent requirements under cultivation. Improvisation of the cultivation practices and standardization of nursery techniques should be carried out in different states.
- Establishment of the simple and inexpensive methods of preserving harvested raw material before transportation is needed to prevent losses during storage, as these materials are susceptible to pests, microbes and fungi.
- Factories and processing units should be located in the proximity of areas where bamboos and rattans are cultivated. This will solve the problem of long distance transportation.
- Plant tissue culture could be profitably applied to increase the planting material of choice bamboos, especially during periods when seeds are not available. Techniques for micropropagation of rattan need to be taken up on a priority basis.

ORNAMENTALS

There are excellent accounts of the flowers of the Himalaya, some with superb illustration. The subject is too vast to be covered in this lecture. The most well-represented group of flowering plants are the orchids about which several works have already been published.

According to Vishnu Swarup & Sharma (1967) may plant species, namely *Primula, Aconitum, Anemone, Agilegia, Aster, Bergenia, Campanula, Corydalis, Delphinium, Erigeron, Gentiana*, *Geum, Rhododendron, Sorbus, Viburnum* and orchids etc, were introduced from the Indian wild habitats into England, other European countries, USA and Japan. A few of them, like Blue poppy (*Meconopsis*), the climbing clematis (*Clematis montana*), many species of orchids, *Rhododendron, Primula, Balsam, Begnonia*, Fox- tail lily (*Eremurus himalaicus*),Gloriosa lily (*Gloriosa superba*), Musk rose (*Rosa moschata*), etc. are now widely grown in gardens abroad.

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* It is understood that a Bamboo Research Centre will be set upon the basis of the recommendation of All India Seminar on Bamboo development held in New Delhi from august 9 to 11, 1999

Rhododendrons

The genus Rhododendron has over 850 species distributed in the temperate northern hemisphere. Rhododendrons inhabit a vast section of southeastern Asia, stretching from the northwestern Himalaya through Nepal, Sikkim, eastern Tibet, Bhutan, Arunachal Pradesh, upper Myanmaar, western and central China. More than 90% of the world’s natural population of rhododendrons are from this region.

The species of Rhododendron are shrubs or trees with leaves in terminal rosettes bearing flowers of a wide range of colours, shapes and sizes. They are proverbially slow –growing and range in size from 5cm in the alpine zone to giants exceeding 25m in height. The craze for cultivation of rhododendrons, including azaleas of horticulture in the 19th Century Western Europe is comparable to tulipomania. Over 500 species have been cultivated in Great Britain alone. Concentrated efforts were made to introduce and hybridize particularly the Asiatic species by the wealthy and privileged (Mabberley, 1997). Over 1000 cultivars, mostly hybrids between American and Asiatic species are commercially available as potted plants and for planting as shrubs in gardens.

R. arboreum was introduced from India to Britain in 1815 (Vishnu Swarup, 1997). The history of the visit of J.D. Hooker (1817-1911) to India has been colourfully recorded by many, notably Rix (1981). J.D. Hooker, who is immortalised as the author of the Flora of British India (1872-1897), was persuaded by Dr. Falconer, Superintendent of the then Calcutta Botanic Garden, to travel to Sikkim – an un explored paradise for botanists. Arriving at Calcutta in 1848, J.D. Hooker visited Darjeeling and thence Sikkim. The book "Rhododendrons or Sikkim Himalaya" appeared between 1849 and 1851 with 30 folioplates drawn and lithographed by Fitch. Hooker introduced *R. thomsonii, R. falconeri, R. cinnabarium* and the subtropical *R. dalhousiae*, an epiphyte growing on the trunks of oaks and Magnolia cambelli to Britain where they became favorite garden plants (Rix, 1981). These species were followed by *R. edgeworthii, R. grande, and R.griffithianum* (Vishnu Swarup, 1997). The species from the Himalayas which were entirely different from those grown earlier in flower colour and form, foliage and stature, rapidly became popular in gardens. It was after Wilson, Forrest and Rock visited western China that the full impact of the wide spectrum of floral splendour of the genus was realized.

About 98% of the Indian species of Rhododendron are found in the Himalayan region, out of which 72% occur in Sikkim. The genus forms a dominant component of the cool temperate and sub- alpine forests and alpine meadows of the Sikkim Himalaya. Therefore, Sikkim is the most appropriate location for conservation and propagation studies of rhododendrons. Owing to several anthropogenic activities, the natural populations of Himalayan rhododendrons are rapidly dwindling. The major threats are deforestation, unsustainable extraction for fire wood and burning of twigs and leaves for incense by local people. These precious plants may be wiped out unless proper conservation measures are not taken immediately. Rhododendrons support a wide range of birds and butterflies. Therefore, employment of this genus as a key stone element in these high altitudes would substantially contribute to conservation of habitat biodiversity. Both conventional and biotechnological methods are urgently needed for conservation, propagation and restoration of rhododendron populations in the wild. These measures would require generation of baseline data on the present status of distribution and population sizes of the species, a thorough study of their reproductive biology, development of methods for mass propagation using conventional and tissue culture techniques, hardening the plants raised and establishment of a gene pool bank as has been recently initiated at Pangthang. Till now there has been no substantial effort on the estimation of the total number of species, sub species and varieties and this calls for both morphological and molecular characterization of the various categories. About 36 species with 45 different forms including subspecies and varieties of Sikkim Himalayan rhododendrons are presently in definite danger of elimination, unless immediate resurrection measures are made (Table 1). Some of the species have already become scarce, for example. R. *micromeres* is reported to have only 16 individuals. It may be symptomatic of a wider problem and more species may follow suit.

Table 1.Rarity of Rhododendron species in the Sikkim Himalaya

	Availability Space						
	Few	Extremely	Large	Ubiquitous	Localized	Extremely	
R. aeruginosum	*		*		*		Threatened
R. anthopogon			*				Threatened
R. arboreum			*	*			Vulnerable
R. baileyi	*					*	Threatened
R. barbatum	*			*			
R. camelliflorum	*				*		
R. campanulatum			*		*		
R. campylocarpum			*		*		
R. ciliatum	*					*	
R. cinnabarium	*				*		
R. dalhousiae	*			*			
R. decipiens	*					*	Threatened
R. edgeworthii	*			*			
R. falconeri			*	*			Threatened
R. fulgens		*			*		Rare
R.glaucophyllum	*				*		
R. grande			*	*			Threatened
R. griffithianum	*				*		
R. hodgsonii			*		*		
R. lanatum	*				*		
R. lepidotum	*				*		
R. leptocarpum		*				*	Very rare
R. lindleyi	*				*		

R. maddenii		*			*		Rare
R. nivale	*				*		Threatened
R. niveum		*				*	Very rare
R. pendulum		*			*		Rare
R. pumilum		*			*		Very rare
R. setosum			*		*		Threatened
R. sikkimense		*				*	Very rare
R. thomsonii			*		*		Vulnerable
R. triflorum	*				*		
R. vaccinioides	*			*			
R. virgatum	*				*		
R. wallichii		*			*		
R. wightii	*				*		Threatened

From: Baseline Assessment of Sikkim Himalayan Rhododendrons: A Report 1998- GBPIHED, Sikkim.

As rhododendrons are conducive to inter- generic crosses, a new scope of hybridization is open to be tapped to convert the aesthetics of rhododendrons into commercial advantage. Considering the different facets involved, conservation of rhododendrons may be pointed out as one of the prime concerns for the region.

Visits to Royal Botanical Gardens at Kew and Edinburgh and gardens in Berlin will impress a visitor about the rich living collections of rhododendrons preserved for posterity with great care. It is a matter of shame that at a time when rhododendrons have attained a high international trade, we neither have a national collection nor a programme for utilizing their horticultural potential in India. However, at least one professional commercial plant tissue culture unit in our country in engaged in the multiplication, hardening of a large numbers of rhododendrons imported under code numbers from Germany and re- exporting them.

A striking feature of the high alpine zone is the brief and fleeting growing season lasting just 10 or 11 weeks in which the plants have to complete their life cycle. The perennial bushes are completely covered by snow in winter and nearly all of the spring season. Himalayan alpine flora especially in the high reaches contains curious plants with unusual forms “cushions” “snow ball” and “ hot house” types. Remarkably these unusual forms belong to unrelated genera such as *Androsace* (Primulaceae), *Saxifraga* (Saxifragaceae), *Rhodiola* (Crassulaceae), *Thylacospermum* and *Arenaria* (Caryophyllaceae). The knowledge of the survival strategies of these plants should assist humans to learn the secrets of balance, productivity and sustainability and has references against which we compare areas which we have developed (Suzuki, 1996).

The Case Histories of Eremostachys and Nepenthes

Rao and Garg (1994) published a paper entitled “ Can *Eremostachys superba* be saved from extinction?” in Current Science. They were dismayed that only 24 individuals of the potential ornamental plant (with long panicles of beautiful yellow bilipped flowers of the family Labiatae) were surviving at a vulnerable spot along the highway in Mohand, near Dehra Dun. Rao sent seeds to Professor K. R. Shivanna of the University of Delhi for tissue culture. Sunnichan and Shivanna (1998) used the in vitro methods to clone the plants and succeeded in bringing them to flower in the Garden. In the meanwhile Koul et al. (1997) surveyed the floristic literature and noted that *E. superba* is reported from Domel in Jammu and Kangra in Himachal Pradesh. Visiting the former site they located a population of 400 plants were raised at Botanical Garden of the Jammu University.

The important lessons to be learnt from this story are genuine concern about losing a valuable species, immediate scientific attention to propagate it *in vitro* to prevent its extinction, a thorough search for natural population sizes and efforts to understand the breeding system. For each *Eremostachys* plant that has escaped the onslaught of humans, there may be several other species which may have been lost forever. In fact a thorough quantitative study must be taken up for establishing the conservation status using IUCN criteria for all the plants listed in the Red Data Books published from India.

It is important to record appreciation of the work carried out by Professor Pramod Tandon at NEHU, Shillong on the pitcher plant. In insectivorous plants belonging the Cephalotaceae, Sarraceniaceae and Nepenthaceae, leaves are modified into pitcher (in Cephalotus only some leaves take part in pitcher- formation) of various sizes and colours but nearly all of them have a lid. The edge of the pitcher is curved inward and has numerous honey glands (extra floral nectaries) at the entrance. There are other glands for some distance below it. Insects attracted by the honey or the bright colour of the pitcher feed on the secretions of the glands and as they move downwards slip and get drowned in the water. The plant absorbs the products of their decomposition. Whereas Malayasia has 21 species of Nepenthes in especially in *Mt. Kinabalu*, there is only one species of Nepenthes in India, namely *N. khasiana* in a few Northeastern States. Due to over collection by botanist and horticulturist, N.khasiana is placed on the endangered list Tandon has done excellent work on the micropropagation of this insectivorous plant and has also succeded in re- introducing the regenerated plants into the field. Tandon's work has been subsequently adopted at the Tropical Botanical Garden and Research Institute. Pacha Palode, Kerala, for large- scale multiplication, hardening and successful establishment in pots and gardens. Many species of pitcher plants have been cultivated as ornamental plants and are sold in Europe and North America. There is thus much scope for multiplication of botanical curios for sale in international markets.

PLANTS AS HOSTS OF SILKWORMS

Sericulture in India is an important agro and forestry based cottage industry in which over 6 millions people are engaged. India is the second largest silk producer (14% of world production) after China. India is the only country in the world which has four types of silkworms – each producing a unique quality of yarn of its own although there is diversity within each type. Nearly 90% of Indian Silk is "mori silk" produced by Silkworm *Bombax mori* which feeds on mulberrry (*Morus spp.*) leaves. Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal accoutn for the bulk production, although Kashmir has much scope as it provides conditions similar to some silk- producing regions in temperate China.

The primary food plants of tropical tasar worm (Antheraea mylitta) are Terminalia tomentosa and T. arjuna. The secondary hosts are Shorea robusta, Zizyphus mauritiana, Hardwickia binata, Parkia biglandulosa, Dichrostachys cineria that occur in Central India, Bihar and adjacent states. However, the temperate tasar silkworm (mainly A. proylei) feeds on the leaves of *Quercus incana, Q. semecarpifolia, Q. dentata, Q. serrata and Q. himalayana* in the sub-montane forests. The temperate silk is also called the oak silk. Demands for timber, firewood and fodder are causing a marked reduction in the availability of these plants in the Himalayan region for the value-added products of tasar silk. Conservation measures are necessary for oaks. Eri silkworm (Philosamia sp. Which is a polyphagus moth), is raised on castor been leaves. It has been recently shown that the quality that the quality of eri silkworm improves if the larvae fed on castor bean leaves are subsequently fed on Ailanthus excelsa (Maharuk) leaves and not vice-versa. Tapioca leaves can also be used to feed the eri moths. The eri cocoons are not suitable for filature and therefore cannot be woven on large looms but are suitable for preparing mats, coarse material, towelling etc.. The pupae are eaten as a source of high protein.

Muga silk which is unique on account of its golden yellow fibers is exclusively Indian, the moths occurring only in the north-eastern states. The primary hosts of the muga silk moth are saulu (*Litsea monopetala*), som (*Machilus bombycina*) and champak for titasopa (*Michelia champaca*). Secondary hosts include majankari (*Litsea citrata*), dijloti (*L. salicifolia*), kathalua (L. *nitida*), perarichawa (*Actinodaphne angustifolia*, a. *ovata*) and bajarmani (*Zanthozylum limonella*). There is high local and foreign demand for muga silk. However, the production is as low as 60m tonnes per annum. The non-mulberry silkworms are not domesticated and have to be collected from the wild by the tribals. There are gaps in our knowledge about the genotypes of the plants which are suitable for high yield or quality yarn.

The Department of Biotechnology (DBT), Government of India has been championing the cause of non –mulberry silk in collaboration with the Central Silk Board and has supported projects to understand the genes that regulate fibroin and sericin synthesis by the larvae. The DBT has also proposed to set up a conservatory in Meghalaya under the Bioresources Development centre for rearing silk moths that are commercially used as well as their wild relatives on a wide range of host plants.

EPILOGUE

I was deeply moved by reading the Seventh Memorial lecture in this series by Prof. K.S. Valdiya (1997), whom I respect as a friend, humane scientist and a distinguished son of the Himalaya. I share his concerns and commitment. I was not privileged to belong to Himalaya. But Himalaya and Ganga belong to all Indians. It is our responsibility to view development as people matter and commit ourselves to conservation and restoration ecology of the Himalaya and provide the basic necessities, dignity and pride to the inhabitants. The mountain folk have traditionally led simple lives deriving peace and beauty from the majestic mountains, clean air, clear springs and beautiful flowers. They deserve our deep concern and honest support.

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