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Conservation of Floral Biodiversity of Himalayan Mountain Regions with Special Reference to Orchids

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Abstract

India is one of the largest reservoirs of orchid genetic resource in the world. But this genetic wealth of the country is vanishing at an alarming rate due to destruction, degradation, and shrinkage of natural habitats. There is immediate need to take up various conservation measures on scientific lines so that these genetic resources of orchids are conserved for utilization in future.

If benevolence is a part of nature then the trees are its hallmarks. Biodiversity or biological diversity is a term used to describe the variety of life on Earth. It refers to the wide variety of ecosystems and living organisms: animals, plants, their habits and habitats and their genes. Biodiversity is the foundation of life on Earth. It is crucial for the functioning of ecosystems that provide us with products and services without which we could not live. Oxygen, food, freshwater, fertile soil, medicines, shelter, protection from storms and floods, stable climate, and recreation – all have their source in nature and healthy ecosystems. But biodiversity gives us much more than this. We depend on it for our security and health; it strongly affects our social relations and gives us freedom and choice.

Biodiversity is extremely complex, dynamic, and varied like no other feature of the Earth. Its innumerable plants, animals, and microbes physically and chemically unite the atmosphere (the mixture of gases around the Earth), geosphere (the solid part of the Earth), and hydrosphere (the Earth's water, ice, and water vapor) into one environmental system which makes it possible for millions of species, including people, to exist. At the same time, no other feature of the Earth has been so dramatically influenced by man's activities. By changing biodiversity, we strongly affect human well-being and the well-being of every other living creature.

The word Himalaya literally means 'Abode of Snow'. Himalaya separates the Indian subcontinent from Tibetan Plateau. The

Himalayan mountain system is the Earth's highest and home of the world's highest peaks. The main Himalayan range runs west to east from Indus river valley to Brahmaputra river valley forming an arc 2400 km long which varies in width from 400 km in the western (Kashmir-Xinjiang) region to 150 km in eastern Tibet – Arunachal Pradesh region. The climate of this region varies from tropical at the base of the mountain to permanent ice and snow at highest elevation. The amount of yearly rainfall increases from west to east along the front range. The diversity of climate in terms of altitude, temperature, relative humidity, rainfall, wind velocity, sunshine, and soil conditions have led to evolve a variety of distinct plant and animal species.

Global scenario of biodiversity

More than 1800 Botanical Gardens and arboreta are situated in about 148 countries, which together keep more than 4 million living plants belonging to more than 80,000 species of vascular plants. Thus, the Botanical Gardens and other plant conservation centers in the world play a very crucial role as centers for rescue, recovery, and rehabilitation of rare, endangered, and extinction prone species of plants and other valuable plant genetic resources.

The Botanical Gardens also play an important role in education and as a center of training in areas such as horticulture, gardening, landscaping, ex-situ conservation, and environmental awareness. It is estimated that nearly 10,000 species of plants are found in the Himalayan region of which about 3160

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are endemic as are 71 genera. Furthermore, five plant families are endemic to the region: Tetracentraceae, Hamamelidaceae, Circaesteraceae, Butomaceae, and Stachyuraceae. The largest family of flowering plants in the hot-spot is Orchidaceae with nearly 800 species. The Eastern Himalaya is also the center of diversity for several widely distributed plant taxa such as Rhododendron, Primula, and Pedicularis (see box on facing page).

Orchids

Orchids are distinctive plants and highly priced in the international florist trade due to their intricately designed spectacular flowers, brilliant colors, delightful appearance, myriads of sizes, shapes, structures, forms, and long-lasting qualities (Fig. 1). This majesty of nature represents the most highly evolved family Orchidaceae, among monocotyledons. Orchid cut flowers

Figure 1. Orchids valued for spectacular flowers.

Horticultural plants grown in Himalayan regions

Flowering trees: Azalea (*Azalea* spp.), *burans* (*Rhododendron* spp.), camellia (*Camellia* spp.), magnolia (*Magnolia* spp.), *ritha* (*Sapindus mukorossi*), robinia (*Robinia pseudo acacia*), *panger* (*Aesculus indica*), maple (*Acer* spp.), oak (*Quercus* spp.), etc.

Ornamental foliage trees: Birch (*Betula*), cypresses (*surai*), buckeye (*Aesculus* spp.), deodar (*Cedrus deodara*), *chenar* (*Platanus* spp.), elm (*Ulmus*), juniper (*Juniperus* spp.), *chilgoza* (*Pinus gerardiana*), pine (*Pinus* spp.), poplar (*Populus* spp.), thuja (*Thuja* spp.), weeping willow (*Salix* spp.), etc.

Flowering shrubs: Azalea, camellia, damask rose, Edouard rose, fuchsia, geranium, hydrangea, lantana, *Stephnandra incisa* (April plant/pseudo rose plant), shrimp plant (*Beloperone guttata*), *Spirea* spp., *Vinca,* etc.

Ornamental foliage shrubs: Cypresses (*surai*), *panger* (*Aesculus indica*), juniper, thuja, etc.

Flowering climbers: *Abutilon megapotamicum*, *Abutilon vitifolium*, *Californica*, *Canothus*, *Chaenomeles*, *Chaenomeles speciosa*, *Chimonanthus fragrans*, clematis, climber rose, cotoneaster, *Cytisus battandieri*, *Forsythia suspansa*, *Fremontodendron*, honeysuckle (*Lonicera japonica*), hop (*Humulus lupulus*), *Imprepps*, ipomoea, japonica, *Pyracantha*, passion flower, rambler rose, *Solanum crispum speciosa*, *Wisteria sinensis*, etc.

Ornamental foliage climbers: Asparagus, *Hedera helix,* hop (*Humulus lupulus*), etc.

Bulbous plants (perennial herbaceous/annuals):

Corms: Gladiolus, *Crocosmia*, *Crocus* spp., freesia, etc.
Bulbs: Amaryllis, daffodil, tiger/torch lily, lily, narcissus, tulip, anemone, gloxinia, primula
Rhizomes: Iris, *Sterlitzia* (*The Bird of Paradise*), orchids, etc.
Tuberous roots/stems: Begonia (tuberous begonia), caladium, cyclamen, dahlia

Suckers: Chrysanthemum, coreopsis (*Calliopsis*)

Medicinal plants: *Aloe vera*, ephedra, *kala jeera/shahi jeera* (*Carum carvi*), *Chrysanthemum* spp., coreopsis, *Mentha*, seabuckthorn

Succulents: *Argyroderma delaetii*, crassula, *Echeveria potosina*, *Sedum morganianum*

Annual flowering plants: Acroclinum, antirrhinum, calendula, California poppy, carnation, chrysanthemum, cineraria, cocks' comb, coreopsis (*Calliopsis*), cosmos, daisy, dianthus, *Dimorphotheca*, *Digitalis purpurea*, *Gazania*, gaillardia, *Godetia*, golden rod (*Solidago canadensis)*, *Helichrysum*, hollyhock, ice flower, *Kochia*, larkspur, *Linaria*, *Linum*, lupine, marigold (African and French), *Mimulus*, nasturtium, *Nemesia*, pansy, petunia, poppy, salvia, phlox, primrose, silk weed (*Asclepias physocarpa*), sweet pea, sweet william, stock, *Torenia*, *Venedum*, verbena, wallflower, zinnia, etc.

have taken a prime position in the international market and have immensely contributed to the economy of several developed and developing countries.

India is one of the largest reservoirs of orchid genetic resource in the world. But this genetic wealth of the country is vanishing at an alarming rate due to destruction, degradation, and shrinkage of natural habitats. There is immediate need to undertake various conservation measures on scientific lines so that these genetic resources of orchids are conserved for utilization in future. Orchids are commercially grown for cut flowers and ornamental potted plants.

The family Orchidaceae comprises 18500 species of orchids in 788 genera constituting the second largest family of flowering plants in the world. India alone has contributed 1229 species in 184 genera and many more are discovered year after year. India accounts for nearly 7% of total genetic diversity of orchids in the world. The distribution pattern reveals five major phyto-geographical regions namely – Eastern India, Eastern Himalaya, Western Himalaya, Peninsular region, and Andaman and Nicobar Islands. The genus *Dendrobium* with 104 known species constitutes the largest genus of orchids in India. The three genera *Jejosephia*, *Smithsonia*, and *Xenikophyton* and 352 species are endemic to the country. A number of species are near endemic, i.e., extending their distribution only to neighboring countries.

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Orchid habitat

Orchids are herbaceous perennials with wide range of habit and habitat. They can be found on trees and rocks, humus-rich forest floors, humus-rich moist forest floors, forest borders, grassy/gravely slopes, and embankments in shaded, semi-shaded, exposed habitats. They can grow on soil (terrestrials), on other plants (epiphytes), on rocks (lithophytes), and marshy land. As per their distribution they have been broadly classified into tropical, subtropical, and temperate. Some orchids have wide range of occurrence (cosmopolitan), while others are very specific to a particular locality (endemic). Orchids have very wide range of distribution in India (Tables 1 and 2). They have been recorded from low-level plains to an elevation of 4300 m.

Orchidarium

An orchidarium (orchid house/shade house) (Fig. 2) is a structure that provides optimum environmental conditions, viz., temperature, humidity, light, and air circulation, for growth and flowering of orchids. It also provides 50–60% shade to the plants with diffused sunlight and fresh air by covering the top with shade-net.

Figure 2. Orchids grown in an orchidarium.

Table 1. Distribution of orchid genetic resources in different phyto-geographical regions of India.

Phyto-geographical regions	No. of species
Peninsular Region	250
Eastern India	130
Eastern Himalaya	650
Western Himalaya	250
Andaman and Nicobar Islands	80
Central India and Gangetic Plains	60
Western Ghats	5

Table 2. Distribution of commercially potential orchids in India.

Eastern India	Western India	Southern and Central India	Andaman Nicobar Islands
Aerides	*Aerides*	*Aerides*	*Aerides*
Arundina	*Bulbophyllum*	*Calanthe*	*Bulbophyllum*
Bulbophyllum	*Calanthe*	*Coelogyne*	*Cymbidium*
Calanthe	*Coelogyne*	*Cymbidium*	*Dendrobium*
Coelogyne	*Cymbidium*	*Dendrobium*	*Phalaenopsis*
Cymbidium	*Cypripedium*	*Rhynchostylis*	*Pholidota*
Cypripedium	*Dactylorhiza*	*Vanda*	*Rhynchostylis*
Dendrobium	*Dendrobium*	*Vanilla*	*Vanda*
Gastrochilus	*Goodyera*		*Vanilla*
Goodyera	*Rhynchostylis*		
Paphiopedilum	*Vanda*		
Phaius			
Phalaenopsis			
Pholidota			
Rhynchostylis			
Vanda			
Vanilla			

Loss/erosion of orchid biodiversity

Orchids in their natural habitat are highly vulnerable to loss or erosion. The vulnerability to erosion seems from two sources: the first being their highly specialized life cycle – mode of living, dependency on pollinators for pollination, lack of reserved food material in the seed, and reliance on mycorrhizal fungi for seed germination; and second, ornamental and therapeutic value that they possess has made man interested in them. Each species is adapted to live in a specialized environment because of their specialized requirements and many species are very restricted in distribution. Any destruction, degradation, or defragmentation of natural habitat beyond a tolerable limit causes threat for their survival. It is estimated that nearly 250 species of native orchids are under the threats of various categories. Certain species like *Aphyllorchis gollaoii*, *Coelogyne truetleri*, *Anoectochilus rotandifolius*, *Paphiopedilum charlsworthii*, *Paphiopedilum wardii*, *Vanda wightiana*, *Pleione lagenaria*, and *Zeuxine pulchra* probably have vanished from Indian lands. Of the known 1229 species of Indian orchids, 352 are endemic of which 40 are "endangered" and 72 are "vulnerable". These endemic species are exclusive biological capital of the country; once lost or become extinct, it is an irrecoverable loss as biodiversity is the sovereign right of the country as per Convention of Biodiversity. Many plants are often lost due to poor cultural conditions, indifferent housing, changing and often inexperienced staff, and a shortage of funds for the care and maintenance of plants. For maintaining live collections, provenance field data is required to establish and maintain the plants in the most suitable way. The problems that are likely to be confronted in maintaining live collections could be conjectured by their specialized life cycle, distribution, and mode of living. There is urgent need for development of agro-technique for each species to be conserved in field gene banks. Unlike other flowering plants they have complex life cycle and specific requirement for temperature, light, nutrient, etc. for proper growth and development. It would be difficult to maintain the germplasm at one place until the center is equipped with environmentally controlled glasshouses and the targeted orchids are studied for their climatic requirements and agronomic practices. For example, at Royal Botanical Garden, Kew, nearly 5000 species of orchids from different parts of the world have been conserved in greenhouses having eight different sets of environmental conditions. There are various other organizations working for ex-situ conservation of orchids in different agroclimatic zones of India. There is an urgent need to bring such organizations under the National Active Germplasm Sites.

Biodiversity conservation

In-situ conservation

In-situ conservation of species ensures their natural growth, proliferation, and perpetuation without hindering the process of evolution as part of natural ecosystem. India has an elaborate Protective Area Network (PAN)

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comprising 86 National Parks, 480 wildlife sanctuaries covering about 4.66% of total geographical area of the country. There is further plan to expand this network to 160 national parks and 698 wildlife sanctuaries to cover 5.69% of total geographical area of the country. This network automatically provides the protection to the species that lie in them. Unfortunately, many important and endangered orchids, viz., *Paphiopedilum druryi* in Aghasthymalai hills of Kerala, *Vanda coerulea* in Meghalaya, *Paphiopedilum wardii* and *P. specerianum* in Assam, *Renanthera imscootiana* in Arunachal Pradesh and many more lie outside PAN. A few conscious State Governments like Arunachal Pradesh, Sikkim, Karnataka, and West Bengal have designated the orchid rich habitats as "Orchid Sanctuaries". These sanctuaries attract Wildlife Protection Act, 1972 as amended in 1992.

Ex-situ conservation

Field gene banks. In India, orchids have been the concern of botanists who collected them for study and conserved them from fear of loss in their natural habitats. The Botanical Survey of India has established three National Orchidaria at Shillong, Yurcaud, and Howrah for conservation and multiplication of orchids. Similarly, states like Arunachal Pradesh, Assam, Mizoram, Karnataka, Nagaland, West Bengal, Sikkim, Himachal Pradesh, and Orissa have also collected and conserved the orchids. The Tropical Botanical Garden Research Institute (TBGRI), Kerala, National Research Centre for Orchids, Sikkim, and several other organizations are also engaged in conserving orchids. The orchids germplasm available with various institutions in different regions is given in Table 1. Orchids are often conserved in polyhouse/ glasshouse termed as orchidarium. These structures need to be constructed keeping in view the climatic conditions required for the species to be conserved. The germplasm lines conserved in such structures are also at high risk of diseases and pests and require proper care and monitoring of the plants.

Artificial natural habitats. Other than orchidaria, orchids can also be conserved in "artificial natural habitat" where epiphytic orchids are tied on suitable host plant and terrestrials are planted in pots or in the ground (Fig. 3). The objective of this method is providing similar condition as that of nature. This method of conserving orchid germplasm reduces the cost on maintenance and incidence of diseases and pests. But its applicability is limited by availability of

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Figure 3. Terrestrial orchids in "artificial natural habitat".

suitable host and adaptability of species in new environment. The species having wider adaptability or specific to that particular locality can be conserved by this method. This method has successfully been tried for conserving various epiphytic and terrestrial orchids at Darjeeling Campus of National Research Centre for Orchids.

Orchid seed banks. Orchids produce millions of seed in a single capsule but they lack in metabolic machinery and functional endosperm and therefore, require mycorrhizal association for germination in nature. Consequently, the percentage of germination is calculated to be 0.01 to 0.2%. Many of the orchids have been germinated through asymbiotic technique where germination has been found as high as 90%. The seeds of orchids are orthodox in nature and provide a great scope for long-term storage through cryopreservation technique. Owing to their minute size, a large number of seeds can be maintained in small volume. However, long-term storage of orchid seeds would require studies on storage duration, seed viability, etc.

In-vitro conservation

Maintenance of orchid germplasm in field gene bank requires huge investment and the germplasm is also affected by insect pests and diseases. Therefore, in-vitro conservation of orchid germplasm requires attention. In-vitro conservation technique can also be used for revitalization of orchid germplasm affected by virus and virus-like diseases as meristem culture technique is found to eliminate many of the viruses. Though the orchids were the first plants to be tissue cultured, for in-vitro conservation of orchids, studies on genetic stability, storage duration, etc. need to be carried out.

Conclusion

- India is one of the primary/secondary center of orchid biodiversity and the major regions of diversity are Northeastern Himalayas, Western Ghats, and Andaman and Nicobar Islands. The systematic collection and conservation of orchids for value addition through crossing and selection has started very recently.

- The climatic conditions of Himalayas are more suitable for cultivation of standard *Cymbidium* cultivars rather than intermediates and miniatures (Fig. 4). The standard *Cymbidium* cultivars fetch higher price in the market than miniature or intermediate *Cymbidium* cultivars. The cultivars given below (see box) may be chosen for cultivation under high altitude conditions of Northeastern Himalayas.

Classification of *Cymbidium* cultivars

***Cymbidium* cultivars classified on the basis of raceme length**

50–60%: Sensation 'Cecil Park', Arunta 'Lovely Lips', Kenny 'Wine Color', Yankalilia, Vivacious 'Super White', Margaret Thatcher 'Perfection', Minisarah 'Artition'

40–50%: Hawtescence, Levis Duke 'Bella Vista', Eden Valley 'Bonanza', Soul Hunt-6, Pine Clash 'Moon Venus', Showgirl 'Cooksbridge', Bertha 'Petel Short', September 'Sunset', Kenny 'Wine Color'

30–40%: Tahiti, Ann Green, Lillian Stewart 'April Blush', Angelica 'December Gold', San Francisco 'The Beat', Swallow var. Takarazukzuki

20–30%: Sleeping Nypmph 'Glacier', Princess Elizabeth 'Linda'

***Cymbidium* cultivars classified on the basis of flower count**

<9: Hawtescence, Sleeping Nymph 'Glacier', Princess Elizabeth 'Linda', Soul Hunt-6, Swallow var. Takarazukzuki

9–12: Tahiti, Vanguard 'Christmas Beauty', Vivacious 'Super White', San Francisco 'The Beat', Kenny 'Wine Color', Arunta 'Lovely Lips'

12–14: Sensation 'Cecil Park', Hawtescence, Eden Valley 'Bonanza', Pine Clash 'Moon Venus', Showgirl 'Cooksbridge', Minisarah 'Artition'

>14: Lillian Stewart 'April Blush', Margaret Thatcher 'Perfection', Amesbury 'Frank Slattery', Bertha 'Petel Short', September 'Sunset', Yankalilia

Different categories of *Cymbidium* cultivars suitable for cut flower production under hill conditions

Standard

Early season: Hawtescence, Eden Valley 'Bonanza', Pine Clash 'Moon Venus'
Mid season: Vivacious 'Super White', Sensation 'Cecil Park'
Late season: Margaret Thatcher 'Perfection', Levis Duke 'Bella Vista'

Miniatures and Intermediates

Mid season: Arunta 'Lovely Lips', Kenny 'Wine Color', Showgirl 'Cooksbridge', Bertha 'Petel Short', Amesbury 'Frank Slattery'

Late season: Minisarah 'Artition', Yankalilia

Figure 4. ***Cymbidium*** **orchid.**

- The indigenous species need to be evaluated for the desired attributes so that these can be used as potted plants or as parents for hybridization. The field gene banks may suffer due to disease and improper management, which would result in erosion of genetic resources. Hence, seed conservation and in-vitro conservation deserves attention.
- For promoting the production of flowers (loose flowers or cut flowers) and decorative plants, and contract seed multiplication, sophisticated technology may be imported initially. However, the infrastructure should then be built up within the country. There is no dearth of brain and bank.
- A moral awakening is the need of the hour. Nudge the economy toward capitalism.
- Nevertheless, the interaction between the universities and industry has to be encouraged and nurtured. However, shared ambition would be the vital nexus between them.

Orchids produce millions of seed in a single capsule but they lack in metabolic machinery and functional endosperm and therefore, require mycorrhizal association for germination in nature.

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