

## **Diversity and Conservation of Rare and Endemic Orchids of North East India - A Review**

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Received 12.11.2013. Revised 25.4.2014, Accepted 15.5.2014

### **ABSTRACT**

Northeast India, a mega-diversity centre, comprises eight states, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. It occupies 7.7% of India's total geographical area supporting 50% of the flora (ca. 8000 species), of which 31.58% (ca. 2526 species) are endemic. The region is rich in orchids, ferns, oaks (*Quercus* spp.), bamboos, rhododendrons (*Rhododendron* spp.), magnolias (*Magnolia* spp.) etc. Orchids, believed to have evolved in this region, form a very noticeable feature of the vegetation here. Of about 1331 species of orchids, belonging to 186 genera reported from India; Northeast India sustains the highest number with about 856 species. Amongst them, 34 species of orchids are identified among the threatened plants of India and as many as endemic to different states of this region. Out of the eight orchid habitat regions in India, the two most important areas namely; the Eastern Himalayas and the North Eastern Region fall within the political boundaries of North Eastern Region. Terrestrial orchids are located in humus rich moist earth under tree shades in North Western India. Western Ghats harbour the small flowered orchids. Epiphytic orchids are common in North-Eastern India which grows up to an elevation of 2,000 mmsl. Some of valuable Indian orchids from this region which are used in hybridization programme are *Aerides multiflorum*, *Aerides odoratum*, *Arundina graminifolia*, *Arachnis*, *Bulbophyllum*, *Calanthe masuca*, *Coelogyne elata*, *C. flavida* *C. corymbosa*; *Cymbidium aloifolium*, *C. lowianum*, *C. devonianum*, *C. hookerianum*, *C. lancifolium*, *Dendrobium aphyllum*, *D. nobile*, *D. chrysanthum*, *D. farmeri*, *D. chrysanthum*, *D. densiflorum*, *D. moschatum*, *D. fimbriatum*, *D. jenkinsii*, *Paphiopedilum venustum*, *P. spicerianum*, *P. hirsutissimum*, *P. insigne*, *Phaius wallichii*, *Pleione praecox*, *Renanthera imschootiana*, *Rhyncostylis retusa*, *Thunia alba*, *Vanda cristata*, *Vanda coerulea* and *Vanda coerulescens*. Habitat

loss, deterioration and fragmentation, introduction of exotic species, over-exploitation, environmental pollution, global warming, commercialization of agriculture and forestry, and *jhum* cultivation are the major causes for the loss of diversity. India has strengthened on diversity conservation by implementing a series of acts, rules, laws, regulations, agreements and developing network of protected areas.

**Keywords:** Diversity, Orchid, Species, Conservation, North East India

## INTRODUCTION

Species diversity indicates the number of species of plants and animals present in a region. Maintaining a wide diversity of species in each ecosystem is necessary to preserve the web of life that sustains all living things. Biological diversity is also essential for preserving ecological processes, such as fixing and recycling of nutrients, soil formation, circulation and cleansing of air and water, global life support (plants absorb CO<sub>2</sub>, release O<sub>2</sub>), maintaining the water balance within ecosystems, watershed protection, maintaining stream and river flows throughout the year, erosion control and local flood reduction (Chatterjee et al. 2006).

Northeast India, a hotspot of biodiversity, comprises eight states *viz.* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. It occupies 7.7% of India's total geographical area supporting 50% of the flora (ca. 8000 species), of which 31.58% (ca. 2526 species) is endemic (Hedge 2000). The region is rich in orchids, ferns, oaks (*Quercus* spp.), bamboos, rhododendrons (*Rhododendron* spp.), magnolias (*Magnolia* spp.) etc.

Orchids, believed to have evolved in this region (Kumaria and Tandon 2007) form a very noticeable feature of the vegetation here. Of about 1331 species of orchids belonging to 186 genera reported from India, Northeast India sustains the highest number of about 850 species. As many as 34 species of orchids from North East India are listed among the threatened plants of India (Nayar and Sastry 1987, 1988, 1990; Ahmedullah et al. 1999) and 85 species are endemic to this region (Das and Deori 1983). Out of the eight orchid habitat regions in India, the two most important areas namely; the Eastern Himalayas and the Northeastern Region fall within the political boundaries of NER.

More than 1/5th of the orchid species found in the region are endemic i.e., they are unique to the region and are not found anywhere in the world.

Indian terrestrials are located in humus rich moist earth under tree shades in North Western India. Western Ghats harbour the small flowered orchids whereas epiphytic orchids are common in North-Eastern India which grows up to an elevation of 2000m MSL. Indian orchid species with high ornamental values originated that from this region are *Aerides multiflorum*, *Aerides odoratum*, *Arundina graminifolia*, *Arachnis*, *Bulbophyllum*, *Calanthe masuca*, *Coelogyne elata*, *Coelogyne flavida*, *C. corymbosa*; *Cymbidium aloifolium*, *C. lowianum*, *C. devonianum*, *C. hookerianum*, *C. lancifolium*, *Dendrobium aphyllum*, *D. nobile*, *D. chrysanthum*, *D. farmeri*, *D. chrysanthum*, *D. densiflorum*, *D. moschatum*, *D. fimbriatum*, *D. jenkinsii*, *Paphiopedilum venustum*, *P. spicerianum*, *P. hirsutissimum*, *P. insigne*, *Phaius wallichii*, *Pleione praecox*, *Renanthera imschootiana*, *Rhyncostylis retusa*, *Thunia alba*, *Vanda cristata*, *Vanda coerulea* and *Vanda coerulescens* (Singh 1990).

#### *Endemic orchids*

Orchids are distributed from tropical to alpine zones in forest trees, secondary vegetations, river banks, bamboo and palm thickets, forest floor, grassy slopes and rocky areas and are considered as an element in Farming System Research (Chowdhery 1998, 2001). The North East India has highest flora of monotypic orchid genera (Table 2) (Tandon et al. 2007). North East India is reported to harbor a large number of valuable threatened orchids also (Table 3). It is to be noted that there are some orchid species which are endemic not only to this region, but also to the home states in which they are distributed like in Sikkim and Arunachal Pradesh Himalayas, the Naga and Manipur hills, the Lusai - Mizo hills and Khasi –Jaintia hills (Nayar 1996).

These are

- *Dendrobium spatella*, *Dendrobium parciflorum* and *Luisia macrotis* from Assam
- *Vanda coerulea* and *Dendrobium palpebrae* from Arunachal Pradesh
- *Renanthera imschootiana* and *Cymbidium tigrinum* from Nagaland
- *Anoectochilus crispus*, *Cymbidium eburneum*, *Habenaria khasiana*, *Liparis deliculata*, *Paphiopedilum venustum*, *Taeniophyllum khasianum* and *Tainia khasiana* from Meghalaya

- *Renanthera imschootiana* from Tripura
- *Dendrobium palpebrae* from Mizoram
- *Ascocentrum ampullaceum* var. *auranticum*, *Epidendrum radicans* and *Vanda stangeana* from Manipur
- *Calanthe whiteana*, *Cymbidium whiteae* and *Vanda pumila* from Sikkim (Nayar 1996)

**Table 1:** Orchid distribution under forest cover in North East (Kataki et al. 1984)

State	Area	Dense Forest	% Forest Cover	Orchid	
				Genera	Species
	000 km <sup>2</sup>				
Arunachal Pradesh	83,743	54,542	65.13	130	600
Assam	78,438	15,842	20.19	74	182
Manipur	22, 327	5,309	23.77	67	207
Meghalaya	22,429	3,305	14.73	98	352
Mizoram	21,081	4,279	20.29	74	249
Nagaland	16,579	3,531	21.29	64	241
Sikkim	7,096	2,403	38.86	132	540
Tripura	10,488	1,825	17.40	37	66

**Table 2:** Some monotypic orchid genera of North East India

Name of orchid genera	
<i>Anthogonium</i> Wall. Ex Lindl.	<i>Arundina</i> Bl.
<i>Acrochaene</i> Lindl.	<i>Bulleyia</i> Schltr.
<i>Cremastra</i> Lindl.	<i>Cleisocentron</i> Bruhl
<i>Dickasonia</i> L.O. Williams	<i>Diglyphosa</i> bl.
<i>Eriodes</i> Rolfe	<i>Herpysma</i> Lindl.
<i>Jejosephia</i> A.N. Rao & Mani	<i>Mischobulbum</i> schltr.
<i>Myrmechis</i> (Lindl.) Bl.	<i>Neogyne</i> reichb.f.
<i>Ornithochilus</i> (Lindl.) Wall. Ex Benth.	<i>Risleya</i> King & Pantl.
<i>Renanthera</i> Lour.	<i>Tipularia</i> Nutt.

**Table 3:** Some threatened orchids of North East India (Tandon et al. 2007)

Name of orchid species	
<i>Acanthephippium sylhetense</i>	<i>Bulleyia yunnanensis</i>
<i>Cymbidium eburneum</i>	<i>Cym. devonianum</i>
<i>Cym. tigrinum</i>	<i>Dendrobium chrysotoxum</i>
<i>Den. densiflorum</i>	<i>Den. falconeri</i>
<i>Eria fragrans</i>	<i>Paphiopedilum fairreanum</i>
<i>P. insigne</i>	<i>P. venustum</i>
<i>P. villosum</i>	<i>Renanthera imschootiana</i>
<i>Vanda coerulea</i>	<i>Vanilla pilfera</i>
<i>Vanda pumila</i>	<i>Epigeneium rotundatum</i>

*Orchid diversity in Eastern Himalayas and North-Eastern India*

This region includes Darjeeling district of West Bengal and other North-eastern states, i.e., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region is relatively warmer with high humidity and heavier precipitation and endowed with 870 species in 159 genera constituting 72.8% of the total orchid species in this country. A state wise analysis indicates that Arunachal Pradesh has the highest number of orchid species (622) followed by Sikkim (543 species) and Meghalaya with 389 species. Among the other states of this region, Assam accounts for 290, Nagaland for 246, Mizoram for 234, Manipur for 215 and Tripura for 57 species (Hajra and De 2010).

*Orchids in Arunachal Pradesh*

There are 600 species of orchids in Arunachal Pradesh alone – the highest number in any State (377 epiphytes, 160 autophytic terrestrials, about 20 saprophytes). Major epiphytic genera include *Aerides*, *Arachnis*, *Bulbophyllum*, *Coelogyne*, *Dendrobium*, *Cymbidium*, *Eria*, *Cleisostoma*, *Rhynchostylis*, *Vanda* etc. Most of the epiphytic orchids are ornamentals (Hedge 2005). In the tropical valleys of Arunachal Pradesh, one can find cascades of colorful flower-spikes of *Rhynchostylis retusa*, *Aerides odorata*, *A. williamsii*, *A. rosea*, *Cymbidium pendulum*, *C. aloifolium*, *Dendrobium aphylla*, *D. nobile*, *D. moschatum*, *D. fimbriatum* etc., loaded on tree trunks during spring which add beauty to the surrounding wood. In sub-tropical hill forests, bunches of "pineapple-orchids" the *Dendrobium densiflorum*, *D. giganteum*, *D. grandiflorum*, *D. eburneum*, *D. mastersii*, *Vanda coerulea*, *Renanthera imschootiana* (red vanda), *Coelogyne* etc., greet the onlookers. The pink flowers of *Anthogonium gracile* found on the cut ends of rocks and edges carpet the exposed areas adding beauty to the landscape.

Among terrestrials, *Acanthephippium*, *Arundina*, *Anoectochilus*, *Calanthe*, *Phaius*, *Paphiopedilum* are common. Amongst them, *Arundina graminifolia*, the "bamboo orchid" is normally seen grown in the open sunny areas amongst grassy patches in the foothills. In the thick forests, *Anoectochilus* and *Geodorum*, popularly referred to as the "Jewel orchids" group having beautifully designed velvety leaves. Arunachal is the home state of rare and endangered Lady's Slipper orchids, *Paphiopedilum* species viz. (1)

*P. fairrieanum* (2) *P. venustum* and (3) *P. spicerianum*. Saprophytic genera like *Epipogium*, *Stereosandra*, *Gastrodia*, *Eulophia* and *Galeola* grow on decaying organic matter on the forest floor (Tripathi and Barik 2003).

#### *Orchids in Assam*

In Assam, as many as 182 species of orchids are identified. Tropical wet evergreen forests of Lakhimpur district and its adjoining foot hills of Arunachal Pradesh is very much rich and more than hundreds of eye-catching and colorful wild orchids are seen to bloom throughout the year. Mostly they are epiphytes. *Goodyera procera* and *Spiranthis sinensis* are adapted to aquatic habitat whereas *Vanilla ptilifera* and *Galeola altissima* are climbers. Orchids grow best in the evergreen and semi-evergreen forest and to some extent in moist deciduous forests. Species belonging to genera *Acanthephippium*, *Anoectochilus*, *Apostasia*, *Agrostophyllum*, *Coelogyne*, *Cymbidium*, *Dendrobium*, *Eria*, *Oberonia*, *Calanthe*, *Eulophia*, *Geodorum*, *Habenaria*, *Malaxis*, *Nephelaphyllum*, *Vanilla*, *Zeuxine*, *Didymoplexis*, *Galeola*, *Bulbophyllum*, *Camarotis* are the commonly found orchids. Assam has as many as 26 species of threatened orchids. Amongst endemic orchids, *Bulbophyllum obrienianum*, *Calanthe odora*, *Dendrobium parciflorum*, *D. spatella*, *Eria pumila*, *Eulophia candida*, *Liparis plantaginea*, *Luisia macrotis*, *Phalaenopsis mastersii*, *Tainia barbata* are reported from the state.

#### *Orchids in Manipur*

Many epiphytic and terrestrial orchids of immense horticultural value are grown in wild. About 207 species of orchids belonging to 67 genera have been reported from this state. *Vanda coerulea* (Blue Vanda) and *Ranantthera imschootiana* (Red Vanda) are included in schedule VI (plants) of the Indian Wildlife (Protection) Act, 1972 (Amended 1991). Due to over-exploitation, most of the orchids have already been depleted considerably and several are seen only in orchidaria. Some of the taxa facing threat of survival are *Anoectochilus tetraplerus*, *Aldrovenda vasiculosa*, *Ascocentrum ampullaceum*, *Ascocentrum miniatum*, *Dendrobium bensoniae*, *Dendrobium draconis*, *Dendrobium heterocarpum* and *Dendrobium wardianum* (Hedge 2012).

*Orchids in Meghalaya:*

The Khasi, Jaintia and Garo hills around Shillong in the state of Meghalaya boast of more than 300 species of orchids. Epiphytic orchids can be seen on the stunted trees of *Rhodendron arboreum*, *Quercus* and *Castanopsis* species. Ground orchids like *Anoectachilus brevilabris*, the jewel orchid and *Liparis pulchella* can be seen. Other orchid species available in the state are *Paphiopedilum insigne*, *P. venustum*, *Rhynchostylis retusa*, *Coelogyne corymbosa*, *Dendrobium devonianum*, *Cymbidium elegans* and *Vanda coerulea* (Nayar and Sastry 1987, 1988, 1990; Haridashan and Rao 1985).

*Orchids in Mizoram:*

Mizoram is the home land of *Vanda coerulea* (Blue Vanda) and *Renanthera imschootiana* (Red Vanda). Mizoram is also the natural home of *Paphiopedilum hirsutissimum* and *P. villosum*. Apart from these, there are many orchid species which are having ethnobotanical values are *Arundina graminifolia*, *Eria spicata*, *Eulophia nuda*, *Geodorum densiflorum*, *Malaxis acuminata*, *Phaius tankervilleae*, *Pholidota imbricata*, *Rhynchostylis retusa* and *Vanda testacea* (Nayar and Sastry 1987, 1988, 1990). Other tuberous orchids having medicinal importance are *Eulophia* and *Habenaria*.

*Orchids in Nagaland:*

Nagaland has about 241 species. Most of the orchids here are epiphytes or lithophytes. A few terrestrial orchids are also found in the state. Major genera are *Acampe*, *Acanthephippium*, *Aerides*, *Anoectochilus*, *Anthogonium*, *Aphyllorchis*, *Arachis*, *Ascocentrum*, *Bulbophyllum*, *Calanthe*, *Ceratostylis*, *Cleisostoma*, *Coelogyne*, *Cryptochilus*, *Cymbidium*, *Dendrobium*, *Diplomeria*, *Eria*, *Eulophia*, *Flickingeria*, *Galeola*, *Gastrochilus*, *Goodyera*, *Habenaria*, *Kingidium*, *Liparis*, *Luisia*, *Malaxis*, *Micropera*, *Oberonia*, *Otochilus*, *Paphiopedilum*, *Papilionanthe*, *Perisrtylus*, *Phaius*, *Pholidota*, *Pleione*, *Renanthera*, *Rhynchostylis*, *Spathoglottis*, *Thunia*, *Vanda* and *Zeuxine* (Nayar and Sastry 1987, 1988, 1990).

*Orchids in Sikkim:*

The entire peculiar geographical feature helps Sikkim to become a biodiversity hot spot (Nayar and Sastry 1997, 1998, 1999) and it harbours around 540 species which are distributed in humid sub-tropical, temperate and alpine forest up to an elevation 5000m msl. The most beautiful and very rare plants of the Alpine zone are *Cypripedium tibeticum*, *C. himalicum* and *C. elegance*. Some endemic species of orchids reported are *Oberonia micranthus*, *Malaxis saprophyllum*, *Liparis dongchenii*, *Calanthe trulliformis*, *C. alpina*, *C. whiteana*, *C. chloroleuca*, *C. anganii*, *C. keshabii*, *C. yuksomensis*, *Risleya atro purpurea*, *Dedicea cunninghamii*, *Cymbidium whiteae*, *Taeniophyllum retro – apiculatum*, *T. crepidiforme*, *Thrixpernum pygmaeum*, *Uncifera lancifolia*, *Biermannia bimaculata*, *Gastrochillus affinis*, *Vanda pumila* (Medhi and Chakrabarti, 2009). Other rare species of the state are *Satyrium nepalense*, *Anoectochilus sikkimensis*, *Coelogyne cristata*, *Cymbidium eburneum*, *Cymbidium devonianum*, *Dendrobium falconeri* and *Vanda pumila*. *Cymbidium eburneum*, *Cymbidium devonianum*, *Dendrobium chrysotoxum*, *Dendrobium densiflorum*, *Dendrobium wardianum* and *Vanda pumila* are the most threatened species of the state

*Orchids in Tripura:*

There are 66 species of orchids of which *Dendrobium* has the highest species diversity (14 species). Endangered orchids like Blue vanda (*Vanda coerulea*) and Red Vanda (*Renanthera imschootiana*) are found in the state (Tripathi and Barik 2003).



**Table 4:** Distribution of major orchids in North East States (Chowdhery 2009)

State	Orchid species
Arunachal Pradesh	<i>Cymbidium ensifolium</i> , <i>C. grandiflorum</i> , <i>Dendrobium aphylla</i> , <i>D. chrysanthum</i> , <i>D. gibsonii</i> , <i>D. nobile</i> , <i>Paphiopedilum fairrieanum</i> , <i>P. venustum</i> , <i>P. spicerianum</i> , <i>Calanthe masuca</i> , <i>Rhyncostylis retusa</i>
Assam	<i>Arundina graminifolia</i> , <i>Eulophia mannii</i> , <i>Goodyera procera</i> , <i>Calanthe angusta</i> , <i>Rhyncostylis retusa</i> , <i>Aerides multiflora</i> , <i>Aerides odorata</i> , <i>Acampe papillosa</i> , <i>Cymbidium aloifolium</i> , <i>Dendrobium aphyllum</i> , <i>D. acinaciforme</i>
Manipur	<i>Ascocentrum ampullaceum</i> , <i>Paphiopedilum spicerianum</i> , <i>Vanda amsiana</i> , <i>Vanda stangeana</i> , <i>Vanda coerulea</i>
Meghalaya	<i>Paphiopedilum insigne</i> , <i>P. venustum</i> , <i>R. retusa</i> , <i>Coelogyne corymbosa</i> , <i>Phaius tankervilleae</i> , <i>Dendrobium devonianum</i> , <i>Cymbidium elegans</i> , <i>Vanda coerulea</i>
Mizoram	<i>Vanda coerulea</i> , <i>Renanthera imschootiana</i> , <i>Paphiopedilum hirsutissimum</i> , <i>P. Villosum</i>
Nagaland	<i>Goodyera viridiflora</i> , <i>Liparis caespitosa</i> , <i>Luisia trichorrhiza</i> , <i>Malaxis latifolia</i> , <i>Oberonia pyrulifera</i> , <i>Spiranthes sinensis</i>
Sikkim	Alpine zone (2500-3000m): <i>Orchis</i> , <i>Habenaria</i> , <i>Tipularia</i> , <i>Satyrium</i> , <i>Cypripedium</i> Temperate & Sub-temperate zone(1850-3500m): <i>Goodyera</i> , <i>Calanthe</i> , <i>Pleione humilis</i> , <i>Cymbidium hookerianum</i> , <i>C. devonianum</i> , <i>C. longifolium</i> , <i>Coelogyne cristata</i> , <i>Dendrobium hookerianum</i> Subtropical zone (850-1250m): <i>Anoectichilus</i> , <i>Calanthe</i> , <i>Phaius</i> , <i>Eulophia</i> , <i>Paphiopedilum fairrieanum</i> , <i>P. venustum</i> , <i>Dendrobium</i> , <i>Bulbophyllum</i> , <i>Coelogyne</i> , <i>Arachnis</i> . Tropical Zone (250-850m): <i>Phalaenopsis</i> , <i>Dendrobium</i> , <i>Aerides</i> , <i>Vanda</i> , <i>Arundina graminifolia</i>
Tripura	<i>Dendrobium</i> (14 spp.), <i>Vanda teres</i> , <i>V. coerulea</i> , <i>Renanthera imschootiana</i> (Tripathi and Barik, 2003)

#### Utilization of the diversity

Orchid hybrids of *Cymbidium*, *Dendrobium*, *Vanda*, *Phalaenopsis*, *Oncidium*, *Cattleya*, *Paphiopedilum*, *Mokara*, *Aranda*, *Renantanda* etc. with different colour and forms are used as cut flowers, floral display and as exhibits (Medhi et al. 2012).

Tribal people of North -eastern hill region use wild orchids for a variety of folk medicine as orchids are rich in alkaloids, flavonoids, glycosides, carbohydrates and other phytochemicals (De 2011). Fragrant orchids like *Aerides multiflorum*, *Aerides odoratum*, *Cattleya maxima*, *Coelogyne cristata*, *Coelogyne ochracea*, *Dendrobium chrysotoxum*, *Lycaste*, *Oncidium spaceolatum*, *Rhyncostylis retusa* and *Zygopetalum intermedium* are delightful in outdoor living areas. Leaves, tubers and pseudobulbs of different species are used for edible purposes. Vanilla- a major spice crop and source of vanillin comes from *Vanilla planifolia*. *Anoectochilus* leaves are used as vegetables in Indonesia and Malaysia. Pseudobulbs of *Cymbidium maladimum* and *Dendrobium speciosum* and tubers of *Microtis uniflora* and *Caladenia carnea* are also edible. Miniature cymbidiums can be used as value added packed items. Bright flowers of orchid genera like *Dendrobium*, *Cymbidium*, *Paphiopedilum*, *Cattleya*, *Pholidota* etc. can be used for drying. Among orchids, *Cymbidium*, *Dendrobium* and *Phalaenopsis* are excellent for wedding counter-pieces.

*Orchids – genetic materials for breeding and species trade*

Several local species of *Vanda*, *Cymbidium*, *Ascocentrum*, *Paphiopedilum*, *Phalaenopsis*, *Calanthe*, *Coelogyne*, *Dendrobium* etc are in great demand in international market for breeding materials (Table 5). In breeding programme, selection of good and healthy plant and flower by visual observation accounts to a great extent. Evidences of natural hybridizations occurring among wild species were reported (Abraham and Vatsala 1981). Hundreds of natural inter-generic, inter-specific or intra-specific natural hybrids of *Dendrobium* are found in nature. Most of Indian species of *Cymbidium*, *Dendrobium* and *Vanda* studied have been recognized in breeding programme specially to produce primary hybrids due to their inherent attractiveness coupled with their ability to transmit these characters to hybrids. In *Dendrobium*, offspring's of reciprocal crosses show variations in characters like cane length and flower colour, flower size, flowering season and flower yield (Kamemoto et al. 1989; Connel and Kamemoto 1983). Selection of flower size and flower colour is effective in *Dendrobium* improvement programme (Bobisud and Kamemoto 1982). In *Cymbidium*, fragrance is the most important character sought after by breeders. *Cymbidium munronianum* has been used as parent in several breeding programmes (Singh 1984). The higher order hybrid, *Paphiopedilum* F.C. Puddle with six species in parentage plays a predominant role in breeding for white flower colour in the genus (Rogersen 1991). An extensive breeding programme in *Phalaenopsis* using 29 wild species and 873 varieties were studied by a group of workers (Chen et al. 1995) for development of new hybrids. They succeeded in developing 35 new hybrids and studied protoplast fusion, isozyme electrophoresis and DNA finger printing to assist in varietal identification. Inter-group hybridization between *Phalaenopsis* type *Dendrobiums* extends flowering season, expands the range of flower colours and shapes and increases the flowering (Davidson 1994). Majority of commercially grown orchids today are hybrids derived from *Arachnis*, *Vanda*, *Renanthera*, *Ascocentrum*, *Cymbidium*, *Cattleya*, *Dendrobium*, *Oncidium*, *Phalaenopsis* and *Paphiopedilum* (Mercy and Dale 1997). *Vanda sanderiana* and *V. coerulea* are the two important vanda species found in the back ground of most of the vandaceous hybrids (Fuchs 1997). Polyploidy and introgressive hybridization have played an important role in the development of orchid hybrids. Genera like *Cattleya*, *Cymbidium*, *Paphiopedilum*, *Vanda*, *Dendrobium* etc.,

have given maximum number of man-made hybrids. Most orchids have two basic sets (diploid, 2x) of chromosomes. Tetraploid plants are more fertile bearing flowers of better texture, bigger and more intense colouration (Kumar and Sheela 2007).

Many Indian species have earned world wide recognition in breeding program due to their inherent attractiveness coupled with their ability to transmit these characters to hybrids. Some of the leading species are *Aerides multiflorum*, *Cymbidium devonianum*, *C. lourianum*, *C. tracyanum*, *C. elegans*, *Dendrobium aggregatum*, *D. chrysotoxum*, *D. formosum*, *D. nobile*, *Paphipedilum venustum*, *Vanda coerulea* etc. (Bose and Bhattacharjee, 1980).

**Table 5:** Orchid species suitable for breeding (Bose and Bhattacharjee 1980; Kumar and Sheela 2007)

<i>Arachnis cathcartii</i>	<i>Ascocentrum ampullaceum</i>	<i>Bulbophyllum leopardinum</i>	<i>Bulbophyllum putidum</i>
<i>Calanthe chloroleuca</i>	<i>Calanthe herbacea</i>	<i>Calanthe masuca</i>	<i>Calanthe plantaginea</i>
<i>Calanthe triplicata</i>	<i>Coelogyne barbata</i>	<i>Coelogyne corymbosa</i>	<i>Coelogyne cristata</i>
<i>Coelogyne fuscescens</i>	<i>Coelogyne nitida</i>	<i>Coelogyne ochracea</i>	<i>Cymbidium devonianum</i>
<i>Cymbidium eburneum</i>	<i>Cymbidium hookerianum</i>	<i>Cymbidium iridioides</i>	<i>Cymbidium lancifolium</i>
<i>Cymbidium longifolium</i>	<i>Cymbidium lowianum</i>	<i>Cymbidium munronianum</i>	<i>Cymbidium tigrinum</i>
<i>Cymbidium tracyanum</i>	<i>Cymbidium whiteae</i>	<i>Dendrobium bensoniae</i>	<i>Dendrobium candidum</i>
<i>Dendrobium densiflorum</i>	<i>Dendrobium farmeri</i>	<i>Dendrobium formosum</i>	<i>Dendrobium gibsonii</i>
<i>Dendrobium infundibulum</i>	<i>Dendrobium nobile</i>	<i>Dendrobium parishii</i>	<i>Dendrobium pendulum</i>
<i>Dendrobium primulinum</i>	<i>Dendrobium wardianum</i>	<i>Dendrobium williamsonii</i>	<i>Paphiopedilum fairrieianum</i>
<i>Paphiopedilum hirsutissimum</i>	<i>Paphiopedilum insigne</i>	<i>Paphiopedilum spicearum</i>	<i>Paphiopedilum venustum</i>
<i>Paphiopedilum villosum</i>	<i>Papilionanthe teres</i>	<i>Pecteilis gigantea</i>	<i>Phaius flavus</i>
<i>Phaius tankervillea</i>	<i>Phalaenopsis decumbens</i>	<i>Phalaenopsis lobii</i>	<i>Phalaenopsis mannii</i>
<i>Pleione hookeriana</i>	<i>Pleione humilis</i>	<i>Pleione maculata</i>	<i>Pleione praecox</i>
<i>Renanthera imschootiana</i>	<i>Spathoglottis plicata</i>	<i>Thunia alba</i>	<i>Thunia marshalliana</i>
<i>Thunia venosa</i>	<i>Vanda coerulea</i>	<i>Vanda corulescens</i>	<i>Vanda cristata</i>
<i>Vanda pumila</i>	<i>Vanda stangeana</i>	<i>Vanda tessellata</i>	<i>Vandopsis undulata</i>

*Conservation of orchid diversity*

Tea plantations, timber felling, forest fires, unscientific method of harvesting, hunting, soil erosion, encroachment problem, construction of reservoirs and dams, charcoal making, grazing are the causes for loss of diversity. India has strengthened its hold on biodiversity conservation by implementing the Indian Forest Act, 1927; the Wildlife (Protection) Act, 1972; the Forest (Conservation) Act, 1980; the Environment (Protection) Act, 1986; the Biodiversity Act, 2002; the Biodiversity Rule, 2004, etc. India became a party to Convention on International Trade in Endangered Species (CITES) since 1976. India is also a signatory of the Convention on Biological Diversity (CBD) since 1992. A network of protected areas – biosphere reserves, sanctuaries, national parks, arboreta, botanical gardens, etc. have been established throughout the country, of which this region had its share (pl quote ref). The region has four biosphere reserves, 48 sanctuaries, 14 national parks, and two world heritage sites (Yumnam 2008). There is urgent need to conserve the valuable biological resources in natural habitats supplemented with preservation using modern methods of conservation like *in vitro* conservation, seed storage and cryo-preservation. A networking of institutions engaged in conservation of orchids coupled with strong orchid breeding programme would enhance judicious utilization of orchids (Medhi et al. 2012).

Using Satellite Remote Sensing and Geographic Information System by the Indian Institute of Remote Sensing and Department of Space (IIRS), Government of India priority sites identified in all the states of the region and accordingly, actions and strategies have been taken up. Institutions like Indian Institute of Spices Research and Indian Institute of Horticulture Research are actively involved in using DIVA-GIS for preparing biological richness maps of commercial orchid species.

Strategic framework

Goal	Approach	Performance Measure
Conservation of genetic resources	Integrated orchid conservation approach including GIS survey and remote sensing	<ul style="list-style-type: none"> <li>• Conservation genetics with molecular methods and phylogenetic studies</li> <li>• Epiphytic (70%) and terrestrial (20%) mycorrhizal associations with analysis of DNA sequences</li> <li>• All Pollinators interactions with population genetics and phylogenetic analysis of orchids and pollinators</li> <li>• <i>In situ</i> conservations (Biosphere Reserves, National Parks, Sacred Grooves, Gene Sanctuary and Individual Trees ) of all available species)</li> <li>• <i>Ex situ</i> conservations (Field gene banks, Botanical garden, Herbal Garden, in vitro-conservation, Cryo-preservation and DNA conservation) of more than 100 species</li> </ul>
Evaluation, valuation and improvement of genetic resources effectively to meet the challenges of biotic and biotic stresses to sustain the impact of climate change in addition to quality	Character specific collection of exotic and indigenous germplasm, locating resistance source and evolving high yielding and disease resistant lines through selection, mutation, inter-generic and inter-specific crosses, polyploidy breeding and biotechnological tools for orchid improvement	<ul style="list-style-type: none"> <li>• Specific collection of 850 indigenous germplasm from NEH region, 288 species of North Western Himalayas, 379 species of Peninsular India and 115 species of Andaman and Nicobar Islands. Exotic germplasm from Thailand, Britain, Singapore, Australia, Hawaii, New Zealand will be attempted to enrich basic genetic materials.</li> <li>• Genera and species wise cataloguing of all 1350 germplasm of India collections using IPGRI descriptors.</li> <li>• Identification of genes contributing resistance to biotic and abiotic stress factors and quality characteristics of major 10 commercial orchid genera.</li> <li>• Improvement of <i>Cymbidium</i> to develop hybrids or varieties with less pre-blooming period and resistance to viruses.</li> <li>• Varietal evaluation of newly developed genotypes of commercial orchid genera to suit specific agro-ecological conditions.</li> <li>• Development of highly adaptive and tolerant genotypes to mitigate climate change and water stress</li> <li>• Genetic engineering and transformation for early flowering and extending shelf-life in commercial orchids</li> <li>• Development of Bar codes for germplasm identification at species level.</li> </ul>

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