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THE ROLE OF ORCHIDS IN THE HIMALAYAN ECOSYSTEM: NRC PERSPECTIVE

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Abstract

Orchids are amongst the most prized flowering plants which are traded as cut flowers and pot plants. These belong to the second largest family of the flowering plants, with 29,481 orchid species worldwide. The Eastern and NorthEastern Himalayas, NorthWestern Himalayas, Peninsular India, and Andaman and Nicobar Islands are the major orchid regions of India. There are three prominent methods of conserving the genetic resources of orchid species: i) Legislative measures; ii) *in situ* conservation in sanctuaries, National Parks, and Secred Groves Reserves; and iii) *ex situ* conservation in Orchidaria, field gene banks, *in vitro* conservation, cryo-preservation, and Botanic gardens. Globally, trade in artificially propagated live plants is dominated by orchid hybrids (28.7%), *Cymbidium* species (26.9%), Orchidaceae species (18.9%), *Phalaenopsis* hybrids (10.1%), *Phalaenopsis* species (4.4%), *Dendrobium* species (3.4%), *Cymbidium* hybrids (3.3%), *Dendrobium* hybrids (2.3%), *Cattleya* species (0.4%), and *Oncidium* species (0.2%). Indian orchid species with high ornamental values are used as breeding material. In India, some of the native genera like *Arachnis, Cymbidium, Dendrobium, Paphiopedilum,* and *Vanda* are cultivated on a large scale for cut flower production. *Cymbidium* is mainly grown in NorthEastern Himalayan Region, Sikkim, Darjeeling hills, Arunachal Pradesh, and Assam. Tropical orchids are cultivated in Kerala and some parts of Tamil Nadu, Karnataka, and Maharashtra. There is a need to prefer those species which flower during winter and spring months so as to export their flowers to temperate regions from December to May.

Introduction

THE CONSUMPTION of exotic flowers is increasing in India, with the demand increasing more in metropolitan cities due to the growth in consumption on various occasions, such as birthdays, festivals, anniversaries, Valentine's Day, and religious ceremonies. The significant markets include Bengaluru, Delhi, Hyderabad, Kolkata, and Mumbai, which are the major cities in India. These areas have witnessed excessive demand growth during festivals and wedding seasons. The Indian exotic flower market reached INR 320.14 billion in 2023. The floriculture industry is expected to grow at a Compound Annual Growth Rate (CAGR) of around 19.50 % in the forecast period of 2024-2032 to reach a value of around INR 1591.17 billion by 2032. Based on these characteristics, the Indian exotic flower industry can be divided into loose and cut flowers. Based on the variety, the floricultural industry is divided into lotus, *Hibiscus*, tulips, lavender, orchids, carnations, lily, and daffodils. Based on these sectors, the industry is divided into organized and unorganized sectors. Based on the distribution channels, the industry is categorized into unorganized retail, florist, supermarket/ hypermarket, and online amongst others. The major states that produce cut flowers include West Bengal, Karnataka, Orissa, Uttar Pradesh, and Maharashtra. The major regions that produce loose flowers include Tamil Nadu, Karnataka, Madhya Pradesh, Mizoram, and Gujarat.

Orchids are amongst the most prized flowering plants and are traded as cut flowers and potted plants. These belong to the second largest family of flowering plants (Willis, 2017) with 29,481 orchid species worldwide (WFO, 2023). IUCN Global Red List has assessed about 1641 orchid species, of which 747 are categorized as *Threatened* with 197 listed as *Critically Endangered*. India is home to 1256 species belonging to 155 genera (Singh *et al*., 2019). Of these, 307 are endemic to the country. Experimental evidence suggests that orchids emerged 120 million years ago (cf. Givnish *et al*., 2015). These plants have the smallest seeds amongst the flowering plants in the world and require unique microhabitats for growth. Approximately, 8% of all flowering plants are orchids which are recognized for their medicinal properties in the ancient Indian Ayurvedic system.

According to the Angiosperm Phylogeny Group (APG) III classification system (2009), the family Orchidaceae is divided into five subfamilies, namely, Apostasioideae, Cypripedioideae, Vanilloideae, Epidendroideae, and Orchidoideae (Li *et al*., 2016). These plants are highly sensitive to pollution in their habitats and require special attention to ensure their survival (Barua *et al*., 2019). The entire group of orchids faces threats due to the severe reduction of forest areas. In addition, habitat degradation and various human activities have led to a decline in a number of certain orchid species in India (Bhandari *et al*., 2018). Nearly 50% of orchid species face threats due to their extensive use in traditional

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medicine. Primarily due to habitat degradation and extensive collection, approximately 90% of *Cypripedioideae* species (slipper orchids) in the Global Red List are declared as threatened (Fay, 2018). Appendix I of the Red List includes *Renanthera imschootiana* (commonly known as Red Vanda in Manipur), and approximately ten species of *Paphiopedilum*. *Liparis olivacea* has become extinct and *Dactylorhiza hatagirea* (Himalayan medicinal orchid) is critically endangered and listed in Appendix I of Convention on International Trade in Endangered Species (CITES) (Giri *et al*., 2008; Subedi *et al*., 2013). Many orchid species are classified as endangered, rare, and included in Appendix II of CITES due to natural and human-induced threats. Appendix II lists many Indian orchids including *Aerides*, *Acampe*, *Androcorys*, *Bulbophyllum*, *Ceratostylis*, *Cymbidium*, *Dactylorhiza*, *Epipactis*, *Gastrochilus*, *Goodyera*, *Habenaria*, *Herminium*, *Liparis*, *Malaxis*, *Nervilia*, *Ornithochilus*, *Peristylis*, *Pholidota,* and *Rhynchostylis retusa* (Hagsater *et al*., 1996). By the end of 2017, 948 orchid species had been mentioned in the IUCN Global Red List, with approximately 56.5% classified as threatened (Herrera *et al*., 2019). To prevent the continued extinction of these rare plants, protecting and conserving them must be a top priority.

Orchids are traded globally. In 2021, the top exporters of orchids were Netherlands ($73.7M), Thailand ($67.6M), Chinese Taipei ($34.7M), Malaysia ($7.75M), and Vietnam ($7.27M). In 2021, the top importers of Orchids were Japan ($61.2M), Italy ($22.8M), United States ($19M), China ($15.3M), and Germany ($13.6M). Nineteen countries and territories actively exported orchids from India. The top five countries that exported orchids from India were Belgium, Republic of Korea, The Netherlands, France, and Germany. The top countries in which India exports orchids are New Zealand, Thailand, and Columbia. The major ports for orchid imports to India are BOMBAY AIR CARGO (20.3935 USD $ Million), DELHI AIR CARGO (12.3671 USD $ Million), and CHENNAI AIR CARGO (7.7151 USD $ Million).

Resource Inventory

One of the well-known plant groups in the global horticultural and cut flower trades, orchids are also harvested, grown, and traded for a variety of purposes, including as ornamental plants, medicinal products, and food. The most popular global orchid trade involves artificially propagated cut flowers and plants are grown under controlled conditions. During the period of 1996 to 2015, Taiwan and Thailand were the largest exporters, with most plants sent to South Korea (40 %), U.S.A (27 %), and Japan (20 %) (UNEP-WCMC, 2017). India is reported to harbour ten species of valuable threatened orchids included in Appendix I of CITES and those are *Paphiopedilum charlesworthii* (Rolfe) Pfitzer, *P. druryi* (Bedd.) Stein, *P. fairrieanum* (Lindl.) Stein, *P. hirsutissimum* (Lindl. ex Hook.) Stein, *P. insigne* (Wall. ex Lindl.) Pfitzer, *P. spicerianum* (Rchb.f.) Pfitzer, *P. venustum* (Wall. ex Sims) Pfitzer, *P. villosum* (Lindl.) Stein, *P. wardii* Summerh, and *Renanthera imschootiana* Rolfe. Appendix II includes all species that although not necessarily now threatened with extinction, may become so unless trade in specimens of such species is subject to strict regulations to avoid utilization incompatible with their survival. The entire Orchidaceae family is included in Appendix II, except for the genera *Paphiopedilum* (10 spp.) and *Renanthera imschootiana*. Appendix II includes genera *Acampe* (5 species), *Acanthephippium* (3 species), *Acriopsis* (2 species), *Aenhenrya* (1 species), *Acrochaene* (1 species), *Aerides* (8 species), *Agrostophyllum* (5 species), *Androcorys* (6 species), *Ania* (2 species), *Anoectochilus* (6 species), *Anthogonium* (1 species), *Aorchis* (2 species), *Aphyllorchis* (3 species), *Apostasia* (3 species), *Appendicula* (2 species), *Arachnis* (2 species), *Archineottia* (1 species), *Arundina* (1 species), *Armodorum* (1 species), *Ascocentrum* (4 species), *Bhutanthera* (2 species), *Biermannia* (4 species), *Bletilla* (2 species), *Brachycorythis* (7 species), *Bulbophyllum* (117 species), *Bulleyia* (1 species), *Calanthe* (27 species), *Cephalanthera* (3 species), *Cephalantheropsis* (1 species), *Chamaegastrodia* (2 species), *Ceratostylis* (2 species), *Cheirostylis* (12 species), *Chiloschista* (4 species), *Chrysoglossum* (2 species), *Chusua* (5 species), *Cleisocentron* (1 species), *Cleisostoma* (20 species), *Coeloglossum* (1 species), *Coelogyne* (45 species), *Collabium* (2 species), *Corallorhiza* (1 species), *Cremastra* (1 species), *Corymborkis* (1 species), *Cottonia* (1 species), *Corybas* (1 species), *Cryptochilus* (2 species), *Cryptostylis* (1 species), *Cymbidium* (28 species), *Cymbi-diopsis* (2 species), *Cypripedium* (5 species), *Cyrtosia* (1 species), *Dactylorhiza* (2 species), *Dendrobium* (117 species), *Dickasonia* (1 species), *Didiciea* (1 species), *Didymoplexis* (3 species), *Diglyphosa* (1 species), *Diphylax* (2 species), *Diplocentrum* (2 species), *Diplomeris* (3 species), *Diploprora* (2 species), *Disperis* (3 species), *Doritis* (1 species), *Epigeneium* (8 species), *Epipactis* (6 species), *Epipogium* (6 species), *Eria* (60 species), *Eriodes* (1 species), *Erythrodes* (2 species), *Erythrorchis* (1 species), *Esmeralda* (2 species), *Eulophia* (24 species), *Flickingeria* (9 species), *Galeola* (5 species), *Gastrochilus* (21 species), *Gastrodia* (6 species), *Geodorum* (6 species), *Goodyera* (18 species), *Grosourdya* (2 species), *Gymnadenia* (3 species),

Habenaria (68 species), *Hemipilia* (1 species), *Herminium* (10 species), *Herpysma* (1 species), *Hetaeria* (5 species), *Holcoglossum* (1 species), *Hygrochilus* (1 spe-cies), *India* (1 species), *Ione* (6 species), *Ipsea* (1 species), *Jejosephia* (1 species), *Kingidium* (1 species), *Lecanorchis* (1 species), *Liparis* (49 species), *Listera* (11 species), *Luisia* (19 species), *Luisiopsis* (1 species), *Macropodanthus* (2 species), *Malaxis* (14 species), *Malleola* (1 species), *Micropera* (4 species), *Mischobulbum* (2 species), *Monomeria* (1 species), *Myrmechis* (2 species), *Neogyna* (1 species), *Neottia* (9 species), *Neottianthe* (3 species), *Nephelaphyllum* (3 species), *Nervilia* (16 species), *Oberonia* (58 species), *Odisha* (1 species), *Odontochilus* (8 species), *Oreorchis* (4 species), *Ornithochilus* (2 species), *Otochilus* (4 species), *Pachystoma* (2 species), *Panisea* (4 species), *Pantlingia* (2 species), *Papilionanthe* (4 species), *Pecteilis* (5 species), *Pelantheria* (1 species), *Penkemia* (1 species), *Pennilabium* (2 species), *Peristylus* (33 species), *Phaius* (7 species), *Phalaenopsis* (12 species), *Pholidota* (12 species), *Phreatia* (3 species), *Platanthera* (14 species), *Pleione* (7 species), *Plocoglottis* (2 species), *Podochilus* (5 species), *Polystachya* (1 species), *Pomatocalpa* (7 species), *Porpax* (6 species), *Pteroceras* (6 species), *Rhinerrhiza* (1 species), *Rhomboda* (3 species), *Rhynchostylis* (1 species), *Risleya* (1 species), *Robiquetia* (6 species), *Saccolabiopsis* (1 species), *Sarcoglyphis* (1 species), *Sa-tyrium* (2 species), *Schoenorchis* (6 species), *Seidenfadeniella* (2 species), *Seidenfia* (6 species), *Sirhookera* (2 species), *Smithsonia* (3 species), *Smitinandia* (2 species), *Spathoglottis* (3 species), *Spiranthes* (1 species), *Staurochilus* (3 species), *Stereo-chilus* (2 species), *Stereosandra* (1 species), *Sunipia* (2 species), *Taeniophyllum* (11 species), *Tainia* (3 species), *Taprobanea* (1 species), *Thecostele* (1 species), *Thelasis* (4 species), *Thrixspermum* (13 species), *Thunia* (3 species), *Tipularia* (1 species), *Trachoma* (1 species), *Trias* (6 species), *Trichoglottis* (4 species), *Trichotosia* (3 species), *Tropidia* (5 species), *Uncifera* (3 species), *Vanda* (15 species), *Vandopsis* (1 species), *Vanilla* (6 species), *Vrydagzynea* (1 species), *Xenikophyton* (2 species), *Yoania* (2 species), and *Zeuxine* (22 species) (De, 2020a; 2021a).

The Eastern and NorthEastern Himalayas, NorthWestern Himalayas, Peninsular India, and the Andaman and Nicobar Islands are the major orchid regions of India. Indian terrestrial orchids grow in humus rich moist earth under tree shade in NorthWestern India. Western Ghats harbour small flowered orchids. Epiphytic orchids are common in NorthEastern India and grow to an elevation of 2000 m amsl (De *et al*., 2016a).

Eastern Himalayas and NorthEastern India

It include the Darjeeling district of West Bengal and other NorthEastern states, such as Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. This region is relatively warmer, with high humidity and heavy precipitation and endowed

Table1. Climatic zones of orchids in NorthEast India.

Zones	Vegetation	Orchid species
Tropical (250-800m)	Trees (*Mangifera, Ficus, Shorea, Cassia, Bombax and Artocarpus*)	*Ascocentrum ampullacum, Cymbidium aloifolium, Dendrobium jenkensii, D. formosum*
	Secondary vegetation	*Bulbophyllum* spp., *Eria* spp., *Phalaenopsis mannii, P. lobbii*
	River banks	*Anoectochilus roxburghii, Calanthe* spp.
	Sandstone outcrops and cliffs	*Diplomeris hirsuta, Arundina graminifolia, Eulophia, and Habenaria* spp.
Sub-tropical Zone (800-1800m)	Trees (*Quercus, Prunus, Magnolia, Schima, Alnus, Bauhinia, Leucospermum*)	*Bulbophyllum* spp., *Esmeralda cathcartii, Cymbidium* spp., *Oberonia* spp., *Pleione maculata*
	Bamboo and palm thickets	*Paphiopedilum venustum, Eulophia* spp., *Calanthe* spp., *Phaius* spp.
	Forest Floor	*Paphiopedilum fairreanum, Anthogonium gracile, Habenaria* spp., *Bulbophyllum leopardinum*
Sub-temperate to temperate Zone (1800-3500m)	Trees (*Alnus, Acer, Abies, Pinus, Quercus, Magnolia and Rhododendron*)	*Cymbidium grandiflorum, C. elegans, Coelogyne cristata, Pleione hookeriana, Dendrobium candidum, D. hookerianum, Vandopsis undulata*
	Forest Floor	*Goodyera fusca,* Jewel Orchids*, Calanthe chloroleuca*
	Grassy Slopes	*Habenaria* spp., *Liparis* spp., *Satyrium nepalense*
	Rocky Outcrops	*Pleione humilis, Satyrium nepalense, Anthogonium gracile, Spathoglottis ixioides*
Alpine Zones (>3500m)	Open Grassy Meadows	*Orchis, Herminium*
	Rocky banks	*Cypripedium* spp., *Satyrium nepalense*
	Rhododendron and Conifer	*Cypripedium* spp., *Listera*

Table 2. Orchid distribution under forest cover in the NorthEast India.

State	Geographical area (km^2)	Forest area (km^2)	Forest (%)	Orchid genera	Orchid species
Arunachal Pradesh	83,743	65, 881	80	130	622
Assam	78,438	26,832	34	81	290
Manipur	22,327	17,418	78	67	215
Meghalaya	22,429	17,119	76	98	389
Mizoram	21,081	18,005	86	75	350
Nagaland	16,579	12,251	74	64	246
Sikkim	7,096	3,341	47	132	543
Tripura	10,486	6,249	60	37	57

with 870 species in 159 genera, constituting 72.8 % of the total orchid species in this country (Table 1).

A state wise analysis indicated that Arunachal Pradesh had the highest number of orchid species (622), followed by Sikkim (543 species), and Meghalaya (389 species). Amongst the other states in this region, Assam accounts for 290, Nagaland for 246, Mizoram for 350, Manipur for 215, and Tripura for 57 species (Table 2).

It should be noted that there are some orchid species that are endemic not only to this region, but also to the home states in which they are distributed in the Sikkim and Arunachal Pradesh Himalayas, Naga and Manipur hills, Lusai-Mizo hills and Khasi-Jaintia hills. These are *Dendrobium spatella*, *Dendrobium parciflorum,* and *Luisia macrotis* (Assam); *Vanda coerulea* and *Dendrobium palpebrae* (Arunachal Pradesh); *Renanthera imschootiana* and *Cymbidium tigrinum* (Nagaland); *Anoectochilus crispus*, *Cymbidium eburneum*, *Habenaria khasiana*, *Liparis deliculata*, *Paphiopedilum venustum*, *Taeniophyllum khasianum,* and *Tainia khasiana* (Meghalaya); *Renanthera imschootiana* (Tripura); *Dendrobium palpebrae* (Mizoram); *Ascocentrum ampullaceum* var. *auranticum*, *Epidendrum radicans,* and *Vanda stangeana* (Manipur); *Calanthe whiteana*, *Cymbidium whiteae,* and *Vanda pumila* (Sikkim).

NorthEast India has the highest flora of monotypic orchid genera (Tandon *et al*., 2007): such as *Anthogonium* Wall. ex Lindl., *Arundina* Bl. *Acrochaene* Lindl., *Bulleyia* Schltr. *Cremastra* Lindl., *Cleisocentron* Bruhl *Dickasonia* L.O. Williams, *Diglyphosa* Bl. *Eriodes* Rolfe, *Herpysma* Lindl. *Jejosephia* A.N. Rao and Mani, *Mischobulbum* Schltr. *Myrmechis* (Lindl.) Bl., *Neogyne* Reichb.f. *Ornithochilus* (Lindl.) Wall. ex Benth, *Risleya* King, and Pantl. *Renanthera* Lour., *Tipularia* Nutt. (Table 3).

Table 3. Monotypic orchids of NorthEast India.

Acrochaene Lindl.	*Amitostigma* Schltr.
Androcorys Schltr.	*Anthogonium* Wall. ex Lindl.
Arundina Bl.	*Bulleyia* Schltr.
Cleisocentron Bruhl	*Corymborkis* Thou.
Cremastra Lindl.	*Cryptostylis* R.Br.
Dickasonia L.O. Williams	*Diglyphosa* Bl.
Diploprora Hook.f.	*Eriodes* Rolfe
Herpysma Lindl.	*Jejosephia* A.N. Rao & Mani
Katherinea Hawkes	*Mischobulbum* Schltr.
Monomeria (Lindl.) Bl.	*Myrmechis* (Lindl.) Bl.
Neogyne Reichb.f.	*Neotainiopsis* Bennet & Raiz.
Ornithochilus (Lindl.) Wall. Ex Benth.	*Pennilabium* J.J. Sm.
Renanthera Lour.	*Risleya* King & Pantl.
Saccolabiopsis J.J. Sm.	*Stereosandra* Bl.
Tipularia Nutt.	*Trachoma* Garay
Tylostylis Bl.	*Vrydagzynea* Bl. *Ritaia* King & Pantl.

NorthEast India is also enriched with a huge number of rare orchids such as *Acanthephippium sylhetense*, *Anoectochilus grandiflora*, *A. sikkimensis*, *Bulbophyllum leptanthum*, *B. moniliforme*, *B. triste*, *Calanthe alpina*, *C. herbacea*, *C. odora*, *Coelogyne arunachalensis*, *C. nitida*, *C. cristata*, *Cymbidium cochleare*, *C. eburneum*, *C. devonianun*, *Dendrobium chrysotoxum*, *D. falconeri*, *D. densiflorum*, *D. ochreatum*, *Eria crassicaulis*, *E. spicata*, *E. fragrans*, *Eulophia candida*, *E. manni*, *Galeola cathcarti*, *Habenaria khasiana*, *Herminium haridasanii*, *Liparis acuminata*, *Malaxis aphylla*, *Nervilia scottii*, *Oberonia clerkei*, *Phaius tankervilleae*, *Phalaenopsis mastersii*, *Pleione maculata*, *P. praecox*, *Tainia khasiana*, *Thunia marshalliana*, *Vanda parviflora,* and *Zeuxine longifolia* (Table 4).

Table 4. Distribution of major orchids in NorthEastern States.

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

Source: De and Medhi (2014).

NorthWestern Himalayas

This region covers the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. The Western Himalayan region is blessed with a larger size, higher elevations, cooler drier climate, and the wider mountain mass. The pre-dominant forest flora is pine, deodar, and far. In total, 288 species under 75 genera were found to occur in this region, constituting 24.1 % of the total Indian orchids. Four species of ground orchids found mainly in this region, namely, *Crepidium acuminatum, Habenaria intermedia*, *Herminium edgeworthii*, and *Malaxis muscifera* form important constituents of *Astavarga* (a group of eight herbs used in the preparation of *Chyavanprash*).

Amongst epiphytes, *Dendrobium* and *Bulbophyllum* are the largest genera, comprising 16 and 12 species, respectively, whereas, amongst the terrestrial orchids, *Habenaria* is the largest group, with 13 species. Eleven species were endemic in this region: *Dendrobium normale*, *Eria occidentalis*, *Flickingeria hesperis*, *Gastrochilus garhwalensis*, *Herminium kumaunensis*, *Neottia mackinnonii*, *Neottia nandadeviensis*, *Peristylus duthiei*, *Peristylus kumaunensis*, *Peristylus fallax,* and *Ponerorchis renzii* (Jalal *et al*., 2009, 2010).

Peninsular India

This region comprises Madhya Pradesh, parts of Orissa, Andhra Pradesh, Gujarat, the extra peninsular region of Central India, and the Gangetic plains, along with the Eastern and Western Ghats. The Western Ghats harbour dense forests with high humidity and rainfall, and the vegetation is rich in scrub jungles, moist and dry deciduous forests, tropical evergreen forests, and montane grasslands containing a large number of orchid species. The Eastern Ghats consists of broken hills. Orchid diversity in the Eastern Ghat is poor as compared to that in the Western Ghats. This region is enriched with 379 species belonging to 89 genera constituting 31.72 % of the total Indian orchid flora. Predominant terrestrial orchid species available in Western Ghats are *Acanthephippium bicolor* Lindl., *Aenhanhreya rotundifolia* Blatt., *Anoectochillus elatus* Lindl., *Calanthe masuca* (D.Don) Lindl., *Calanthe triplicata* (Willemet) Ames, *Eulophia epidendraea* J.Konig ex Relz. C.E.C. Fisch, *Epipogium roseum* D.Don, *Geodorum densiflorum* Lamk., *Habenaria longicorniculata* Grah., *H. longicornu* Lindl., *H. multicaudata* Sedgw., *H. roxburghii* Nicolson, *Liparis atropurpurea* Lindl., *Malaxis versicolor* Lindl., *Nervilia aragona* Gaud., *Paphiopedilum* d*ruryii* Bedd., *Tainia bicornis* Lindl., *Vanilla walkeriae* Wight., *Zeuxine gracilis* Breda., and *Z. longilabris* Lindl. Some rare and endemic epiphytic species from Western Ghats are *Aerides ringens* Fischer, *Bulbophyllum aureum* Hook.f., *B. fuscopurpureum* Wight, *B. fimbriatum* Lindl., *B. fischeri* Seid, *B. tremulum* Wight., *B. neilgherrense* Wight., *Coelogyne breviscapa* Lindl., *C. nervosa* A. Rich., *Cottonia peduncularis* Lindl., *Cymbidium bicolor* Lindl., *Dendrobium aqueum* Lindl., *D. crepidatum* Lindl., *D. herbaceum* Lindl., *D. microbulbon* A. Rich, *D.*

ovatum Lindl., *Diplocentrum recurvum* Lindl., *Eria nana* A. Rich, *E. pseudoclavicaulis* Blatt., *Flickingeria nodosa* Daiz., *Liparis elliptica* Wight., *L. viridiflora* Bl., *Luisia zeylanica* Lindl., *Oberonia brunoniana* Wight., *Papilionanthe subulata* J. Koen., *Pholidota imbricata* Hook., *Rhynchostylis retusa* Bl., *Sirhookeria lanceolata* Wight., *Taeniophyllum alwisii* Lindl., *Trias stocksii* Benth., *Vanda testacea* Lindl., and *Xenikophyton smeeanum* Reich. f. Garay.

Andaman and Nicobar Islands

The Andaman and Nicobar (A&N) Islands are comprised of a group of approximately 319 islands and islets in the Bay of Bengal. The SouthEast monsoon governs these islands' climate. Heavy mist over the forests in the morning, high rainfall from May to November, and constant sea currents keep the forests moist throughout the year. These types of climates provide congenial habitats for the luxuriant growth of the unique orchid flora in the area. This region is home to 115 species thar belong to 53 genera. Genera such as *Grosourdya*, *Plocoglottis,* and *Vrydagzynea* are considered confined to this region.

Conservation Status

Orchids are highly sensitive to climatic changes in their habitats and show extensive interconnected symbiotic relationships with organisms, such as insects, plants, and fungi. Their presence is a positive indicator of a healthy ecosystem and the biodiversity of their habitat. Orchid habitats range from tropical to alpine zones in forests, riverbanks, bamboo plantations, palm thickets, grassy slopes, and rocky areas. The plants are distributed in the Himalayan Region, the Peninsular Region and A&N islands.

- The IUCN Red List includes *Paphiopedilum druryi, P. fairrieanum, P. charlesworthii, P. venustum, P. spicerianum, P. insigne, P. wardii, P. villosum*, and *P. hirsutissimum* and other 154 genera.
- Under the Wildlife Protection Act of 1972, *Vanda coerulea* (Blue Vanda), *Renanthera imschootiana* (Red Vanda) and all nine species of *Paphiopedilum* are legally protected.
- Conservation on International Trade in Endangered Species of Wild Flora and Fauna (CITES) envisages *Dendrobium cruentum* (Pigeon Orchid), *Paphiopedilum* spp., and *Renanthera imschootiana* (Red Vanda) of Appendix-I and all species of Orchidaceae excluding the species included in the Appendix I (De, 2021a).
- The Export of plants and plant parts of wild origin of species specified in the Export Licensing Note 1 is prohibited.
- A special exemption can be granted to research, education, and lifesaving drugs on a case by case basis.
- There are three prominent methods for conserving the genetic resources of orchid species: legislative measures; *in-situ* conservation in sanctuaries, national parks, Secred Groves Reserves; and *ex-situ* conservation in Orchidaria, Field Gene Banks, *in-vitro* conservation, cryo-preservation, and Botanic gardens.

Threats

- Habitat destruction and degradation pose serious threats to orchids. In addition, climate change is a harmful species that has a significant impact on pollination services and affects plant communities where orchids exist.
- Illegal harvesting and over-exploitation are serious threats to *Cypripedium, Paphiopedilum,* and *Renanthera imschootiana*.
- Orchids are collected illegally and traded as ornamental plants, traditional medicines, and food. Owing to increasing demand, orchids such as *Eulophia dabia* and *Dactylorhzia hatagirea* succumb to unsustainable harvesting practices.
- Orchid species used in *Chyavanprash* preparation such as Cr*epidium acuminatum, Malaxis muscifera, Herminium edgeworthii* and *Habenaria intermedia* are collected from the wild for their medicinal properties.

Production Status

The total orchid cut flower trade of the world mostly consists of 85 % *Dendrobium* species and 15 % *Phalaenopsis* and *Cymbidium* species. Globally, trade in artificially propagated live plants is dominated by Orchidaceae hybrids (28.7 %), *Cymbidium* species (26.9 %), Orchidaceae species (18.9 %), *Phalaenopsis* hybrids (10.1 %), *Phalaenopsis* species (4.4 %), *Dendrobium* species (3.4 %), *Cymbidium* hybrids (3.3 %), *Dendrobium* hybrids (2.3 %), *Cattleya* species (0.4 %), and *Oncidium* species (0.2 %). India comprises 1256 species belonging to 155 genera (Singh *et al.*, 2019). Indian terrestrials are commonly located in humus rich moist earth under tree shades in NorthWestern India. Western Ghats harbour the small

flowered orchids. Epiphytic orchids are common in NorthEastern India which is found up to an elevation of 2000 m from sea level. Indian orchid species with high ornamental values are used as breeding materials. In India, some of native genera like *Arachnis, Cymbidium, Dendrobium, Paphiopedilum,* and *Vanda* are cultivated on a large scale for cut flower production. *Cymbidium* is mainly grown in NEH Region, Sikkim, Darjeeling hills, Arunachal Pradesh, and Assam. Tropical orchids are cultivated in Kerala and some parts of Tamil Nadu, Karnataka and Maharashtra. We should prefer those species which flower during winter and spring months to export flowers to temperate regions from December to May.

Growing Environment

A humidity range of 75-85% in summer season and 50-55% in winter season is ideal for the growth of orchids. Most orchids prefer indirect or filtered lights. Although it varies with species to species, growth habit, and habitat, as at rule of the thumb, 50% shading is always advised for most of the commercial orchids. Warm orchids such as *Aerides*, *Rhynchostylis, Vanda*, and some *Dendrobium* species grow at day temperatures of upto 32.2°C and 15.5°C for a minimum night temperature; intermediate species such as *Brassovola, Cattleya, Laelia, Miltonia, Oncidium, etc*. prefer 26.6°C days and 12.8°C nights. Cool species, such as *Cymbidium, Cypripedium, Odontoglossum, etc.* prefer 24°C and 10°C nights. Most orchids require a lower night temperatures for both robust growth and bloom initiations. Night temperature of 10-13°C is ideal for flowering initiations in *Cymbidium*. Fresh air and adequate air circulation are essential for orchid production. Monopodial orchids such as *Aerides*, *Arachnis Mokara,* and *Vanda* can be propagated using top cuttings. In *Calanthe, Phalaenopsis*, *Phaius*, and *Thunia*, flower stalks give rise to the plants. Sympodial orchids such as *Cattleya, Cymbidium, Dendrobium*, *Miltonia, Oncidium,* and *Paphiopedilum* can be propagated by division. Shoots growing on plants called 'keikis,' can also be used. Keikis are common in *Ascocenda, Dendrobium,* and *Epidendrum*. Backbulbs (already flowered bulbs) can also be used as propagules in *Cattleya, Coelogyne,* and *Cymbidium*. Earthen pots, plastic pots, baskets, tree fern blocks, wooden trays, and whole husks of coconut are the common containers used to plant orchids.

Terrestrial and semi-terrestrial plants such as *Cymbidium* and *Paphiopedilum* perform better in deep pots. Basket culture is useful for orchids such as *Arachnis*, *Rhynchostylis, Vanda,* which have pendent flower spikes and long dangling roots. Orchids in hanging pots or baskets are grown in lighter media, such as charcoal, coconut husk, and tree fern fibre. Clay pots are most suitable for terrestrial orchids. Plastic pots were used for the epiphytes. Tree fern slabs or logs are effective for cool growing orchids. A potting medium consisting of wood chips, brick pieces and leaf mould in equal proportions is ideal for the vegetative growth and flowering of epiphytic orchids. In *Cymbidium,* the pots were placed at a spacing of 60 cm x 60 cm, which accommodates approximately 3 pots per m^2 (gross). The total number of plants will be approximately 30,000/ha. In *Dendrobium*, the planting density should be 100,000-1,50,000 plants/ha. During flower initiation and inflorescence development, plants are fed less nitrogen, more phosphorus, and more potassium. During the blooming period, low levels of nitrogen and phosphorus, and high levels of potassium were maintained. Foliar feeding is considered ideal for orchids. Frequent application of fertilizers at low concentrations is the best method for feeding orchids. A concentration of 0.2 to 0.3 % at 30:10:10 (N:P:K) at vegetative stage and 10:20:20 (N:P:K) at blooming stage is applied for high quality flower production. Chemical fertilizers should be properly balanced with organic manure, cowdung, cow urine, groundnut cake, fish emulsion, and neem oil cake. The solutions are diluted prior to application. Because urine contains high salt levels, a dilution of 1:25 is necessary. For the other samples, 1:10 dilution is ideal. A single spray of organic manure per week is sufficient. In *Dendrobium*, the spikes of orchids are harvested when a few buds on the top remain unopen, whereas in *Cymbidium* two buds open stage or 70% bloom stage. The pricing of spikes depends on the type of orchid and spike grade. The cost of one *Dendrobium* spike ranges from Rs. 10 to 25, depending on the grade. For *Oncidium* and *Vanda*, the usual pricing is between Rs. 10 and 20, and in *Cymbidium*, the cost of one spike ranges from Rs.100/ to Rs.200/. A *Cymbidium* grower can earn Rs. 40 lakhs in 10 years from an area of 500 m^2 accommodating 1500 plants after investing 10 lakhs and selling 55000-60,000 cut spikes. From an area of 500m^2 containing 3000 plants, a *Dendrobium* grower can earn five lakhs in three years after selling 3000 cut spikes and 3000 mother plants.

Collection, Conservation, Characterization, and Multiplication

- Explorations were performed in nine (9) different states, and a total number of 1653 accessions

comprising 278 species were collected, and the IC number was allotted in 968 germplasm by NBPGR (Annual Report, ICAR-NRC, 2015-16).

- Developed *ex-vitro* orchid conservatory (362 species from 124 genera, 3130 species, digital herbarium of 70 species, and conventional herbarium of 60 species) (Annual Report, ICAR-NRC, 2016-17).
- PGRC registration (IC 566525) of 'Red *Vanda*' and molecular profiling of 18 *Vanda* species, 17 *Cymbidium* species, 8 *Aerides* species and 37 *Dendrobium* species completed (Annual Report, ICAR-NRC, 2017-18).
- A patent filed an efficient DNA extraction method for orchids (No. 826/KOL/2013) (Chakrabarti and Jain, 2015).
- Protocols for meristem culture of *Cymbidium* orchid hybrids 'Golden Girl', 'Lunavian Atlas','Baltic Glaciers Mint Ice', 'Soul Hunt,', 'Sleeping Nymph', 'PCMV,' 'Star Guard Mc Angel, 'Show Girl Cooks Bridge' developed.
- Protocols for seed cultures of *Zygopetalum intermedium, Coelogyne cristata, Phaius tankervilleae, Vanda coerulea, Cymbidium dayanum, Cattleya maxima*.
- New genotypes in species *Pleione humilis, Coelogyne punctulata, Coelogyne nitida, Pleione praecox, Dendrobium amoenum, Cymbidium lowianum, Paphiopedilum villosum* and *Liparis bootanensis* have been identified. 4 (four) new species, *Cymbidium cyperifolium*, *Calanthe mannii*, *Calanthe yucksomnensis*, *Calanthe davidii* have been recorded for the first time in West Bengal.
- The Native *Vanda* DNA Barcode sequence of the RNA polymerase C (rpoC) gene and RNA polymerase beta subunit (rpoB) gene of Chloroplast DNA was submitted to 410nos. to NCBI (Annual Report, ICAR-NRC, 2015-16).
- Putative apomix seed production techniques for orchids have been developed for orchids. Technologies for producing plantlets from *Cymbidium* backbulbs and improved propagation techniques for *Lilium* have been developed. *In vitro* techniques for clonal propagation of orchid species and hybrids have been developed.
- Morphological descriptors have been developed for 40 species of orchids (De, 2020b; 2021b).
- Developed DUS Test Guidelines for 7 orchid genera: *Cymbidium*, *Dendrobium*, *Vanda*, *Phalaenopsis*, *Cattleya*, *Oncidium*, and *Paphiopedilum* (De *et al*., 2015).

Genetic Improvement

Varieties Identified

Cymbidium 'B.S. Basnett', *Cym*. 'Darjeeling Nymph', *Cym*. 'Darjeeling Delight,' *Dendrobium* 'V. 'Nagaraju' & Aranda, 'Kung Gyatso' was identified for release at institute level in 2013. Eight breeding lines (IC 614750 to 614753 and IC 617522 to 617525) of *Paphiopedilum* were identified and registered with NBPGR in 2016. Three breeding lines of *Cymbidium* were identified for release and were registered with NBPGR (IC 614747 to 614749). Three putative apomictic lines of *Zygopetalum* genetic stocks (IC 617526 to 17528) were identified.

New Clones/ Variants/ New Progenies

New genotypes in *Pleione humilis, Coelogyne punctulata, Coelogyne nitida, Pleione praecox, Dendrobium amoenum, Cymbidium lowianum, Paphiopedilum villosum,* and *Liparis bootanensis* have been identified. 4 (four) new species, *Cymbidium cyperifolium*, *Calanthe mannii*, *Calanthe yucksomnensis*, and *Calanthe davidii* have been recorded for the first time in West Bengal.

Paphiopedilum variety Sheetal 1 registered with PPVFRA. Seven breeding lines of *Paphiopedilum* were registered with NBPGR (IC 614750 to 614752 & IC 617522 to 617525) (Annual Report, 2016-17). In *Paphiopedilum*, 9 Advance lines viz. NRCO Paph.1, NRCO Paph.2, NRCO Paph. 3, NRCO Paph.4, NRCO Paph.5, NRCO Paph.6, NRCO Paph.7, NRCO Paph.8, and NRCO Paph.9 identified from a cross *Paph. lawrenceanum* x *Paph.* 'Winston Churchill' (Annual Report, 2023). In *Phalaenopsis*, 13 advance lines, viz. NRCO Phal.1, NRCO Phal.2, NRCO Phal.3, NRCO Phal 4, NRCO Phal 5, NRCO Phal 7, NRCO Phal 10, NRCO Phal 13, NRCO Phal 15, NRCO Phal. 16, NRCO Phal 18, NRCO Phal 20, and NRCO Phal 22 were identified from a cross *Phal. 'Brother & Sister' x P. 'Rousserole'* (Annual Report, 2023). In *Vanda*, 2 (Two) Advance lines viz. NRCO *Vanda* 1 and NRCO *Vanda* 4 identified from a cross *Vanda 'Berniece Miller' x Vanda coerulea*. (Annual Report, 2023). In *Dendrobium*, two (2) Advance lines, NRCO *Dendrobium* 42, and NRCO Dendrobium 58 were identified (Annual Report, 2023).

Physiological and Biochemical Approaches

Techniques for flower induction in *Phalaenopsis* and *Dendrobium nobile* through manipulation of light and temperature standardization.

N-hexadecanoic acid an antidiabetic compound was isolated from bamboo orchids (*Arundina graminifolia*) using GC-MS.

Quantified biologically and medicinally important bioactive compounds possess anti-cancer and antioxidant potential, such as Alpha tocopherol, Anemosapogenin, Gamma tocopherol, Quercetin-3-O galactoside, anthocyanins (delphinidin, petunidin, malvidin, and peonidin) through LC-MS/MS for the first time in 30 different indigenous orchid flowers available at Sikkim.

Explored around 89 non-targeted compounds, such as Gallocatechin, Hederin, Kaempferol-3-O (OH-FA)-diglucoside, Myricetin 3-O-galactoside, Neodiosmin, Rhoifolin, Verbascoside, Umbelliferone, Trans-Resveratrol, Piceatannol, possess several pharmacological benefits such as anti-cancer, anti-ulcer, anti-maleria, anti-hypertensive, anti-inflammatoryn and antioxidant through LC-HRMS from *Dendrobium nobile* flowers for the first time.

We quantified 17 amino acids, including lysine, isoleucine, and phenylalanine, using LC-MS/MS for the first time in 30 different indigenous orchid flowers available at Sikkim.

To the best of our knowledge, this is the first study to quantify 11 different minerals, including Mg, Ca, Cr, Mn, Fe, Co, Cu, Zn, Se, and Mo through ICP-MS from 30 different indigenous orchid flowers available at Sikkim for the first time (Natta *et al*., 2022).

Production and Post-Harvest Management

A *Cymbidium*-based orchid cropping system developed and demonstrated at the Institute (2009) was adopted on a large scale by the Horticulture and Cash Crop Development Department, Govt. of Sikkim.

Cymbidium, Dendrobium, Vanda, Phalaenopsis, Cattleya, Oncidium, Paphiopedilum, and *Mokara* varieties have been identified in cut flower and pot plants in Tropical, Subtropical and Temperate climates (De *et al*., 2014a).

Identified metabolic inhibitor as vase life enhancer of the cut flowers.

Developed modified alkali trap method for estimating metabolic activity of the cut flowers.

Potting mixtures for commercial orchids developed (De *et al*., 2014b).

Developed a plant based organic liquid mix as nutrient and pesticide for orchid cultivation.

Developed organic production technology of *Cymbidium* and *Zygopetalum* orchids.

Package of preparation of slow release organic fertilizers for commercial cultivation of *Cymbidium* orchids.

The package of practices for the cultivation of *Cymbidium, Dendrobium, Vanda, Oncidium, Cattleya Paphiopedilum* and *Phalaenopsis* orchids (De *et al*., 2014c; De and Pathak, 2020).

Year-round orchid production using selected hybrids and species (De and Singh, 2016a).

A steam-based orchid media sterilizer was designed and fabricated to ease sterilization of different orchid media components.

Mushroom based orchid cultivation developed for additional income.

Stages of harvest of spikes and florets of different classes of *Cymbidium* orchids have been standardized to improve vase life (De, 2020c).

Chemical preservatives for pulsing (5 % sucrose), impregnation (1000 ppm $CoCl_2$), bud opening (4 % sugar +200 ppm salicylic acid), and vase solutions (2 % sucrose + 200ppm 8-HQC) of *Cymbidium* orchids were for enhance vase life (De and Singh, 2016b).

Embedded drying in oven with borax or sand at 50-60^{o}C or borax + silica gel at 55^{o}C or Perlite + rice husk, Perlite + borax, Perlite + sand, Silica gel + borax, Perlite + silica gel, borax, perlite under ambient condition (24-25^{o}C and 75-79 % RH) found successful for *Dendrobium*, *Cymbidium*, *Cattleya*, *Oncidium*, *Phalaenopsis*, *Coelogyne,* and *Vanda* orchids (De *et al*., 2017) (Table 5 and Figs. 1-2).

Complete packages for the Post-harvest Technology of *Cymbidium* and *Dendrobium* orchids have been developed (De, 2020c) (Table 6 and Table 7).

Packaging of spikes and single florets of commercial orchids (De, 2020c)

Plant Protection

- About 50 different pathogens were isolated from various orchid diseases four fungal species have been identified for dry rot (*Fusarium solani*) of *Cymbidium* bulbs, dry rot of *Dendrobium* canes (*Fusarium verticillioides*), dry rot of *Coelogyne* bulbs (*Pestalotiopsis* sp.) and Brown circular spots (*Botrytis cinerea)* of *Paphiopedilum* (Annual Report, 2022).

Table 5. Orchid wealth in India

Categories/Types	Species/ Varieties/Hybrids
Common names for orchids	Bamboo orchid: *Arundina bambusaefolia;* Boat Orchid: *Spathoglottis plicata;* Bee Orchid: *Cottonia pedunculata;* Blue orchid: *Vanda coerulea;* Cat's Tail Orchid: *Aerides;* Chinese ground orchid: *Phaius tankervilleae;* Christmas lily: *Calanthe triplicate;* Queen orchid: *Cattleya;* Cut-grass orchid: *Cymbidium lancifolium;* Dancing Girls orchid: *Oncidium;* Dove orchid: *Peristeria elata;* Duck orchid: *Caladenia;* Dwarf orchid: *Orchis ustulata;* Easter orchid: *Cattleya;* Faham tea orchid: *Jumellea fragrans;* Fire/ Red orchid: *Renanthera imschootiana;* Fly orchid: *Orchis muscifera;* Fried egg orchid: *Dendrobium chrysotoxum;* Fringed orchid: *Platanthera cristata;* Foxtail orchid: *Rhynchostylis retusa;* Frog orchid: *Polyrrhiza linden;* Giant orchid: *Epipactis gigantean;* Glory of the East: *Pleione;* Hyacinth orchid: *Blitia striata;* Jewel orchids: *Goodyera*, *Anoectochilus;* Ladies of the night: *Brassovola;* Lady's Slipper: *Paphiopedilum;* Lily of valley orchid: *Eria spicata;* Mayflower orchid: *Laelia majalis;* Moth orchid: *Phalaenopsis;* Moon orchid: *Phalaenopsis amabilis;* Necklace orchid: *Coelogyne;* Nun orchid: *Phaius;* Old man orchid: *Dendrobium senile;* Onion orchid: *Epidendrum;* Pansy orchid: *Miltonia;* Pencil orchid: *Vanda teres ;* Pineapple orchid: *Dendrobium densiflorum;* Popcorn orchid: *Oncidium sphacelatum;* Rainbow orchid: *Epidendrum radicans;* Rattlesnake orchid: *Pholidota;* Scorpion orchid: *Arachnis ;*Snow orchid: *Diplomeris hirsute ;*Spider orchid: *Arachnis ;*Tree orchid: *Cymbidium dayanum;* Violet orchid*: Ionopsis* Wasp orchid: *Ophrys apifera*
Commercial orchids for cut flowers	*Aranda, Cattleya, Cymbidium, Dendrobium, Mokara, Miltonia, Oncidium, Phalaenopsis, Paphiopedilum, and, Vascostylis*
Orchids for International trade	*Cattleya, Cymbidium, Dendrobium, Oncidium Phalaenopsis*
Parents for Standard *Cymbidium* hybrids	*Cymbidium erythrostylum, C.eburneum, C. hookerianum* (syn. *C. grandiflorum*), *C. insigne, C. iridioides* (syn. *C. giganteum*), *C. lowianum*, *C. tracyanum*, *C. sanderae*
Parents for Miniature *Cymbidium* hybrids	*Cymbidium devonianum, C. ensifolium, C. tigrinum*
Parents for potted *Dendrobium*	*D. bigibbum* var. *compactum, D. carronii, D. canaliculatum, D. phalaenopsis*
Parents for *Phalaenopsis* hybrids	*Doritis pulcherrima* var. *coerulea, Phalaenopsis amabilis*, *P. aphrodite, P. formosana* and *P. lueddemanniana, P. manni, P. sanderiana, P. schileriana, Phalaenopsis violacea* var. *coerulea*
Parents for *Paphiopedilum* hybrids	*Paphiopedilum bellatulum, Paphiopedilum callosum* var. *sanderae, P. charlesworthii* var. *album P. godefroyae, P. fairrieanum* var. *album*, *P. rothschildianum,*
Parents for *Vanda* hybrids	*Vanda coerulea, V. hookeriana, V. sanderiana, V. teres,*
Indian species for hybrid development	*Aerides multiflorum*, *Cymbidium devonianum*, *C. lowianum*, *C. tracyanum*, *C. elegans*, *Dendrobium aggregatum*, *D. chrysotoxum*, *D. formosum*, *D. nobile*, *Paphiopedilum venustum*, *Vanda coerulea*
Monopodial orchids	*Phalaenopsis, Vanda, Vanilla*
Sympodial orchids	*Cymbidium, Cattleya, Dendrobium, Oncidium*
Epiphytic orchids	*Aranda, Cattleya, Cymbidium, Dendrobium, Miltonia, Mokara, Oncidium, Phalaenopsis, Vanda, Vascostylis*
Terrestrial orchids	*Calanthe, Eulophia, Phaius, Paphiopedilum, Spathoglottis*
Saphrophytic orchids	*Neottia*
Temperate orchids	*Cymbidium*, *Cypripedium, Disa, Habenaria*, *Masdevallia*, *Odontoglossum, Pleione, Zygopetalum*
Subtropical orchids	*Bulbophyllum, Lycaste, Miltonia*, *Oncidium*, *Paphiopedilum*,
Tropical orchids	*Ascocenda*, *Calanthe, Cattleya*, *Phalaenopsis, Vanda*,
C3 orchids	*Arundina graminifolia, Coelogyne masangeana, Cymbidium cynense, Oncidium* spp.*, Eulophia keithii, Habenaria platyphylla, Spathoglottis plicata, Vanda tessellata,*
C4 orchids	*Arundina graminifolia*
CAM orchids	*Aerides odoratum, Aranda, Aranthera, Bulbophyllum, Calanthe vestita, Cattleya, Coelogyne cristata, Dendrobium, Laelia* spp., *Phalaenopsis, Thunia marshiliana, Vanilla,*
Cymbidium hybrids	**White**: Jungfrau 'Snow Queen', Jungfrau 'Dos Pueblos', Camalex, Showgirl 'Cooksbridge', Showgirl 'Marion Miller', Swallow var. 'Takarazuki' **Pink**: Lilian Stewart 'Coronation', Lilian Stewart 'Party Dress', Orkney 'Pink Heather',Ensikhan, 'Alpha Orient', Pacific Rose 'Swansea', Soulhunt Series,Valley Paradise 'Shangriila', Rievaulx 'Cooksbridge', Rincon Fairy 'Pink Perfection'. **Yellow:** Angelica 'December Gold', Highland Sunset 'Plumpton', Mini Sarah 'Artisan',Hawtescens,

Table 5. Orchid wealth in India (contd.).

Categories/Types	Species/ Varieties/Hybrids
	Gwen Sherman, 'Arthur Fetzer', San Francisco 'Mona Lisa', Valya Craig 'Sutherland', Luana 'Imperial', 'Pine Clash Moon Venus', 'Valley Legend Steff' **Green:** Joyce Duncan 'Susan Hughes', 'R.D. Hughes', Miretta 'Mcbean', Lucense, Tricia Allen 'The Globe',Sparkle 'Late Green', Levis Duke 'Belle Vista', Sparkle 'Late Green', Amsebury 'Frank Slattery', 'Valley Zenith 'Top Spot', 'Madrid Forest King', 'Winter Beach Sea Green' **Red**: Chief Joseph 'Pathfinder', Sensation 'Chianti' 4N, Terama 'Robin,'Barushka 'Dos Pueblos', Khyber Pass 'Rowes Red', James Toya, 'Fire Storm Ruby', 'Fire Storm Blaze' 'Bob Marlin Lucky', 'Red Beauty Evening Star'
Dendrobium hybrids	**White**: 'Snow White', 'Pagoda White', 'Emma White', 'White Surprise', 'Jacquelyn Concert x Walter Oumae', 'Kasem White', 'Big White 4N', 'Big White Jumbo', 'White 5N' **Blue**: 'Vorawit Blue', 'Lee Chong Blue', 'Kultana Blue', 'Kiyoshi Izumi', 'Blue Fairy', 'Lee Chong Blue', 'Bangkok Blue' **Pink**: 'Chiengmai Pink', 'Ekapol Panda', 'Jisu's Star', 'Juree Red', 'Kiilani Stripe', 'Long Champ', 'Penang Sugar', 'Sagura Pink', 'Miss Singapore', 'Madam Pink', 'Sonia -16', 'Ear Sakul', 'Candy Stripe Pink', 'Sonia-17', 'Sonia -28', 'Dr. A. Abraham' **Yellow**: 'Sri Siam', 'Swan Lake', 'Thongchai Gold', 'Bonchoo Gold', 'Sarifa Fatima' **Green**: 'Daangsaard', 'Kanjana Green', 'Green Mist', 'Little Green Apples' **Red**: 'Meike Beauty', 'Pathum Red x Sabin', 'Little Lolita', 'Cleopatra', 'Diamond Star', 'Fireball', 'Little Lolita', 'Kating Daang'.
Phalaenopsis hybrids	**Standard white:** 'Elisabethe', 'Doris', 'Alice Gloria', 'Cast Iron Monarch', 'Dos Pueblos', 'Elinor Shaffer', 'Gladys Read', 'Grace Palm', 'Joseph Hampton', 'Juanita', 'Palm Beach', 'Ramona', 'Richard Shaffer', 'Sonja', 'Taisuco Brigh't, 'Taisuco Crane', 'Taisuco Snow', 'Cygnus', 'Brother Sister Windian' **Semi - alba Hybrids:** 'Roselle', 'Ruby Lips', 'Sally Lowry', 'Judy Karleen', 'Sharon Karleen', 'Karleen's Wendy', 'Bright Lights', 'Devon Michele', 'Spitfire', 'Mad Hatter', 'Rodco's Lady', 'Lipstick', 'Career Girl', 'Show Girl', 'Miki Wata Nabe', 'Memoria Francis Hunter', 'Dtps. Ox Prince Thunder', 'Dtps. Chian Xen Magpie' **Striped Hybrids:** 'Robert W. Miller', 'Peppermint', 'Samba', 'Barbara Freed Saltzman', 'Career Girl', 'Chorus Girl', 'Ella Freed', 'Marginata', 'Kaleidoscope' **Spotted White Hybrids:** 'Elise de Valec', 'Rouserrole', 'Dame de Coeur', 'Snow Leopard', 'Marry Krull', 'Ann Krul'l, 'Cabrillo Star', 'Paifang's Queen' **Pink Hybrids:** 'Grand Conde', 'Versailles', 'Alger', 'Reve Rose', 'Zada', 'Barbara Bread', 'Ann Marie Beard', 'Lipperose', 'German Pinks', 'Danse', 'Ida Fukumura' **Standard Yellow :** 'Bonnie Vasquez', Sogo Manager 'Nina', Brother Lawrence 'Montclair', 'Brother Oxford', 'Brother Passa't, 'Brother Stage', 'Golden Gift', 'Goldiana', 'I- Hsin Sunflower', 'Misty Green', 'Sogo Lisa', 'Taida Lawrence', 'Taipei Gold', 'Hsin Yang Fortune', 'Shih Hua Long First Love', 'Detroit' **Standard Orange:** 'Desert Orange', 'Carnelian Queen', 'Orange Glow', 'Orange Beauty', 'Tangelo', 'Cinnamon Glow,' Brother Sara Gold 'Peach', 'Zuma Creek', 'Burnished Copper', 'Lawless Red Peppers', 'Black Ball', 'Chen', 'Peachy', 'Amber', 'Ember', 'Bold Beauty' **Red and Purple Hybrids:** 'Engine Red', 'Cardinal', 'Ewing', 'Red Galaxy', 'Liberty Hill', 'Imp's Pride', 'Red Hot Imp', 'Venimp', 'Spirit House', 'Summer Morn', 'Red Buddha', 'Mahalo', 'Tapestry', 'Orchidland', 'Bloody Mary', 'Dixie Sunset', 'Peter Lin', 'Hwa Yuan', 'Sogo Grape', 'Taida Salu', 'Katherine', 'Ruby Glow', 'Burgundy Beauty', 'Purple Gem', 'Carol', 'Garnet Beauty', 'Spotted Beauty', 'Strawberry', 'Plum Rose x Ox Black Jack' **Harlequins Hybrids:** Golden Peoker 'BL', Golden Peoker 'Nan - Cho', 'Ever Spring King', 'Beautiful Dreamer', 'Ever Spring Prince', 'Ever Spring Light', 'Ever Spring Pioneer', 'Carolina Bronze Meteor', 'Montclair', 'Brother Jungle Cat', 'Nobby', 'Peacock', 'Celebration'
Cattleya hybrids	**Blue *Cattleya* hybrids**: *Cattleya* Alcmeda, *Cattleya* Bobby Howarth, *Cattleya* Intertexa, *Cattleya* Mrs. Myra Peters, *Cattleya* Veriflora ***Laeliocattleya***: 'Hidden Agenda', 'Magic Road', 'Samba Crown', 'Tropical Fashion', 'Higher Ground', 'Mini Case', 'Nobiles General', 'Spring Parade', 'Upstrart', 'Harmony Show', 'Julie Anne', 'Beautiful Park', 'Orange Sunset','Carbon Lines', 'Good Friend', 'Pat's Golden Dream', 'Sunlight Kiss', 'Sweet Cream', 'Penny Love', 'Big Lucy', 'Blue Boy', 'Gatton Park'. ***Epilaeliocattleya* hybrids**: 'Chocolate Kisses', 'Kopaa', 'Rainbow Sherbet', 'Pixford', 'Tiny Magic', 'Highland Canary', 'Pseudogold', 'Jackie Bright' ***Epicattleya* hybrids**: 'Cathy Meincer', 'Painted Hill Star', ' Calandria', 'Erin Routon', 'Burdekin Honey', 'Peles Flame'
Oncidium hybrids	**Golden Shower type**: 'Aloha Iwanga Dogasima', 'Goldiana', 'Gower Ramsey', 'Golden Shower', 'Sum Lai Who Jungle Queen', 'Taka H & R', 'Sharry Baby Sweet Fragrance '**Red coloured**: 'Popki Red', 'Irine Gleason Red', 'Vision Brownish Red', 'Catherine Wilson x New Calidonia Brownish Red' **Pink Coloured**: 'Robson Orchid Glad'

Table 5. Orchid wealth in India (contd.).

Categories/Types	Species/ Varieties/Hybrids
	Colmanara hybrids: Colm. 'Jungle Monarch', Colm. 'Wildcat', Colm. Wildcat 'Bobcat', Colm. Wildcat 'Cheetah', Colm. Wildcat 'Rainbow', Colm. Wildcat 'Red Star', Colm. Wildcat 'Tiger'
Paphiopedilum hybrids	**Multi-floral or strap leafed Paphiopedilums:** Prince Edward of York', Paph. 'Michel Koopuwitz', Paph 'Saint Swithin', Paph 'Mount Toro' **Fragrant Slipper Orchids:** Paph. 'Joyce Hasegawa', 'Paph. 'Lynleigh Koopwitz', 'Paph. 'Magic Lantern', Paph. 'Harold Koopwitz', **Hybrid Phragmipediums**: Phrag. 'Sorcerer's Apprentice', Phrag. 'Grande', Phrag. 'Don Wimber', Phrag. 'Elizabeth March', Phrag. 'Hanne Popow', Phrag. 'Jason Fischer', Phrag. 'Living Fire'
Vanda hybrids	***Vanda* hybrids**: 'Roberts Delight', 'Dr. Anek', 'Pakchong Blue', 'Miss Joaquim', 'Fuch's Delight', 'Lumpini Red', 'Motes Indogo Blue', 'Pat Delight', 'Rasri Gold', 'Samsai Blue', 'Adisak Smile', 'Robert Sorenson', 'Kasems Delight', 'Richard Brandon', Kultana Delight', 'Brigton's Pride', 'Hope', 'Mark Lewis', 'Dr. Mahathis', 'Kultana Miami White', 'Kultana Violet', 'Grand Lady', 'Fuch's Midnight', 'Motes Nut Brown', Prayoon Delight' ***Aranda* hybrids**: 'City of Singapore', 'Hilda Galistan', 'Urmila Nandey', 'Christine', 'Thailand Sunspot', 'Millenium Dawn', 'Broga Giant', 'Salaya Red', 'Propine White', 'Propin Spot', 'Lueng Cholburi', 'Ishbel Manisaki', 'Baytown', 'Chao Praya Blue', Chao Praya Dot Com', 'Chao Praya Beauty', ' Ethan Pride', 'Taksari Chandrabir' ***Ascocenda* hybrids**: 'Carol Belk', 'Renuka Angle', 'Joyce Bevins', 'Adisak Blue', 'Renu Gold', 'Tipi Blue Boy', 'Bobs Fortune', 'Rubychai', Shah Rukh Khan', Yang Sophia Firuz', 'Abdul Ghani Othman', 'Chunika', 'Fuch's Star', 'Kultana White', 'Golden Peace', 'Lani Beauty', 'Mahogany Gem', 'Copper Pure', 'Pokey Dot' ***Mokara* hybrids**: 'Madam Panne', 'Bangkok Gold', 'Chao Praya Gold', 'Chark Kuan Orange', 'Chark Kuan Pink', 'Kelvin Red', ' Kelvin Orange', 'Walter Ouame', 'Jitti Orange', 'Happy Beauty', 'Margaret Thatcher', 'Sarita Gold', 'Laura Bush', 'Winny Burang', 'Gladys Oumae', 'Denis Child', 'Ratchaburi Blue', 'Lion's Gold', 'Chao Praya Sunrise', 'Pak-Kred', 'Golden Rooster', 'Jasso's Pride', 'Chao Praya Classic', 'Chao Praya Spots', ' Calypso', 'Bota Gold' ***Kagawara* hybrids**: 'Red Lava Orange', 'Mist', 'Christie Low Redland', 'Broga Cemerlang', 'Chao Praya Fantasy', 'Curtis Lutchman', 'Emily Kavita Rajah', 'Diinesh Gold', 'Lion's Flame', 'Irene Hew', 'Bukit Timah', 'Sandy Gold' ***Vascostylis* hybrids**: 'Ique Pink', 'Kruewan', 'Banjong Jasmine', 'Mishima Lime', 'Vanity Fair', 'Firuz', 'Pine Rivers', 'Banjong Elite', 'Pichtawit Gold', 'Chao Praya Lime', 'Lanna Rosy', 'Jeans Delight', 'Bay Sapphire', 'Spring Hill' ***Aeridovanda* hybrids**: 'Bensiri', 'Noreen', 'Early Bird', 'Shiv Sidhu', 'New Dawn', Harrison Luke Somsri Sunlight'
Bigeneric hybrids	*Aerdachnis = Aerides × Arachnis, Aeridocentrum = Aerides × Ascocentrum, Aredopsis = Aerdies × Phalaenopsis, Ansidium = Anselia × Cymbidium, Aredovanda = Aerides x Vanda, Aranda = Arachnis × Vanda, Aranthera = Arachnis x Renanthera, Ascocenda = Ascocentrum × Vanda, Brassolaelia = Brassovola × Laelia, Doritaenopsis = Doritis × Phalaenopsis, Epicattleya = Epidendrum × Cattleya, Epilaelia = Epidendrum × Laelia, Laeliocattleya = Laelia × Cattleya, Miltonidium = Miltonia × Oncidium, Odontocidium = Odontoglossum x Oncidium, Odontonia = Odontoglossum × Miltonia, Renades = Renanthera × Aerides, Renanopsis = Renanthera × Vandopsis, Renancentrum = Renanthera × Ascocentrum, Renantanda = Renanthera × Vanda, Renanthopsis = Renanthera × Phalaenopsis, Rhynchovanda = Rhyncostylis × Vanda, Sophrocattleya = Sophronitis × Cattleya, Sophrolaelia = Sophronitis × Laelia, Vandoritis = Vanda × Doritis*
Trigeneric hybrids	*Brassolaeliocattleya = Brassavola × Laelia × CattleyaColmanara = Miltonia × Odontoglossum × OncidiumDekensara = Brassovola × Cattleya × SchomburgkiaDialaeliocattleya = Diacrinum × Laelia × CattleyaEpilaeliocattleya = Epidendrum × Laelia × CattleyaHartara = Broughtonia × Laelia × SophronitisLaeliocattkeria = Laelia × Cattleya × BarkeriaLaycockara= Arachnis × Phalaenopsis × VandopsisLowara = Brassavola × Laelia × SophronitisLyonara = Cattleya × Laelia × SchomburgkiaMizulara = Cattleya × Diacrinum × SchomburgkiaMoirara = Phalaenopsis × Renanthera × VandaMokara = Vanda × Arachnis × AscocentrumNakamotora = Ascocentrum × Neofinetina × VandaOsmentara = Broughtonia × Cattleya × LaeliopsisRhyndoropsis = Rhyncostylis × Doritis × PhalaenopsisSappanara = Arachnis × Phalaenopsis × RenantheraSophrolaeliocattleya = Sophronitis × Laelia ×CattleyaTrevorara = Arachnis ×Phalaenopsis ×VandaVascostylis = Vanda × Ascocentrum × RhyncostylisWilsonara = Cochlioda ×Odontoglossum × OncidiumYapara = Phalaenopsis × Rhyncostylis × Vanda*
Tetrageneric hybrids	*Iwanagara = Brassavola × Cattleya × Diacrinum × LaeliaKirchara = Cattleya × Epidendrum × Laelia × SophronitisPotinara = Brassavola × Cattleya × Laelia × SophronitisRecchara = Brassavola ×Cattleya × Laelia × SchomburgkiaWithnearara= Aspasia × Miltonia × Odontoglossum × OncidiumYamadara = Brassavola × Cattleya × Epidendrum × Laelia*

Table 5. Orchid wealth in India (contd.).

Categories/Types	Species/ Varieties/Hybrids
Pentageneric hybrids	*Goodlera = Brassia × Cochlioda × Miltonia × Odontoglossum × OncidiumHasegawara = Cattleya × Brassavola × Broughtonia × Laelia × sophronitis*
Hexa-generic hybrids	*Brilliabdera = Aspasia × Brassia × Cochlioda × Odontoglossum × Onciodium × Miltonia*
Polyploids	Amphidiploids (*Dendrobium*) : 'Jacquelin Thomas Y 166' Tetraploid (*Phalaenopsis*): 'Riverbend' Tetraploid (*Oncidium*): 'Popcorn' Tetraploid (*Spathoglottis*) : 'Lion' Tetraploid (Vanda): 'Atherton', 'Juliet', 'Hula Girl', 'Wood Lawn' and 'Douglas'
Potted orchids	*Phalaenopsis,Oncidium, Miltonia, Cymbidium, Paphiopedilum, Dendrobium, Cattleya, Ascocenda, Vanda, Brassia, Miltonia, Epidendrum, Lycaste, Rhyncostylis, Renanthera, Coelogyne*
Medicinal orchids	***Anti cancer/Anti-tumor**: Anoectochilus formosanus, Bletilla striata, Bulbophyllum kwangtungense, Dendrobium chrysanthum, Dendrobium fimbriatum, Dendrobium nobile, Ephemerantha ionchophylla, Gastrodia elata, Spiranthes australis, Bulbophyllum odoratissimum; **Convulsive diseases**: Gastrodia elata, Goodyera schlechtendaliana, Anoectochilus formosanus; **Anti-microbial**: Vanilla planifolia, Galeola foliata, Cypripedium macranthos* var. *rebunense, Spiranthes mauritianum, Gastrodia elata; **Anti-inflammatory:** Anoectochilus formosanus, Gastrodia elata, Dendrobium moniliforme, Pholidota chinensis; **Antioxidant:** Anoectochilus formosanus, Anoectochilus roxburghii, Dendrobium amoenum, Dendrobium moniliform, Gastrodia elata, Pholidota yunnanensis; **Antidiabetic**: Anoectochilus formosanus, Dendrobium candidum; **Diuretic:** Cymbidium goeringii; **Antihepatotoxic**: Anoectochilus formosanus, Goodyera schlechtendaliana, Goodyera matsumurana, Goodyera discolor; **Neuroprotective:** Coeloglossum viride, Gastrodia elata; **Pain treatment**: Maxillaria densa, Scaphyglottis livida, Epidendrum Mosenii; **Anti-viral**: Epipactis helleborine, Listera ovata, Gastrodia elata, Cymbidium* spp.*; **Relaxation:**Scaphyglottis livida, Gastrodia elata, Maxillaria densa; **Antiplatelet aggregation:** Dendrobium loddigesii, D. densifiorum, Ephemerantha lonchophylla, Gastrodia elata; **Anti-allergic:** Gymnadenia conopsea; **Antipyretic**: Dendrobium moniliforme; **Antimutagenic activity**: Dendrobium nobile; **Endurance capacity:** Anoectochilus formosanus; **Ameliorative**: Anoectochilus formosanus; **Anthelmintic**: Bletilla striata,; **Anti-aging**: Coeloglossum viridevar. Bracteatum; **Gastric**: Dendrobium nobile, Gastrodia elata; **Herbicidal agent:** Epidendrum rigidum; **Maturation**: Anoectochilus formosanus; **Phytoalexin**: Coelogyne cristata; **Skin blood flow**: Calanthe discolor; **Wound healing**: Vanda roxburghii*
Fragrant orchids	*Aerides multiflora, Aerides odorata, Aeranthes, Bulbophyllum odoratissimum, Cattleya maxima, Coelogyne cristata, Coelogyne ochracea, Cymbidium ensifolium, Dendrobium nobile, Epidendrum cristatum, Epidendrum floribundum, Epidendrum nocturnum, Lycaste, Oncidium sphacelatum, Phaius tankervilleae, Rhyncostylis retusa, Vanda cristata, Vanda tesselata, Zygopetalum intermedium*

- Pathogens for other orchid diseases were identified including leaf spot in *Aerides odorata,* bulb rot in *Phaius* spp., brown spot in *Cleistoma* sp., brown spot in *Oncidiun sphacelatum,* browning of leaf tip in *Acampe* spp., and grey spot in *Cymbidium devonianum*.
- 4 isolates of *Trichoderma* were isolated from rhizosphere soil collected from three species of orchids using *Trichoderma* Selective Media.
- Dipstick was developed as a virus indexing method for the easy detection of viruses in orchid samples.
- Successful management of black rot in *Cymbidium* orchids using fungicide metalaxyl (0.1 %), was followed by thiophenate-M and carbendizm was recorded.
- Isolation, purification, and pathogenicity of anthracnose disease in orchids caused by *Colletotrichum gloeosporioides* and its control by application of Carbendizm (0.05 %), and Mancozeb (0.1 %), and *Trichoderma viridae* were successfully performed.
- Pest control measures in *Cymbidium, Dendrobium, Vanda, Phalaenopsis,* and *Paphiopedilum*, biocontrol measures developed for mites and aphids (a new aphelinid parasitoid, *Coccophagus ceratoplastae*) as a parasitoid of soft scales, *Coccus hesperidum* infesting orchids from Sikkim, India, and a new report of *Aphytis* spp. as parasitoids of *Cymbidium* scale, *Lepidosaphes pinnaeformis* (Bouche) infesting *Cymbidium*.
- Management of shoot borer (*Peridaedala* sp) with econeem (2.5 mlL^{-1}) and chloropyriphos 20EC 5 5mlL^{-1} in *Dendrobium* and with BT (Dipel) (0.012 %) and neem oil (0.03 %) at 5mlL^{-1} in *Epidendrum.*
- Effective IPM module comprising of 5 % tobacco extract, 0.03 % neem oil (5mlL^{-1}) and bifenthrin

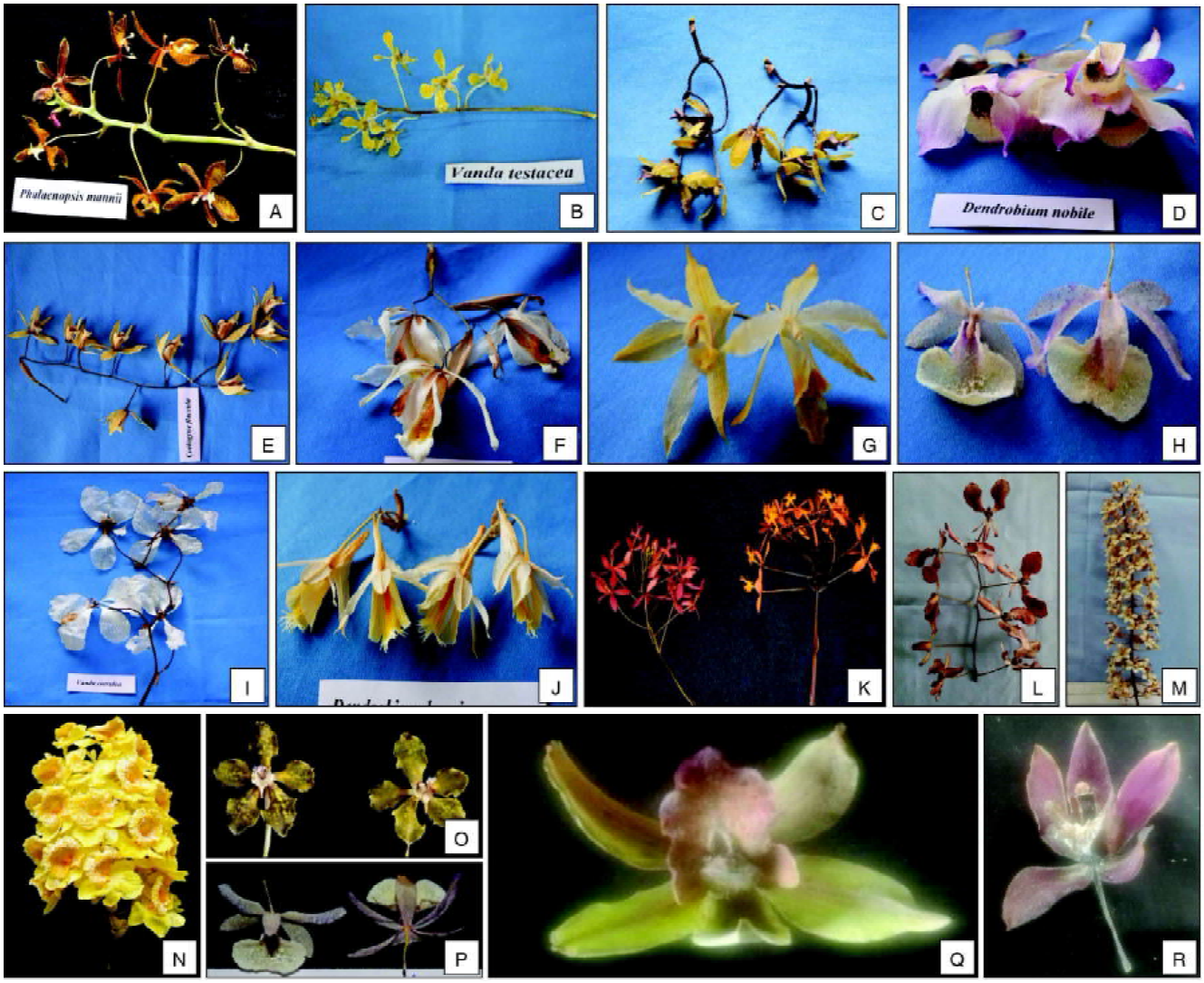

Fig. 1. A-R. Dried orchid flowers: A, *Phalaenopsis mannii;* B, *Vanda testacea;* C, *Vanda cristata;* D, *Dendrobium nobile;* E, *Coelogyne flaccida;* F, *Coelogyne cristata;* G, *Dendrobium williamsonii;* H, *Dendrobium primulinum;* I, *Vanda coerulea;* J, *Dendrobium longicornu;* K, *Epidendrum* spp.; L, *Renanthera imschootiana;* M, *Rynchostylis retusa;* N, *Dendrobium densiflorum;* O, *Vanda tessellata;* P, *Dendrobium aphyllum;* Q, *Cymbidium* 'Amesbury'; R, *Cymbidium* 'Bartha Peterson'.

10EC 0.25 % for control of mites on *Cymbidium* standardized (Meena *et al*., 2018).

- Developed Effective management of aphids in *Cymbidium* by using Econeem (3000 ppm) 2 mIL^{-1} and neem oil 0.03 % EC 5 mIL^{-1}.

Information technology (IT) and Information and Communication Technology (ICT) Applications

- 4 (Four) Mobile apps on *Orchid Farming* (Cultivation and management), *Orchidopedia* (native species description) (Tomar *et al*, 2022), *Orchidman* (Orchid data record (ORCHIDMAN, and 'Orchid Pest Management (Fig. 3).
- A prototype modular self-watering pot was designed using 3D printing technology, which was specifically optimized for orchids (Annual Report, 2022).
- A sensor-based microcontroller was programmed, and a PCB was designed to automate the irrigation system for vertical farming and terraria.

Future thrusts

- Collection of all available orchids of India.
- Characterization, evaluation and documentation of the collected orchid resources.
- Promotion of suitable indigenous species for trade (cut flower/potted plant/value-added products).
- Identification of genera and species for making new generation hybrids.

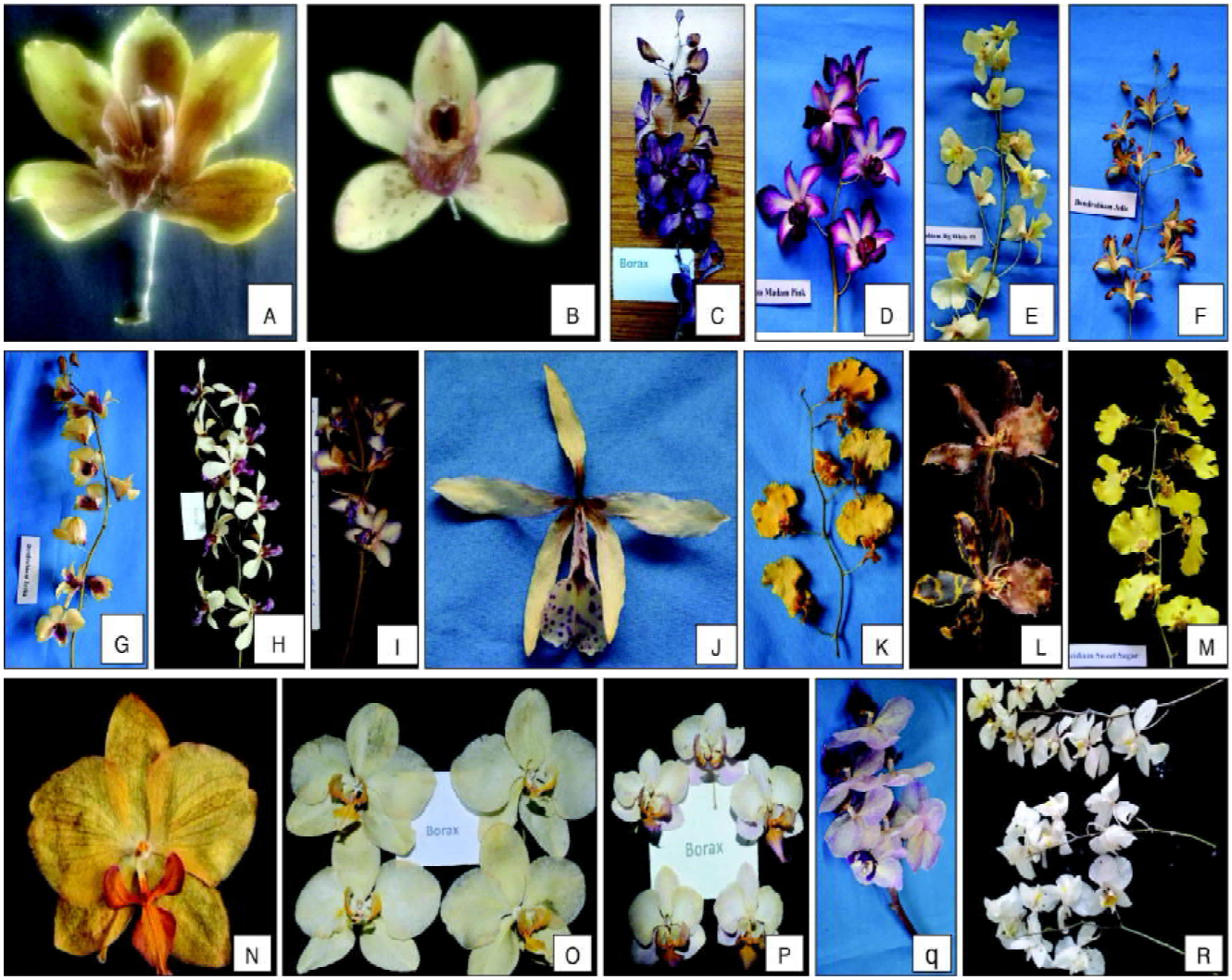

Fig. 2. A-R. Dried orchid flower: A, *Cymbidium* 'Forty Niner'; B, *Cymbidium* 'Valley Teaser'; C, *Dendrobium* 'Kating Dang'; D, *Dendrobium* 'Madam Pink'; E, *Dendrobium* 'Big White 4N'; F, *Dendrobium* 'Julie'; G, *Dendrobium* 'Erika'; H, *Dendrobium* 'Lervia'; I, *Dendrobium* 'Bangkok Blue'; J, Blc 'Guanmiau City'; K, *Oncidium* 'Taka Yellow'; L, *Oncidium* 'Wildcat Bobcat'; M, *Oncidium* 'Sweet Suagar'; N, *Phalaenopsis* 'Shih Hua Long First Love'; O, *Phalaenopsis* 'Detroit'; P, *Phalaenopsis* 'Buenos Aires'; Q, *Phalaenopsis* 'Vienna'; R, 'Casa Blanca'.

- Hybridization, embryo culture, hardening, and selection of noble and superior hybrids for orchid cut flowers and potted plant trade.
- Micropropagation in important orchids. Collaborative researches on active components for medicinal and other useful properties of orchids need to be carried out.
- Standardization of primary and secondary hardening of micropropagated orchids.
- Detailed researches on reduction of gestation period of orchids.
- Standardization of cost-effective production technology. Weather management, growth media, nutrients and watering schedules.
- Manipulation of light and weather parameters for early, regular, and higher flower production. Multi-tier production.
- Standardization of high tech, precision and aeroponic cultivation of orchids.
- Standardization of organic production technology of orchids.
- Pest and disease management practices keeping in mind the regulatory requirements of targeted markets.
- Researches on solar and wind power for the energy need in production chain.
- Standardization of post-harvest handling practices, packaging boxes, value-added display

Name	Description	Illustrations
Orchids Farming	Gives brief information on cultivation and management of important orchid genera namely *Cymbidium*, *Dendrobium*, *Phalaenopsis* and *Vanda* & *Mokara* by choosing their selective measures. The application gives scientific knowledge and skills to farmers/growers/entrepreneurs and orchid lovers.	
Orchidopedia	Contains vast information about native orchid species that covers 56 genera including 172 species. Each species in the application defines and contains 16 attributes that gives informative details about the specie. This application specially designed to assist researchers, extension personnel of agriculture and farmers for to impart knowledge on orchid's species.	
Orchid Man	For maintaining orchid data records	
Orchid Pest Management	Provides information on orchid pest management	

Fig. 3. ICT based applications.

boxes for single floret or multiple florets, and dry flowers.

- Solar-powered cool carts for vendors/orchid carts. Orchid rentals. Orchid decorations for corporate and social events. Orchids in plug trays and plug panels.
- Collaborations with state governments/ stake holders/private partners to promote orchid clusters augmented with cool chains, marketing channels, and value-added chains.

Challenges

- Growers must anticipate and adapt to climate changes, explore climate-resilient cultivation practices, and develop new orchid-growing territories.
- Orchid cultivation involves the use of pesticides to protect the blooms from pests. However, the overdependence on these chemicals poses environmental risks, including soil and water contamination. Sustainable alternatives and integrated pest management strategies are imperative for mitigating these concerns.
- Unsustainable harvesting practices and habitat destruction not only disrupt ecosystems, but also threaten the biodiversity of natural orchid species. Conservation efforts and ethical sourcing have become paramount for addressing this environmental challenge.
- The implementation of eco-friendly transportation methods, such as carbon-neutral shipping or localized cultivation, has emerged as a critical consideration for environmentally conscious consumers and businesses.
- Orchid exports require stringent phytosanitary regulations imposed by the importing countries to prevent the spread of pests and diseases. Navigating these regulations requires meticulous adherence to inspection and certification processes, which adds complexity to the export journey.
- Orchid trade encounters intricacies in customs procedures and tariffs that vary across countries.

Table 5. Embedded drying of orchid in oven.

Species and Varieties	Recommendations
Vanda teres, Dendrobium moschatum, Arundina graminifolia, *Den*. 'Madam Pink', *Den*. 'Lervia', *Den.* 'Abraham', *Phal.* 'Casa Blanca', *Phal.* 'Detroit' and *Oncidium* 'Sweet Sugar'	Embedded drying with borax at 50°C in oven
Epidendrum spp., *Cattleya bowringiana* and Cattleya hybrids, *Phal*. 'Ox Plum Rose x Black Jack' and *Den.* 'Big White'.	Embedded drying with borax at 60°C in oven
Coelogyne flaccida, Coelogyne cristata, Dendrobium nobile, Dendrobium williamsonii, Dendrobium aphyllum, *Den*. 'Erika', *Den*. 'Big White 4N', *Den*. 'Bangkok Blue', *Phal.*'Nagasaki' and *Cym*. 'Sungold'	Embedded drying with borax and silica gel at 55°C in oven
Dendrobium, Phalaenopsis, Cattleya, Cymbidium, Aranda, Mokara hybrids	Perlite, Perlite + borax and Perlite + Silica gel under room condition (24-25°C and 75-79%RH)
Cattleya 'Guanmian City', *Dendrobium* 'Lervia, *Phalanopsis* 'Vienna ', *Vanda tessellata*, *Oncidium* 'Taka Yellow', *Phalaenopsis* 'Taida S.Red'	Embedded drying with sand at 50°C in oven
Den. 'Thongchai Gold', *Den.* 'Bangkok Blue', *Paphiopedilum*, *Vanda*, *Phalenopsis* 'Detroit', *Phalaenopsis* 'Buenos Aires'	Embedded drying with borax and silica gel at 45-55°C in oven
Phal. 'Nagasaki, *Phal.* 'Manchester', 'Boston', *Phal.* 'Detroit', *Den.* 'Emma White', *Den.* 'Lervia', *Den*. 'A. Abraham', *Den*. 'Triple Pink', Epidendrum spp. and *Cym.* 'Valley Teaser', *Cym.* 'N. Cherry', *Cym.* 'Bartha Peterson', and *Cym*. 'Platinum Gold'	Embedded drying with borax at 50-60°C in oven

The imposition of tariffs can affect orchid competitiveness in the global market. To maintain a competitive edge, exporters must stay abreast of evolving trade agreements and tariff structures.

- Orchids, especially rare and endangered species, fall under the purview of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Compliance with CITES regulations is essential to ensure legal and sustainable orchid trade and to safeguard both ecosystems and industry.
- Sustainable farming practices, such as organic cultivation methods and eco-friendly pest control have emerged as a pivotal solution to environmental concerns. This not only aligns with consumer preferences for ethically sourced

Table 6. Post-harvest technology in *Cymbidium*.

Particulars	Recommendations
Evaluation of elite hybrids for vase life	Bob Marlin Lucky (57 days), Fire Strom Blaze (53 days), Hazel Fay Tangerine (50 days), Everett Stockstill Bullai (48 days), Caripepper Peachy Keen (43 days), Hana Akari (41 days), Fire Storm Ruby (36 days)
Spike length and vase life of different classes of *Cymbidium*	Miniature (30-60cm): 30-34 daysIntermediate (60-75cm): 35-37 daysStandard (> 75cm): 55-59 days
Optimal stages of harvest of *Cymbidium* 'PCMV' for maximum vase life	Two buds opened stage (66.8 days)
Best impregnation treatment of *Cymbidium* 'PCMV' for maximum vase life	$CoCl_2$ (1000ppm) for 15 minutes (46 days)
Best pulsing treatment of *Cymbidium* for maximum vase life	5% sucrose for 8 hours (56 days)
Best pre-harvest spray of *Cymbidium* for maximum growth and vase life	GA_3 (50 ppm) + BA (200 ppm)
Best chemical treatment for opening of tight buds of *Cymbidium* cut flowers	Sucrose 4% + Salicylic acid 200 ppm with 75% opening and vase life of 45 days
Best holding solution for improved vase life of *Cymbidium*	2% sucrose + 200 ppm 8-HQS with vase life of 76.6 days
Best packaging material of *Cymbidium* spikes and florets for improved vase life	Cellophane (56 days)
Best harvesting stage of *Cymbidium* florets for improved vase life	Fully opened florets with vase life of 48 days.

Table.7 Post-harvest technology in *Dendrobium.*

Particulars	Recommendations
Evaluation of commercial hybrids of *Dendrobium* for vase life	Triple Pink (40 days), Emma White (37 days), Madam Pompadour (37 days), Erika (34.8 days), Ear Sakul (33.5 days), Thongchai Gold (30.4 days), Big White Jumbo (29.5 days), Kating Dang (28 days), Lervia (28 days), Daang Saard (27.5 days), Julie (25 days)
Best harvesting stage of *Dendrobium* for maximum vase life	50 % opened stage with 60 days of vase life
Best bud opening of *Dendrobium* for improved vase life	4% Sucrose + 100 ppm Salicylic acid
Best holding solution of *Dendrobium* for improved vase life	2% sucrose + 200 ppm ASA and 2% glucose + 100 ppm ASA were found as best holding solutions for maximum vase life (80 days) over control (without treatment) (48 days).

products but also contributes to the long-term health of orchid ecosystems.

- The orchid export industry can leverage technology, including blockchain, to enhance traceability and transparency in the supply chain. This will not only aid in regulatory compliance but also will build trust among consumers regarding the origin and production management of the orchids, they purchased.
- Collaborations amongst orchid exporters, regulatory bodies, and environmental organizations is crucial for collectively addressing challenges. Sharing best practices, fostering research initiatives, and collectively advocating sustainable policies can pave the way for a vibrant and responsible orchid exports industry.

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