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PGR Diversity and Economic Utilization of Orchids

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A B S T R A C T

Orchids are one of the highly commercial crops in floriculture sector and are robustly exploited due to the high ornamental and economic value. ICAR-NRC for Orchids Pakyong, Sikkim, India, majorly focused on collection, characterization, evaluation, conservation and utilization of genetic resources available in the country particularly in north-eastern region and developed a National repository of orchids. From 1996 to till date, several exploration programmes carried across the country and a total of 351 species under 94 genera was collected and conserved at this institute. Among the collections, 205 species were categorized as threatened species, followed by 90 species having breeding value, 87 species which are used in traditional medicine, 77 species having fragrance and 11 species were used in traditional dietary. Successful DNA bank of 260 species was constructed for future utilization in various research works. The collected orchid germplasm which includes native orchids was successfully utilized in breeding programme for development of novel varieties and hybrids. This paper aims that the status of collection and conservation, utilization of indigenous orchid germplasm resources at this institute reflecting ITPGRFA and CBD guidelines.

Introduction

Orchidaceae is one of the most ecologically and morphologically diverse families of flowering plants. It is the second largest family of flowering plants in the world, comprising of nearly 800 genera and 22,500 species (Mabberley, 2008; Meitei, 2019; Singh, 2019). Orchids are one such group of plants which grow in a variety of habitats throughout the globe, but they are very sensitive to habitat change. Understanding the prospects, horticultural and medicinal value, and the family is gaining much attention throughout the world to unfold the biology, evolution, taxonomy, cytology, chemistry, hybridization and cultivation etc. In North East India, many orchids are used for different

purposes such as ornamentals, medicine, food, also in socio-cultural events (Deb and Imchen, 2008; Deb, 2009; Medhi and Chakrabarti, 2009). Orchids are used as cut flowers, bouquet, loose flowers, dried flowers, as single flower mountings, potted plant display, in perfumery industries and by products in handicrafts (Singh, 2019).

ICAR- NRC for Orchids, Pakyong exclusively working on orchid breeding as well as production of quality planting materials which are considered as major bottlenecks in the development of orchid industry (Meitei *et al.,* 2019). This institute plays a crucial role for with an aim that of research was on collection, characterization, evaluation, conservation conserving the indigenous orchid resources and utilization of genetic resources available in the country particularly in north-eastern region. And carry out research in identification, isolation, characterization of novel genes from native species, development of hybrids for commercial cultivation. And the institute is one of the National Active Germplasm Sites (NAGS) units in the Indian Plant genetic resource information system. This paper aims that the status of collection and conservation, utilization of indigenous orchid germplasm resources at this institute.

Materials and Methods

Several exploration programmes were carried since 1996 for collecting the valuable orchid germplasm various parts of the country (Fig. 1). Structural and well planned explorations conducted in the orchid rich biodiversity hotspots. Plant material in the form of plantlets, bulbs, capsule fruits, seeds and floral parts were collected and these plant materials was acclimatized and conserved in ICAR-NRCO polyhouses and used for breeding programmes. The collected orchids were identified up to the species to tribe level with the help of published literature such as, Hooker (1888–1890), Blatter (1928), Pradhan (1976), Bose and Bhattacharjee (1980), Rao (1998), Ahmedullah and Nayar (1987), Ansari and Balakrishnan (1990), Kumar and Manilal (1994), Lakshminarasimhan (1996), Nayar (1996), Karthikeyan (2000), Singh (2001), Pearce and Cribb (2002) Mishra (2007), Lucksom (2007, 2011), Mabberley (2008) Rampal and Singh (2016) and Singh (2019). The online databases, namely, Govaerts (2012) http://apps. Kew.org/wcsp, Tropicos (2018) www.tropicos.org, IPNI (2018) www.ipni.org, eFloras (2018) www.efloras.org, www.theplantlist.org (2018) were also consulted for recent updates on the plant names and distribution. The species were confirmed with the help of herbaria of The Botanical Survey of India, (CAL) and Regional Centre (BHSC), Gangtok, Sikkim, Sikkim University, Sikkim (SKM) and were visited and data on habitat, locality, altitude and flowering were gathered. Based on this information past localities from where the species were collected were also visited, to know the present status and changes in population-size if any. The RET orchid species are listed based on IUCN red list category, the economic importance and mode of utilization of the species such as medicinal, dietary and breeding purposes are also provided (Table 1). *Ex-situ* conservation of orchids in the institute poly houses and new techniques developed for conservation of orchids through indigenous technologies and DNA barcoding for few species were carried.

DNA barcoding of Indian orchids

The conservation of orchids is carried out considering their status in the habitat. The basis of conservation is laid on the basis of certain objectives such as conservation of threatened species, Molecular approaches, such as DNA-based methods have transformed understanding and appreciation of conservation issues associated with orchids.

Molecular data provide an empirical framework through which conservation practitioners are in a more informed position to define priorities, reduce costs and optimize management decisions (Zaman, 1998). In particular, molecular data enable conservationists to address questions of genetic variation within and between populations, species or provenance delimitation and the maintenance of evolutionary processes (Fay and Krauss, 2003).

Results and Discussion

A total of 351 species from 94 genera were collected through several explorations carried across the country. Among the collections, 205 species were categorized as threatened species, followed by 90 species having breeding value, 87 species which are used in traditional medicine, 77 species having fragrance and 11 species were used in traditional dietary (Table 1). The genus *Dendrobium* representing highest number of species (68), followed by *Bulbophyllum* (30), *Cymbidium* (21), *Coelogyne* (19), *Calanthe* (12), *Liparis* (11), *Vanda* (10), *Eria* (9), *Pinalia* (8), *Paphiopedilum* (7), *Aerides, Gastrochilus, Oberonia, Pholidota* (6), *Cleistostoma, Goodyera* (5), *Luisia, Papilonanthe, Phalaenopsis, Pleione, Sunipia* (3), *Agrostophyllum, Crepidium, Epidendrum, Micropera, Otochilus, Phaius, Thunia,Zeuxine* (3), *Acampe, Ascocentrum, Callostylis, Ceratostylis, Cryptochilus, Esmeralda, Habenaria, Herminium, Panisea, Phreatia, Thelasis* and 45 genus representing single species respectively (Fig. 1–5).

Importance of orchids

Breeding value

Plant Breeders carry out the hybridization program based on various objectives such as better flower colour, shape and size, length of inflorescence, increasing number of flowers, producing miniature forms, blooming season and period, fragrant harbouring, suitable potted plants, hybrids for different temperature and light regimes; resistant lines for biotic and abiotic stresses etc. A total of 90 species having potential breeding value which was conserved at the institute in the following genera *viz., Calanthe, Cymbidium, Dendrobium, Phalaenopsis, Cattleya, Oncidium, Platanthera, Masdevallia, Paphiopedilum and Vanda* were utilized in breeding programmes to develop hybrids or improve lines. Subsequent milestones have been marked in the field of hybrid development throughout the globe using modern technologies and approaches. Extensive researches *viz.* species compatibility, apomixis, genetic engineering, mutation breeding, ploidy breeding etc., have been done by utilizing the natural species and hybrids in the orchid improvement programmes. Populations were developed viz., intergeneric combination (1 no.), primary species hybrid combinations (5 no.), secondary hybrid (10 no.), tertiary hybrid combinations (11 no.) and somaclonal mutants (2 no.) using existing germplasm collections. Of which, 18 breeding lines/ genetic stocks are registered with national register for IC numbers with national gene back ICAR-NBPGR, New Delhi and 45 breeding lines were submitted. The State flower of Mizoram and endangered species, *Renanthera imschootiana* known as 'Red Vanda' was registered with NBPGR (IC 566525/INGR 10113) for floral characters in 2010. In the year 2012, the breeding cycle of orchids was re-invented in India after the flowering of primary hybrid from first indigenous cross, PBX-05-56/2012 (*C. lowianum* x *C. tigrinum*), which was earlier bred by R.I. Measures in 1903 from United Kingdom. Two scented lines PBX-05-772 ad PBX-05-751 were developed by 2013 using native scented

species, *Cymbidium iridiodes* as male parent. The three varieties *viz.*, 'B. S. Basnet'(*Cymbidium*) from *C. lowianum* x *C. tigrinum*, 'Kunga Gyatso' (*Aranda*) from (*Arachnis clarkii* x *Vanda coerulea*) and 'V. Nagaraju' (*Dendrobium*) were identified at institution level for cultivation based on VCU basis. In 2016, Paphiopedilum variety (Lady's Slipper Orchid) 'Sheetal 1' (IC 614753) was filed with PPVFRA, New Delhi for legal protection and received acknowledgement (No: REG/2016/1534 date: 16.09.2016). Cross variability in Moth Orchid (Phalaenopsis) breeding lines (PBX-12-99) derived exotic varieties as parents was established during 2016. Promising Vanda breeding lines (PBX-12-169) using native bred species with commercial hybrid resulted from cross breeding was established by 2017.

Behavior pattern of Asiatic *Dendrobium* species at both intra and inter-sectional compatibility at species level and with modern hybrids was established and reported (Devadas 2016). High compatibility nature among Indian *Cymbidium* species and as well as with modern Cymbidium hybrids was reported (Devadas, 2013, 2014) and *Vanda* species was proven (in press). High level of incompatibility was observed *Phaius* genera with other Orchid genera, like similar sympodial orchids like *Calanthe, Coelogyne, Phalaenopsis, Lycaste, Dienia, Cymbidium, Thunia, Paphiopedilum, Coelogyne, Eria* and monopodial orchids like *Paplionanthe, Dendrobium, Arundina* and *Vanda*. However, primary species hybrid was made with *Phaius* using native species in both direct (PBX-11-22) and reciprocal combinations (PBX-11-25), where the natural hybrid was never reported earlier (Devadas, 2019).

Socio-cultural importance

The beautiful fox-tail orchid (*Rhynchostylis retusa*) locally called 'Kopou Phul'in Assam is worn by ladies on their head as ornament during different festival especially during 'Bihu' festival in Assam. It symbolizes youthfulness during springtime a symbol of love by the youth of the Ahom community (Deb 2013; Medhi and Chakrabarti, 2009). In Nagaland, *Dendrobium hookerianum, Dendrobium nobile*symbolizes purity and holiness. *Dendrobium acinaforme* plant is worn by the head hunting community with the belief giving courage and good luck in their hunt (Deb and Imchen, 2008). In Manipur (erstwhile *Kangleipak*), orchids origination are defined in many historic mentioned and ceremony. The flowers of orchids such as *Vanda tessellata* and *Coelogyne nitida* are used during local festivals in Assam and Arunachal Pradesh and *Papilionanthe teres* flowers are used by the *Tai* ethnics of Assam and Arunachal Pradesh for offerings to Lord Budha and spirits (Medhi and Chakrabarti, 2009). This species are conserved and used in breeding programmes at this institute.

Orchids used in medicine

The medicinal value of orchids is found to be recorded as early as 250 – 300 B.C. by *Susruta* and *Vagbhata* respectively, from ancient Sanskrit. Many orchids are used in traditional medicine treatment as a remedy for several ailments since ancient times. Orchid genera which were used for medicinal purpose Medicinal orchids mainly belong to genera: *Calanthe, Coelogyne, Cymbidium, Cypipedium, Dendrobium, Ephemerantha, Eria, Galeola, Gastrodia, Gymnadenia, Habenaria, Ludisia, Luisia, Nevilia* and *Thunia* (Gutierrez, 2010). In India, some orchids like *Eulophia campestris*, *Orchis latifolia*, *Vanda roxburgii* have drawn the attention of scientific community because of their medicinal properties (Singh *et al.*, 2009). *Dendrobium macraei* and*D. nobile* are another important orchids from Ayurvedic point of view as it is reported to be source of Jivant (Kasera 2001; Meitei 2019).

Table.1 List of orchid species collected and conserved at ICAR-NRC for orchids

S. No.	Botanical Name	RET status	Medicinal value	Dietary suppliment	Fragrant	Breeding value	Remarks
1	*Acampe praemorsa* (Roxb.) Blatt. and McCann		√		√		
2	*Acampe rigida* (Buch.-Ham. ex Sm.) P.F.Hunt	√	√		√		
3	*Acanthephippium sylhetense* Lindl.	√			√		
4	*Acrochaene punctata* Lindl.	√					
5	*Aerides crispa* Lindl.	√					
6	*Aerides maculosa* Lindl.	√			√		Endemic
7	*Aerides multiflora* Roxb.		√		√		
8	*Aerides odorata* Lour.		√		√		
9	*Aerides rosea* Lodd. ex Lindl. and Paxton	√	√		√		
10	*Agrostophyllum brevipes* King and Pantl.		√				
11	*Agrostophyllum callosum* Rchb.f.		√				
12	*Agrostophyllum planicaule* (Wall. ex Lindl.) Rchb.f.						
13	*Anthogonium gracile* Wall. ex Lindl.		√				
14	*Anthogonium gracile* Wall. ex Lindl. (White variant)						Variant
15	*Arachnis labrosa* (Lindl. and Paxton) Rchb.f.					√	
16	*Arundina graminifolia* (D.Don) Hochr.	√	√				
17	*Ascocentrum ampullaceum* (Roxb.) Schltr.	√				√	
18	*Ascocentrum aurantiacum* Schltr.					√	
19	*Bulbophyllum affine* Wall. ex Lindl.	√					
20	*Bulbophyllum careyanum* (Hook.) Spreng.	√	√				
21	*Bulbophyllum caudatum* Lindl.						
22	*Bulbophyllum cauliflorum* Hook. f.	√					
23	*Bulbophyllum crassipes* Hook.f.	√					
24	*Bulbophyllum cylindraceum* Wall. ex Lindl.	√					
25	*Bulbophyllum eublepharum* Rchb.f.	√					
26	*Bulbophyllum fimbriatum* (Lindl.) Rchb.f.						
27	*Bulbophyllum fischeri* Seidenf.	√					
28	*Bulbophyllum guttulatum* (Hook.f.) N.P.Balakr.	√					
29	*Bulbophyllum gymnopus* Hook.f.	√					
30	*Bulbophyllum hirtum* (Sm.) Lindl. ex Wall.	√			√		
31	*Bulbophyllum interpositum* J.J.Verm., Schuilt. and de Vogel						

32	*Bulbophyllum jejosephii* J.J.Verm., Schuit. and de Vogel						Endemic
33	*Bulbophyllum leopardinum* (Wall.) Lindl. ex Wall.	√	√		√	√	
34	*Bulbophyllum mysorense* (Rolfe) J.J.Sm.	√					Endemic
35	*Bulbophyllum nodosum* (Rolfe) J.J.Sm.	√					Endemic
36	*Bulbophyllum odoratissimum* (Sm.) Lindl. ex Wall.	√	√		√		
37	*Bulbophyllum polyrrhizum* Lindl.	√					
38	*Bulbophyllum protractum* Hook.f.	√					
39	*Bulbophyllum refractum* (Zoll.) Rchb.f.						
40	*Bulbophyllum repens* Griff.	√					
41	*Bulbophyllum reptans (Lindl.) Lindl. ex Wall.*	√					
42	*Bulbophyllum rigidum* King and Pantl.	√					
43	*Bulbophyllum roxburghii* (Lindl.) Rchb.f.	√					
44	*Bulbophyllum sarcophyllum (King and Pantl.) J.J.Sm.*						
45	*Bulbophyllum sterile* (Lam.) Suresh		√				Endemic
46	*Bulbophyllum striatum* (Griff.) Rchb.f.	√					
47	*Bulbophyllum trichocephalum* (Schltr.) Tang&F.T.Wang *var trichocephalum*						
48	*Bulbophyllum triste* Rchb.f.	√					
49	*Bulbophyllum umbellatum Lindl.*						
50	*Bulbophyllum viridiflorum* (Hook.f.) Schltr.	√					
51	*Bulbophyllum wallichii* Rchb.f.	√					
52	*Bulleyia yunnanensis* Schltr.	√					
53	*Calanthe biloba Lindl.*	√					
54	*Calanthe brevicornu Lindl.*	√				√	
55	*Calanthe chloroleuca* Lindl.					√	
56	*Calanthe davidii* Franch.	√				√	
57	*Calanthe herbacea Lindl.*	√					
58	*Calanthe mannii* Hook.f.	√				√	
59	*Calanthe plantaginea Lindl.*	√	√				
60	*Calanthe puberula Lindl.*	√	√			√	
61	*Calanthe sylvatica* (Thouars) Lindl.	√	√			√	
62	*Calanthe triplicata* (Willemet) Ames	√				√	
63	*Calanthe trulliformis* King and Pantl.						
64	*Calanthe yuksomnensis* Lucksom	√				√	Endemic
65	*Callostylis bambusifolia* (Lindl.) S.C.Chen and J.J.Wood	√	√				
66	*Callostylis rigida* Blume						

67	*Cephalantheropsis obcordata* (Lindl.) Ormerod				√		
68	*Ceratostylis himalaica* Hook.f.						
69	*Ceratostylis subulata* Blume	√					
70	*Chiloschista parishii* Seidenf.						
71	*Chrysoglossum ornatum* Blume	√					
72	*Cleisocentron pallens* (Cathcart ex Lindl.) N.Pearce and P.J.Cribb						Endemic
73	*Cleisostoma appendiculatum* (Lindl.) Benth. and Hook.f. ex B.D.Jacks.	√					
74	*Cleisostoma filiforme* (Lindl.) Garay						
75	*Cleisostoma linearilobatum* (Seidenf. and Smitinand) Garay						
76	*Cleisostoma subulatum* Blume						
77	*Cleisostoma tenuifolium* (L.) Garay					√	
78	*Coelogyne barbata* Lindl. ex Griff.	√			√	√	
79	*Coelogyne breviscapa* Lindl	√				√	
80	*Coelogyne corymbosa Lindl.*	√	√		√	√	
81	*Coelogyne cristata* Lindl.	√	√		√		
82	*Coelogyne elata* Lindl.						
83	*Coelogyne fimbriata Lindl.*		√				
84	*Coelogyne flaccida* Lindl.	√	√			√	
85	*Coelogyne fuscescens* Lindl.	√	√				
86	*Coelogyne hitendrae S.Das and S.K.Jain*	√					Endemic
87	*Coelogyne longipes Lindl.*	√			√	√	
88	*Coelogyne nitida* (Wall. ex D.Don) Lindl.	√	√		√		
89	*Coelogyne occultata Hook.f.*	√			√		
90	*Coelogyne ovalis* Lindl.	√	√		√		
91	*Coelogyne pempahisheyana* H.J.Chowdhery						
92	*Coelogyne prolifera* Lindl.	√	√				
93	*Coelogyne punctulata* Lindl.	√	√				
94	*Coelogyne stricta* (D.Don) Schltr.	√	√				
95	*Coelogyne suaveolens* (Lindl.) Hook.f.	√					
96	*Coelogyne viscosa* Rchb.f.	√			√		
97	*Conchidium muscicola* (Lindl.) Rauschert		√				
98	*Cottonia peduncularis* (Lindl.) Rchb.f.						
99	*Cremastra appendiculata (D.Don) Makino*		√	√			
100	*Crepidium acuminatum (D.Don) Szlach.*	√	√	√			
101	*Crepidium bidentiferum (J.J.Sm.) Marg. and Szlach.*						

102	*Crepidium khasianum (Hook.f.) Szlach.*						
103	*Cryptochilus luteus Lindl.*						
104	*Cryptochilus sanguineus* Wall.						
105	*Cymbidium aloifolium* (L) Sw.	√	√				
106	*Cymbidium bicolor* Lindl.	√					
107	*Cymbidium cochleare* Lindl.	√					
108	*Cymbidium cyperifolium* Wall. ex Lindl.	√			√		
109	*Cymbidium dayanum* Rchb.f.	√			√	√	
110	*Cymbidium devonianum* Paxton	√	√			√	
111	*Cymbidium eburneum* Lindl	√	√			√	
112	*Cymbidium elegans* Lindl.	√	√				
113	*Cymbidium ensifolium* (L.) Sw.	√					
114	*Cymbidium erythraeum* Lindl					√	
115	*Cymbidium gammieanum* King and Pantl.	√					
116	*Cymbidium hookerianum* Rchb.f.		√	√	√	√	
117	*Cymbidium iridioides* D.Don	√	√		√	√	
118	*Cymbidium lancifolium* Hook.	√				√	
119	*Cymbidium lowianum* (Rchb.f.) Rchb.f.					√	
120	Cymbidium macrorhizon Lindl.	√	√				
121	*Cymbidium mastersii* Griff. ex Lindl.	√			√	√	
122	*Cymbidium munronianum* King and Pantl				√	√	
123	*Cymbidium tigrinum C.S.P.Parish ex Hook.*	√				√	
124	*Cymbidium tracyanum* L.Castle	√				√	
125	*Dendrobium acinaciforme* Roxb.	√					
126	*Dendrobium aduncum* Lindl.	√			√		
127	*Dendrobium amoenum Wall. ex Lindl.*	√	√		√		
128	*Dendrobium amplum* Lindl.						
129	*Dendrobium anceps* Sw.	√					
130	*Dendrobium aphyllum* (Roxb.) C.E.C.Fisch.	√	√		√		
131	*Dendrobium aqueum* Lindl.	√					Endemic
132	*Dendrobium bellatulum* Rolfe	√			√	√	
133	*Dendrobium bensoniae* Rchb.f.	√					
134	*Dendrobium bicameratum* Lindl.	√					
135	*Dendrobium capillipes* Rchb.f.						
136	*Dendrobium chrysanthum* Wall. ex Lindl.	√	√				
137	*Dendrobium chryseum* Rolfe	√				√	
138	*Dendrobium chrysotoxum* Lindl.	√	√	√	√		
139	*Dendrobium crepidatum* Lindl. and Paxton	√	√			√	
140	*Dendrobium crumenatum* Sw.	√					
141	*Dendrobium cumulatum* Lindl.					√	

142	*Dendrobium densiflorum* Lindl.	√	√		√		
143	*Dendrobium denudans* D.Don	√	√		√		
144	*Dendrobium devonianum* Paxton	√	√				
145	*Dendrobium draconis* Rchb.f.	√			√	√	
146	*Dendrobium eriiflorum* Griff.	√	√		√		
147	*Dendrobium falconeri* Hook.	√	√		√	√	
148	*Dendrobium farmeri* Paxton	√					
149	*Dendrobium fimbriatum* Hook.	√	√		√		
150	*Dendrobium fimbriatum* var. oculatum					√	
151	*Dendrobium formosum* Roxb. ex Lindl.	√					
152	*Dendrobium fugax* Rchb.f.	√	√				
153	*Dendrobium gratiosissimum* Rchb.f.	√					
154	*Dendrobium herbaceum* Lindl.	√					Endemic
155	*Dendrobium heterocarpum* Wall. ex Lindl.	√	√		√		
156	*Dendrobium hookerianum* Lindl.	√			√	√	
157	*Dendrobium infundibulum* Lindl.	√					
158	*Dendrobium jenkinsii* Wall. ex Lindl.	√	√				
159	*Dendrobium kingianum Bidwill ex Lindl.*			√			
160	*Dendrobium lindleyi Steud.*	√			√		
161	*Dendrobium lituiflorum* Lindl.	√					
162	*Dendrobium loddigesii* Rolfe						
163	*Dendrobium longicornu Lindl.*	√	√		√		
164	*Dendrobium macraei* Lindl.		√				
165	*Dendrobium macrostachyum* Lindl.	√			√		
166	*Dendrobium moniliforme (L.) Sw.*	√	√		√		
167	*Dendrobium moschatum* (Buch.-Ham.) Sw.	√	√		√		
168	*Dendrobium nanum* Hook.f.	√				√	Endemic
169	*Dendrobium nobile* Lindl.	√	√	√	√	√	
170	*Dendrobium nobile* Lindl. (White-albus)	√	√	√		√	Variant
171	*Dendrobium nobile* Lindl. (Var. schroderianum)	√	√	√		√	Variant
172	*Dendrobium nodosum* Dalzell	√					
173	*Dendrobium ochreatum* Lindl.	√			√		
174	*Dendrobium ovatum* (L.) Kraenzl.	√				√	Endemic
175	*Dendrobium parishii* Rchb.f.	√			√	√	
176	*Dendrobium pendulum* Roxb.	√					
177	*Dendrobium plicatile.* (Lindl.)	√			√		
178	*Dendrobium polyanthum* Wall. ex Lindl.	√			√		
179	*Dendrobium porphyrochilum Lindl.*	√					
180	*Dendrobium praecinctum* Rchb.f.	√				√	

181	*Dendrobium primulinum* Lindl.						
182	*Dendrobium pulchellum* Roxb. ex Lindl.	√			√		
183	*Dendrobium rotundatum* (Lindl.) Hook.f.						
184	*Dendrobium ruckeri* Lindl.			√			
185	*Dendrobium salaccense* (Blume) Lindl.	√					
186	*Dendrobium stuposum* Lindl.	√					
187	*Dendrobium sulcatum* Lindl.	√					
188	*Dendrobium terminale* E.C.Parish and Rchb.f.	√					
189	*Dendrobium thyrsiflorum* B.S.Williams	√			√		
190	*Dendrobium transparens* Wall. ex Lindl.	√	√		√	√	
191	*Dendrobium wardianum* R.Warner	√			√	√	
192	*Dendrobium williamsonii* Day and Rchb.f.	√			√	√	
193	*Dienia ophrydis* (J.Koenig) Seidenf.						
194	*Diplocentrum recurvum* Lindl.	√					
195	*Diplomeris hirsuta* (Lindl.) Lindl.	√					
196	*Epidendrum ellipticum* Graham					√	Exotic
197	*Epidendrum radicans* Pav. ex Lindl.					√	Exotic
198	*Epidendrum xanthinum* Lindl.					√	Exotic
199	*Epipogium roseum* (D.Don) Lindl.	√					
200	*Eria clausa King and Pantl.*						
201	*Eria coronaria* (Lindl.)Rchb.f.				√		
202	*Eria ferruginea* Lindl.						
203	*Eria globulifera Seidenf.*						
204	*Eria javanica* (Sw.) Blume	√			√		
205	*Eria lasiopetala* (Willd.) Ormerod	√					
206	*Eria porteri* Seidenf. and A.D.Kerr						
207	*Eria sutepensis* Rolfe ex Downie				√		
208	*Eria tomentosa* (J.Koenig) Hook.f.						
209	*Eria vittata Lindl.*						
210	*Esmeralda cathcartii* (Lindl.) Rchb.f.				√	√	
211	*Esmeralda clarkei* Rchb.f.	√			√	√	
212	*Eulophia pulchra* (Thouars) Lindl	√					
213	*Gastrochilus acutifolius* (Lindl.) Kuntze				√		
214	*Gastrochilus calceolaris* (Buch.-Ham. ex Sm.) D.Don						
215	*Gastrochilus dasypogon* (Sm.) Kuntze	√					
216	*Gastrochilus distichus (Lindl.) Kuntze*	√					
217	*Gastrochilus inconspicuus* (Hook.f.) Kuntze	√					
218	*Gastrochilus pseudodistichus (King and Pantl.) Schltr.*						

219	*Geodorum densiflorum* (Lam.) Schltr.	√	√				
210	*Goodyera foliosa (Lindl.) Benth. ex C.B.Clarke*						
211	*Goodyera hispida Lindl.*						
212	*Goodyera hemsleyana King and Pantl.*						
213	*Goodyera procera* (Ker Gawl.) Hook.	√			√		
214	*Goodyera schlechtendaliana Rchb.f.*		√				
215	*Guarianthe bowringiana* (O'Brien) Dressler and W.E.Higgins						Exotic
216	*Habenaria arietina Hook.f.*				√		
217	*Habenaria furcifera Lindl.*	√	√				
218	*Herminium lanceum (Thunb. ex Sw.) Vuijk*		√				
219	*Herminium mackinnonii Duthei*	√					
220	*Herpysma longicaulis Lindl.*	√					
221	*Holcoglossum amesianum* (Rchb.f.) Christenson	√				√	
222	*Hygrochilus parishii* (Veitch and Rchb.f.) Pfitzer	√				√	
223	*Liparis bistriata* E.C.Parish and Rchb.f.						
224	*Liparis bootanensis Griff.*						
225	*Liparis cespitosa* (Lam.) Lindl.						
226	*Liparis cordifolia Hook.f.*						
227	*Liparis deflexa Hook.f.*						
228	*Liparis elliptica* Wight						
229	*Liparis odorata (Willd.) Lindl.*		√				
230	*Liparis latifolia Lindl.*						
231	*Liparis plantaginea* Lindl.						
232	*Liparis resupinata Ridl.*						
233	*Liparis viridiflora* (Blume) Lindl.	√					
234	*Luisia brachystachys* (Lindl.) Blume	√					
235	*Luisia filiformis* Hook.f.	√					
236	*Luisia trichorrhiza* (Hook.) Blume		√				
237	*Luisia tristis* (G.Forst.) Hook.f.	√	√				
238	*Lycaste cruenta* (Lindl.) Lindl.					√	Exotic
239	*Malaxis rheedii* B. Heyne ex Wallace						
240	*Masdevallia ignea* Rchb.f.						Exotic
241	*Micropera mannii* (Hook.f.) Tang and F.T.Wang						
242	*Micropera obtusa* (Lindl.) Tang and F.T.Wang						
243	*Micropera pallida* (Roxb.) Lindl.						

244	*Mormolyca rufescens* (Lindl.) M.A.Blanco						
245	*Mycaranthes floribunda* (D.Don) S.C.Chen and J.J.Wood						
246	*Neogyna gardneriana (Lindl.) Rchb.f.*						
247	*Nervilia macroglossa* (Hook.f.) Schltr.	√	√				
248	*Oberonia acaulis Griff.*						
249	*Oberonia cylindrica* Lindl.						
250	*Oberonia emarginata* King and Pantl.						
251	*Oberonia obcordata Lindl.*						
252	*Oberonia pachyrachis Rchb.f. ex Hook.f.*						
253	*Oberonia prainiana* King and Pantl.	√					
254	*Odontochilus lanceolatus (Lindl.) Blume*						
255	*Ornithochilus difformis* (Wall. ex Lindl.) Schltr.				√		
256	*Otochilus albus Lindl.*		√				
257	*Otochilus fuscus* Lindl.						
258	*Otochilus porrectus Lindl.*						
259	*Panisea demissa* (D.Don) Pfitzer						
260	*Panisea uniflora* (Lindl.) Lindl.					√	
261	*Paphiopedilum fairrieanum (Lindl.) Stein*	√				√	
262	*Paphiopedilum hirsutissimum* (Lindl. ex Hook.) Stein	√				√	
263	*Paphiopedilum insigne* (Wall. ex Lindl.) Pfitzer	√				√	
264	*Paphiopedilum spicerianum* (Rchb.f.) Pfitzer	√				√	
265	*Paphiopedilum venustum* (Wall. ex Sims) Pfitzer	√				√	
266	*Paphiopedilum villosum* (Lindl.) Stein	√	√			√	
267	*Paphiopedilum villosum* var. *boxallii* (Rchb.f.) Pfitzer	√				√	
268	*Papilionanthe subulata* (Willd.) Garay		√			√	
269	*Papilionanthe teres* (Roxb.) Schltr.	√	√			√	
270	*Papilionanthe uniflora* (Lindl.) Garay						
271	*Papilionanthe vandarum* (Rchb.f.) Garay	√			√		
272	*Pelatantheria insectifera* (Rchb.f.) Ridl.	√				√	
273	*Phaius flavus* (Blume) Lindl.	√			√	√	
274	*Phaius mishmensis* (Lindl. and Paxton) Rchb.f.	√				√	
275	*Phaius tankervilleae* (Banks) Blume	√	√		√	√	
276	*Phalaenopsis deliciosa* Rchb.f.	√				√	
277	*Phalaenopsis lobbii* (Rchb.f.) H.R.Sweet	√				√	

278	*Phalaenopsis mannii* Rchb.f.	√			√		
279	*Phalaenopsis taenialis* (Lindl.) Christenson and Pradhan	√					
280	*Pholidota articulata* Lindl.	√	√		√		
281	*Pholidota imbricata* Lindl.	√	√		√		
282	*Pholidota pallida* Lindl.	√					
283	*Pholidota protracta Hook.f.*						
284	*Pholidota recurva* Lindl.						
285	*Phreatia elegans* Lindl.						
286	*Phreatia laxiflora* (Blume) Lindl.						
287	*Pinalia acervata* (Lindl.) Kuntze				√		
288	*Pinalia amica* (Rchb.f.) Kuntze						
289	*Pinalia bipunctata* (Lindl.) Kuntze						
290	*Pinalia bractescens*(Lindl.) Kuntze						
291	*Pinalia excavata (Lindl.) Kuntze*						
292	*Pinalia graminifolia (Lindl.) Kuntze*						
293	*Pinalia pumila* (Lindl.) Kuntze	√					
294	*Pinalia spicata* (D.Don) S.C.Chen and J.J.Wood	√	√				
295	*Platanthera clavigera Lindl.*					√	
296	*Pleione hookeriana* (Lindl.) Rollisson	√				√	
297	*Pleione humilis* (Sm.) D.Don	√	√		√	√	
298	*Pleione maculata* (Lindl.) Lindl. and Paxton	√	√		√	√	
299	*Pleione praecox* (Sm.) D.Don	√	√		√	√	
300	*Podochilus cultratus* Lindl.						
301	*Podochilus malabaricus* Wight						
302	*Polystachya concreta* (Jacq.) Garay and H.R.Sweet	√					
303	*Pomatocalpa armigerum* (King and Pantl.) Tang and F.T.Wang						
304	*Pteroceras teres* (Blume) Holttum					√	
305	*Renanthera imschootiana Rolfe*					√	
306	*Rhynchostylis retusa* (L.) Blume	√	√		√	√	
307	*Satyrium nepalense D.Don*		√	√	√		
308	*Schoenorchis gemmata* (Lindl.) J.J.Sm.	√					
309	*Schoenorchis smeeana* (Rchb.f.)						Endemic
310	*Sirhookera latifolia* (Wight) Kuntze						
311	*Smitinandia micrantha* (Lindl.) Holttum	√	√				
312	*Spiranthes sinensis* (Pers.) Ames	√					
313	*Staurochilus ramosus* (Lindl.) Seidenf.	√					

314	*Sunipia bicolor*Lindl.	√					
315	*Sunipia cirrhata*(Lindl.) P. F. Hunt	√					
316	*Sunipia scariosa Lindl.*						
317	*Taeniophyllum retrospiculatum* (King and Pantl.) King and Pantl.						
318	*Tainia minor* Hook.f.						
319	*Thelasis longifolia* Hook.f.	√					
320	*Thelasis pygmaea* (Griff.) Lindl.						
321	*Thrixspermum musciflorum* A.S.Rao and J.Joseph	√					Endemic
322	*Thunia alba* (Lindl.) Rchb.f.	√	√			√	
323	*Thunia alba* var. *bracteata* (Roxb.) N. Pearce and P.J. Cribb					√	
324	*Thunia alba var. marshalliana* (Rchb.f.)						
325	*Uncifera obtusifolia* Lindl.		√				
326	*Vanda alpina* (Lindl.) Lindl.	√			√	√	
327	*Vanda coerulea* Griff. ex Lindl.		√			√	
328	*Vanda cristata* Wall. ex Lindl.		√			√	
329	*Vanda griffithii* Lindl.					√	
340	*Vanda motesiana* Choltco						
341	*Vanda pumila* Hook.f.					√	
342	*Vanda tessellata* (Roxb.) Hook. ex G.Don	√	√	√		√	
343	*Vanda testacea* (Lindl.) Rchb.f.	√	√			√	
344	*Vanda thwaitesii* Hook.f.	√					
345	*Vanda wightii* Rchb.f.	√					
346	*Vandopsis undulata (Lindl.) J.J.Sm.*	√			√		
348	*Vanillaaphylla Blume*					√	
348	Zeuxine affinis (Lindl.) Benth. ex Hook.f.						
349	*Zeuxine flava* (Wall. ex Lindl.) Trimen						
350	*Zeuxine goodyeroides* Lindl.						
351	*Zygopetalum maculatum* (Kunth) Garay				√	√	Exotic
	Total	**205**	**87**	**11**	**77**	**90**	

Fig.1 Orchid germplasm collecting states across the country

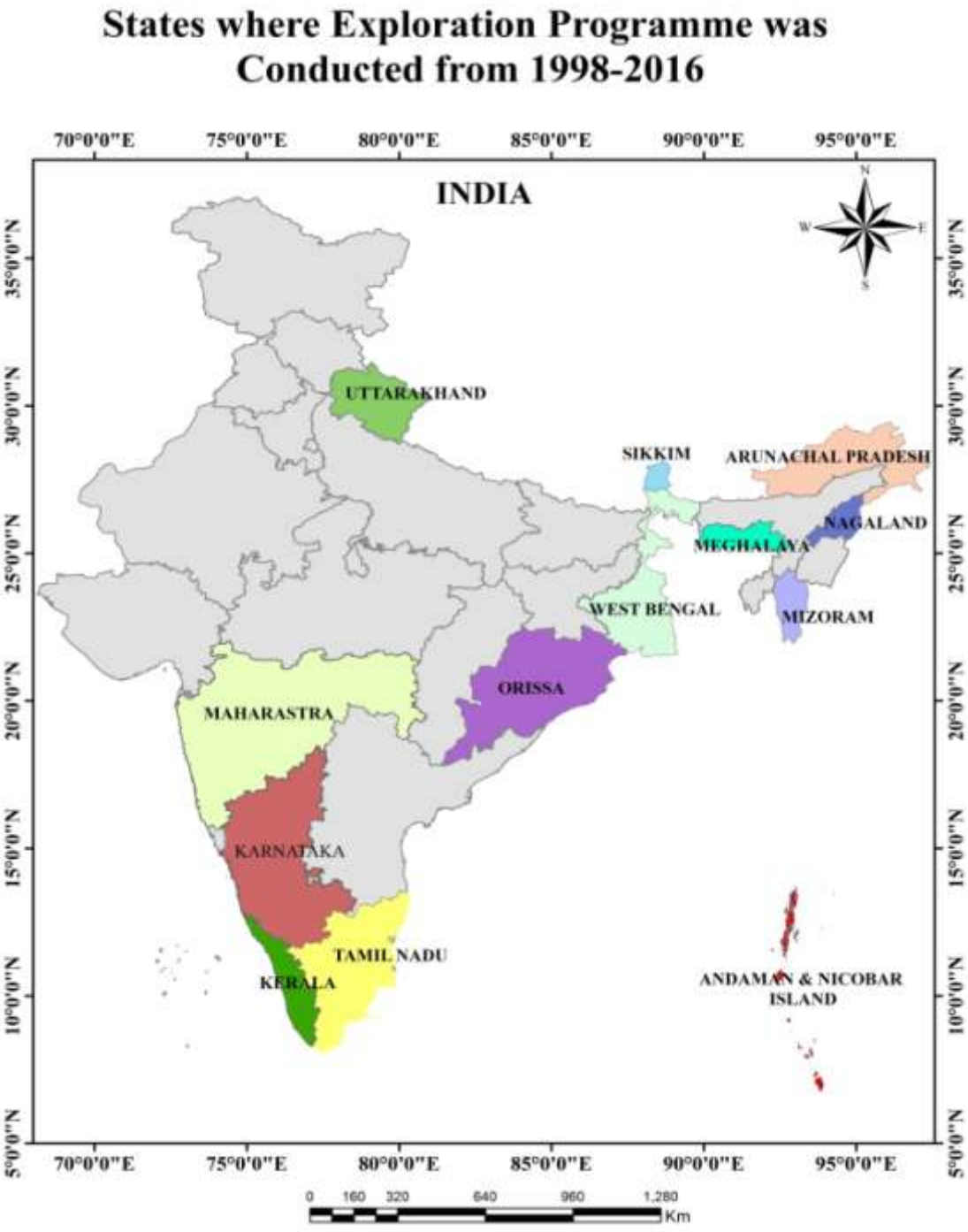


Fig.2 List of rare species which are conserved at ICAR-NRCO

Diplomeris hirsuta (Lindl.)Lindl.*Dendrobium draconis Rchb.f.Vanda coerulea*

Griff.exLindl

Paphiopedilum villosum (Lindl.)Stein*Dendrobium praecinctum* Rchb.f.*Renanthera imschootiana* Rolfe

*Phalaenopsis lobbii (*Rchb.f.) Sweet*Paphiopedilum fairrieanum* (Lindl.)Stein*Paphiopedilum hirsutissimum* (Lindl. ex Hook.) Stein

Dendrobium ruckeri Lindl. *Vanda pumila* Hook.f.*Pleione maculata* (Lindl.)Lindl.& Paxton

Fig.3 List of important medicinal orchids



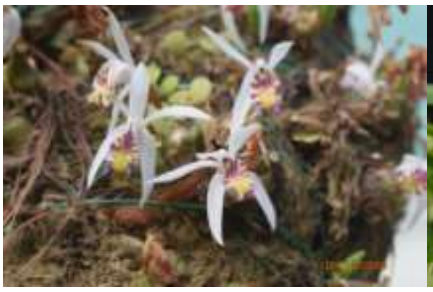
Acampe rigida (Buch.-Ham. ex Sm.)P.F.Hunt *Calanthe sylvatica (Thouars) Lindl. Callostylis bambusifolia*



Dendrobium crepidatum Lindl.& Paxton *Dendrobium densiflorum* Lindl. *Dendrobium fugax Rchb.f.*



Dendrobium moschatum (Buch.-Ham.)Sw.*Dendrobium nobile* Lindl. *Phaius tankervilleae* Blume



Pleione maculata (Lindl.)Lindl.& Paxton*Vanda cristata* Lindl.*Vanda testacea* (Lindl.)Rchb.f.

Fig.4 List of important fragrant orchids

Aerides crispa Lindl *Aerides odoratum* Reinw.ex Blume *Dendrobium heterocarpum* Wall.ex Lindl.

Dendrobium primulinum Lindl.*Dendrobium williamsonii* Day and Rchb.f.*Papilionanthe uniflora* (Lindl.) Garay

*Phalaenopsis lobbii (*Rchb.f.) Sweet*Zygopetalum maculatum* (Kunth) Garay*Rhynchostylis retusa* (L) Blume

Eria javanica (Sw.) Blume*Cephalamtheropsis obcordataGastrochilus dasypogon* (Sm.) Kuntze

Fig.5 Important conservation methods (Field gene bank and DNA bank)

National Active Germplasm Site (NAGS) – Germplasm Polyhouse

Vertically arrangement of germplasm

Dendrobium eryflorum and *Gastrochils dasypogan* on wooden logs

DNA Repository

DNA are stored under -80^{0} C

In Ayurveda, a rejuvenating herbal formulation 'Astavarga' (Chief component of ayurvedic tonic 'Chyavanprash') is derived from a group of 8 herbs, 4 of them are orchids namely Jivak (*Malaxis muscifera*), Rishbhaka (*Malaxis acuminata*), Riddhi (*H. intermedia*) and Vriddhi (*H. edgeworthii*) (Uniyal, 1975).

Orchids as food

Orchid's importance comes into account in traditional food as a side dishes or a supplement in many parts of the world. There are many wild orchid species which are being used a food by the tribal people of North East India (Duggal, 1972). Many tribes of the Nagaland state used leaves of *Cymbidium* species as food. The new shoots of *Cymbidium*s are used with cereals to make sauce, the pseudobulbs of their orchids in combination of common vegetables such as potato, tapioca *etc*. (Medhi and Chakrabarti, 2009). Pseudobulb, root and rhizome of many orchid species, are reported to use as food *viz. Habenaria acuminata, H. susannae, Orchis latifolia, Pholidata articulata, Satyrium species* are used as foods which play an important role in the nutrition of the people of this Nagaland region (Deb 2013).

Endemism

The endemism in the flora of a country or geographical region provides an important insight into the biogeography of that region and also to the centers of diversity and adaptive evolution of the floristic components of that region (Nayar 1996). In India, the Himalayan region has a high degree of endemism making it the richest endemic centre. There are about 307 orchid species are belongs to endemic category (Singh 2019). At present we collected rare and endemic orchid species such as *Diplomeris hirsuta, Lecanorchis sikkimensis, Phalaenopsis lobbii, Renanthera imschootiana etc.* These species are very specific to habitat and sensitive to micro environment.

A number of species are rare and threatened throughout the India, owing to habitat degradation and fragmentation as a result of various anthropogenic influences such as land development activities, building of dams, constructions of roads, commercial exploitation of the species, overgrazing and frequent forest fires. Some orchid species require unique habitat and microhabitats so they are confined to particular elevations and forest types. Some are naturally rare; others are so because of geographic distribution, narrow habitat requirements, and low-density populations.

Conservation

Conservation of orchids through ex-situ and in-situ methods, in the *ex-situ* mode, the orchid species are collected from the native location and conserved in the by tying the plants on wooden logs. While in the *in-situ* approach, the plants are attached with the help of mosses and knotted them tightly with the help of coir ropes. Due to the non–endospermic seeds, the species are normally conserved in the form of field genebanks. Second method is conserving DNA in the form of leaf samples at -80^{o}C in deep freezer.

DNA Bank and NCBI Deposits: Genomic DNA have been isolated from 260 species and stored. 65 DNA barcode sequences (using ITS, matK, rbcL, trnH-psbA primers) were submitted to NCBI.

DNA repository of orchids: The DNA of native orchids is being preserved under -80^{0} C. Nearly 250 species samples are preserved carefully.

North Eastern Himalaya is opulent in orchid resources and indigenous livelihood traditions,

therefore under the framework of proper policy and guidelines, these resources can be more effectively utilized for horticultural crop improvement programmes, sustainable utilization and conservation strategies. The increased number of species at risk as a result of the changing climatic conditions will force the National Active Germplasm Sites (NAGS) which is responsible for plant specific to refocus, to strengthen their conservation policies and to increase their participation in recovery programs for trait specific orchid germplasm and including threatened species. Developments of techniques using both RET and non-RET species, which may have conservation applications which concerning the initiation of plant tissue into culture, multiplication, rooting, weaning, storage (including cryopreservation), are helpful to achieve this conservation programme. Orchids should be one of the premier groups of flowering plants for evolutionary studies, and the massive amounts of DNA data now accumulating are revolutionizing our ideas about these wonderful plants. Conservation through establishing botanic gardens, orchid biosphere reserves, orchid corridors and cryopreservation will helps for sustainable utilization for future generations.

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