

DIVERSITY, DISTRIBUTION, MORPHOLOGICAL DESCRIPTION, AND INDIGENOUS USES OF ORCHIDS OF LADAKH, NORTHWESTERN HIMALAYAS

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Abstract

Orchidaceae is a monocot family of herbaceous perennials that includes terrestrial, mycoheterotrophic, lithophytic, and epiphytic species. It is one of the largest families amongst angiosperms with 705 genera and 29,481 species distributed worldwide. In India, orchids are mainly found in NorthEastern Himalayas, NorthWestern Himalayas and the peninsular regions on the mainland, and the Andaman & Nicobar Islands. NorthWestern Himalayan states, including Ladakh, U.T. (which was a part of the former state Jammu and Kashmir), harbour many orchid species. Various plant explorers from the past a few decades have reported the occurrence of a few orchids from the Ladakh. In the present study, different habitats of Ladakh were explored for the evaluation of diversity and distribution of orchid species. Seven terrestrial species namely *Dactylorhiza hatagirea*, *D. kafiriana*, *D. umbrosa*, *D. viridis*, *Epipactis helleborine*, *E. royleana*, and *Herminium monorchis* growing within an altitudinal range of 1500-4150 m amsl were recorded.

Introduction

THE FAMILY Orchidaceae is a diverse and widespread family of flowering plants with blooms that are often colourful and fragrant. These are herbaceous plants with diverse growth habits, ranging from typical terrestrial to lianas, and even achlorophyllous, but majority of them grow as epiphytes. These plants represent a group of botanically significant and economically important plants distributed in all the continents except Antarctica; the greatest diversity, however, occurs in the tropical and subtropical regions (Prakash and Pathak, 2019; Pridegeon *et al.*, 1999). Orchids occupy a wide range of habitats and exhibit highly specialized pollination mechanisms and morphological, structural and physiological characteristics (Dressler, 1990; Lal *et al.*, 2021; Prakash and Pathak, 2020a, 2022). In India, the family is represented by 155 genera with 1,256 species, of which 307 species are endemics (Singh *et al.*, 2019) and grow from sea level to the alpine regions but their number varies in different regions because of the prevailing environmental conditions of that region (Jalal, 2012). Due to topographical variations within short distances, various aspects of mountain slopes and climate variations due to the influence of monsoon rain from East to West, the Himalayan region is a suitable home for orchids. In India, the distribution pattern of orchids follows the rainfall pattern (Mehra and Bawa, 1970). Orchids are found in several different habitats but not in places that are exceptionally cold all around the year. The NorthWestern Himalayan states harbour many orchid species with the least diversity in the

former state of Jammu and Kashmir. From the Jammu and Kashmir (U.T.) and Ladakh (U.T.), over the last one century, some workers while carrying out general floristic studies from different localities of the region have reported the occurrence of orchids (Blatter, 1928; Coventry, 1923; Dhar and Kachroo, 1983; Dickore and Nusser, 2008; Duthie, 1906; Kachroo *et al.*, 1977; Kapur and Sarin 1990; Murti, 2001; Naqshi *et al.*, 1989; Polunin and Stainon, 1984; Sharma and Kachroo 1981; Sharma and Jamwal, 1998; Singh and Kachroo 1976, 1994; Stewart, 1972; Swami and Gupta, 1998). However, the number of orchid species reported by these workers in the region varies considerably (ranging from 30-50 species). The orchid flora of this region came to light with the publication of the work of Duthie (1906) which deals with illustrated description of 173 species of orchids of NorthWestern Himalayas. Stewart (1972) reported 48 species from the whole of NorthWestern Pakistan and Kashmir, out of which 38 were mentioned from this region. A total of 10 species were recorded from Ladakh by earlier explorers (Akhter *et al.*, 2011; Adhikari *et al.*, 2013; Pratibha and Pathak, 2020), with almost all having medicinal properties and used by the locals. In Ladakh, though the number of orchids is very small, but majority of these are used by many local indigenous tribal and rural communities as an ailment to cure many health issues. Over 60% population of Ladakh is dependent on traditional health care systems which are popularly called Sowa Rigpa or the Amchi system of medicine. Therefore, these plants play a significant role in health care. Due to high demand and anthropogenic pressures on these medicinally and

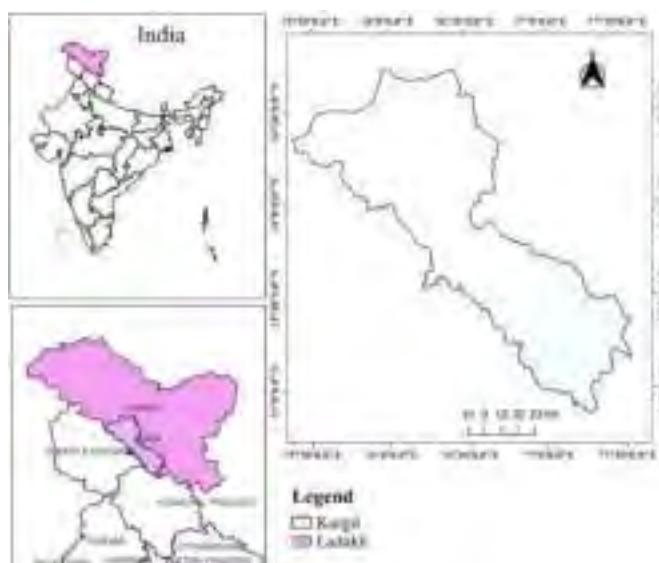


Fig. 1. Map showing the study area of Ladakh.

floriculturally important orchids, their number in natural populations is decreasing in many parts of the world (Balkrishna *et al.*, 2020; Prakash and Pathak, 2020b). Many orchid species are categorized under endangered, threatened, and rare categories in the Red Data Book of International Union for Conservation of Nature (IUCN) due to their habitat destruction and indiscriminate collections. In fact, the entire family is now included in

Appendix-II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2012), where the international trade is strictly prohibited and monitored. So, there is a strong need to keep track on them and conserve these medicinally and economically important orchids. From the Ladakh region, in general, a few studies have been carried out but not much work has been done on the region specific diversity and threat status of orchids, in particular. Therefore, the present attempt has been made to i) assess and identify the diversity of orchids, in Ladakh; ii) assess the status of native and endemic orchid species; iii) study their ethno-medicinal importance; iv) identify the threat category of the species, in the region.

Material and Methods

Study Area

Ladakh, a newly formed U.T., formerly a part of the state of Jammu and Kashmir, is located at Northern most part of India. It lies between 31°44'57"- 32°59'57"N latitude and 76°46'29'- 78°41'34'E longitude (Fig. 1). Commonly referred to as the *Land of Lake*, *The High Mountain Land*, *A Piece Of Land Between Earth And Sky etc.*, remains landlocked for more than 6-7 months every year, when temperature touches below -30°C to -70°C at various localities. There are different valleys



Fig. 2. A-G. Some orchids of Ladakh: A, *Dactylorhiza hatagirea*; B, *D. kafiriana*; C, *D. umbrosa*; D, *D. viridis*; E, *Epipactis helleborine*; F, *E. royleana*; G, *Herminium monorchis*.

and mountains in Ladakh but broadly it can be divided into five major valleys based on the major rivers [Indus, Nubra, Changthang, Zaskar, and Suru] (Kachroo *et al.*, 1977), situated in the two districts, Kargil and Leh. Presently, diversity, distribution pattern, morphological description, and indigenous uses of some orchids of Ladakh, NorthWestern Himalayas have been documented.

Field Surveys, Sampling, Data Collection, and Preparation of Herbaria

Various valleys of the Ladakh region (Nubra, Indus, Suru, Drass *etc.*) were surveyed extensively from May to August during 2021-23. In various regions and different habitats were identified based on the physical characters and dominance of the vegetation. The sites facing high anthropogenic pressures were considered as degraded habitats and sites with high per cent of humus and moisture were considered as alpine moist habitat, whereas low per cent of the same as alpine dry habitat. The site having >50% boulders of the ground cover were considered as bouldary habitat. The river and stream banks as riverine and sites dominated with shrubs as shrubby. Rapid sampling was done along the topographical gradients *i.e.* altitude, habitat, for inventory of orchids. In each site, a plot of 50 × 50 m was demarcated. In each plot, 10 quadrats (10 × 10 m) were placed randomly. Standard ecological methods (Kershaw, 1973; Misra, 1968; Muller-Dombois and Ellenberg, 1974) were followed for the collection and analysis of data from these quadrats. GPS coordinates and altitude were measured with the help of Global Positioning System (GPS). The plant samples were collected from their natural habitats and brought to the Orchid Laboratory, Department of Botany, Panjab University, Chandigarh for identification. The species were identified with the help of different floras (Deva and Naithani, 1986; Singh *et al.*, 2019; Vij *et al.*, 2013) and online platforms (POWO, 2023; WFO, 2023) and herbarium sheets were prepared and submitted in the herbarium, Department of Botany, Panjab University, Chandigarh. Nativity of the species *i.e.* the place of origin/first record of species was also determined by the available literature (Anonymous, 1883-1970; Samant *et al.*, 1998). Endemism of species was identified based on their distribution and by following Dhar and Samant (1993) and Samant *et al.* (1998). Species confined to Indian Himalayan Region (IHR) were considered as endemic and those with a distribution extending up to neighbouring countries *i.e.* the Himalayan region of Afghanistan, Pakistan, Tibet, Nepal, Bhutan, and adjacent states of the IHR were considered as near endemic (Samant *et al.*, 1998). Pursual of literature

(Ballabh and Chaurasia, 2007; Ballabh *et al.*, 2008) and ethnomedicinal surveys involving interviews of various knowledgeable persons from different villages of various valleys helped in analyzing indigenous uses of presently recorded orchid species.

Observation and Results

Diversity and Distribution Patterns

During the present investigation, a total of 7 orchid species belonging to 3 genera were recorded from Ladakh. Amongst the presently studied genera, *Dactylorhiza* (4 species) represented the maximum diversity, followed by *Epipactis* (2 species), and *Herminium* was represented by only single species (Fig. 2). A total number of six major habitats were sampled within an altitudinal range of 2920.9-3974.8 m amsl, out of which *Dactylorhiza hatagirea* was found in maximum number of habitats (05), followed by *Epipactis helleborine* (04), *Herminium monorchis* (02), and *Dactylorhiza kaffiriana*, *D. umbrosa*, *D. viridis*, and *E. royleana* were found to grow only in one habitat (Table 1).

Density

In the present study, the highest density of species was found mainly in protected areas and sparsely distributed in the unprotected wet meadows and other habitats. Highest density was recorded for *Dactylorhiza hatagirea* (1.1-7.3 Ind m⁻²), followed by *Epipactis helleborine* (1.2-3.7 Ind m⁻²), *Herminium monorchis* (0.4-2.1 Ind m⁻²), *Dactylorhiza kaffiriana* (0.6-2.0 Ind m⁻²), *D. umbrosa* (0.3-1.6 Ind m⁻²), and *D. viridis* (0.1 Ind m⁻²) (Fig. 3).

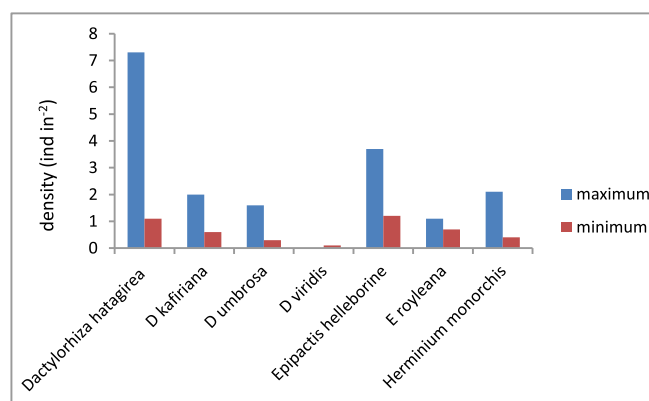


Fig. 3. Species wise density of orchids in Ladakh.

Nativity and Endemism

Two species, *Dactylorhiza hatagirea* and *Epipactis helleborine* are native to Himalayan region and other countries together, while *Herminium monorchis* is non

Table 1. Site representation, habitat, altitudinal range (m), and nativity of the presently studies orchid species.

Species	Site Representation	Habitat	Altitude (m)	Nativity/Endemism
<i>Dactylorhiza hatagirea</i> (D.Don) Soó	05	DH, AM, AD, SH, RI	3160.26	Native and near endemic
<i>D. kafiriana</i> Renz	01	AM	2921.2	-
<i>D. umbora</i> (Kar. & Kir.) Nevski	01	AM	3076.03	-
<i>D. viridis</i> (L.) R.M.Bateman, Pridgeon & M.W.Chase	01	AM	2990.6	-
<i>Epipactis helleborine</i> (L.) Crantz	03	DH, AM, RI	2926.2	Native
<i>E. royleana</i> Lindl.	01	SH	3088.8	Near endemic
<i>Herminium monorchis</i> (L.) R.Br.	02	AM, SH	2920.9	Non native

DH, Degraded habitat; AM, alpine moist; AD, alpine dry; SH, shrubby; RI, riverine.

native. *Dactylorhiza hatagirea* is near endemic to IHR (Fig. 4).

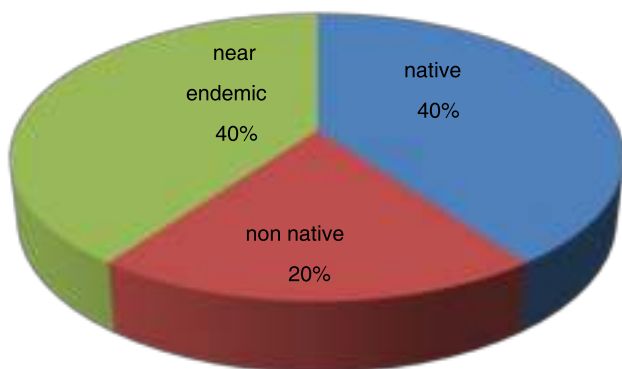


Fig. 4. Nativity and endemism of presently studied species.

Indigenous Uses

Tubers of 3 species (*Dactylorhiza hatagirea*, *D. kafiriana*, and *Herminium monorchis*) and whole plant (*Epipactis helleborine*) are used by the local people to cure many ailments. The inhabitants of Ladakh use many parts of orchid species for the treatment of cold, cough, fever, and various other ailments. Tubers of *Herminium monorchis* are used to cure impotency, amenorrhea, and menorrhagia and these are also used as a substitute for *Dactylorhiza hatagirea* against fever. The whole plant (fresh/dried) of *Epipactis helleborine* is used as an infusion twice or thrice a day for 1 wk to overcome common cold and cough. Tubers of *Dactylorhiza hatagirea* are used along with other medicinal plants to cure amenorrhea, and irregular menstruation and powdered tubers are also used along with other medicinal plants to cure fever.

Morphological Description

Dactylorhiza hatagirea (D.Don) Soó

Local name: *Ambolakpa*

Plant terrestrial. *Tubers* slightly flattened, palmately divided into 3-5, finger like lobes. *Stem* upto 90 cm long, erect, hollow, leafy throughout or the lower portion bear few sheathing scales. *Leaves* 4-6, cauline, leaf blade oblong to linear lanceolate, 8.0-15.0 cm × 1.5-3.0 cm in size, base sheathing, apex obtuse or acuminate. *Inflorescence* is raceme, 5.0-15.0 cm long, crowded with many flowers. *Flowers* purple, about 1.8 cm long, including the curved spur. *Bracts* green, narrowly lance shaped, lower bract longer than the flowers, upper slightly shorter. *Sepals* are nearly equal to *petals*. Three of them form a hood and the two sides spread outwards. *Lip* is rounded and shallowly 3-lobed, spotted dark purple. *Spur* straight, cylindrical, nearly as long as the *ovary*; *column* very short; *anther* adnate to its face, cells diverging, 2, caudicles attached to 2 small globose, viscid glands enclosed in a minute pouch overhanging the broad, 2-lobed stigma.

Distribution

Himalayas, 3100-4000 m (Kashmir, Nepal, Pakistan), South West Tibet.

Presently Collected From

Nubra valley (Leh), Suru Valley, Pashkum, Drass Valley (Kargil)

Flowering

May-July

Fruiting

June-August

Threats to Natural Populations

Overgrazing, shifting of land to cultivation, habitat destruction, cutting etc.

Dactylorhiza viridis (L.) R.M.Bateman, Pridgeon & M.W.Chase

Plant terrestrial. *Tubers* 2, each further divided into finger like segments. *Stem* straight leafy. *Leaves* 3-5, elliptic-oblong, acute, 4-6 cm × 1.5-2 cm. *Spike* lax or densely many flowered, short but sometimes reaching 15 cm in length. *Flowers* 9-13 mm long, green, suffused with red-brown. *Bracts* lanceolate, normally over-topping the flowers. *Sepals* ovate, forming a hood with petals. *Petals* linear-lanceolate, equaling the sepals. *Lip* strap shaped, cuneate-lingulate, 6-8 mm long, bent downwards, tridentate, the side-teeth longer, thickened on each side near the attachment of the column, with a central longitudinal low keel running from the base towards the apex. *Spur* saccate, about 2 mm long.

Distribution

Himalayas, 2900-3900 m (Kashmir, Nepal, Bhutan), North Europe, Siberia, SouthEast Tibet, North America, and China.

Presently Collected From

Drass Valley (Kargil)

Flowering

June-August

Fruiting

August-September

Threats to Natural Populations

Overgrazing, shifting of land to cultivation, habitat destruction, cutting etc.

***Dactylorhiza kafiriana* Renz**

Plant terrestrial. *Tubers* 2-4, finger like. *Stem* straight leafy mainly towards the base. *Leaves* spreading, lanceolate or linear, acuminate. *Inflorescence* normally loose few to many flowered. *Flowers* pale rose violet. *Bracts* green, narrowly lanceolate, lower bract longer than the ovary, upper equaling it. *Sepals* a dorsal converging with the petals to form a loose hood, oblong-lanceolate. The lateral reflexed, as long as the dorsal. *Petals* lanceolate, equaling the sepals or somewhat shorter. Three of them form a hood and the two sides spread outwards. *Lip* is longer than broad, obovate or rhomboidal with an acute and somewhat elongated tip, entire or scarcely 3-lobed, with the mid lobe longest, papillose at base and centre. *Spur* cylindric, more or less equaling the ovary in length.

Distribution

Himalayas, 2000-3700 m (Kashmir, Pakistan) and Afghanistan.

Presently Collected From

Suru Valley, Pashkum (Kargil)

Flowering

July-August

Fruiting

June-August

Threats to Natural Populations

Overgrazing, shifting of land to cultivation, habitat destruction, cutting etc.

***Dactylorhiza umbrosa* (Kar. & Kir.) Nevski**

Plants herbaceous. *Tubers* white- creamish in colour, 3-5 palmately-lobed. *Stem* solid or fistular in large plants, densely leafy often with the leaves clustered towards the base or even rosetted. *Leaves* erect-spreading, lanceolate or oblong lanceolate, sometimes broader, acute, 10-15, basal leaves often short, oblong or ovate, obtuse. *Inflorescence* densely flowered, upto 15 cm long, cylindric. *Flower* purplish-lilac, pale-purple or flesh-coloured, rarely white. *Bracts* lanceolate, acuminate, the inferior exceeding the flowers. *Sepals* the dorsal forming a loose hood with the petals, oblong, lanceolate, slightly concave, 10 mm long; the lateral spreading or reflexed, sometimes purplish spotted, obliquely oblong or lanceolate, acute slightly larger than the dorsal. *Petals* ovate or lanceolate, acute, somewhat shorter than the sepals. *Lip* usually as long as broad, sometimes longer, flat, orbicular or reniform-rhomboidal or rarely ligulate, tapering towards the apex, upto 10 mm long, entire, sub-entire or shortly 3-lobed roundish, mid-lobe smaller, triangular often with elongated apex. *Spur* cylindric, curved outwards or even hooked towards the apex, slightly shorter or equaling the ovary.

Distribution

Himalaya 1000-3900 m (Kashmir, Pakistan), Afghanistan, Iran, Iraq, and Central Asia.

Presently Collected From

Nubra valley (Leh), Suru Valley (Kargil)

Flowering

May-July

Fruiting

June-August

Threats to Natural Populations

Overgrazing, shifting of land to cultivation, habitat destruction, cutting *etc.*

***Epipactis helleborine* (L.) Crantz**

Local name: *Penginlo*

Plants small slender or robust, upto 70 cm high. *Rhizome* very short, woody, with numerous roots. *Stem* with leaves in close succession, lower portion glabrous, the upper portion minutely pubescent. *Leaves* spreading, elliptic to ovate-lanceolate, lower shortened and broadened, upper decreasing and becoming narrower. *Inflorescence* upto 25-35 cm long, loose or dense, many flowered, sometimes one sided. *Flower* green, flushed more or less intensely with red violet or yellowish-green, open bell-shaped. *Bracts* lanceolate, the lower exceeding the flowers, the upper about equaling the ovary. *Sepals* ovate-lanceolate, upto 12 mm long, sometimes brownish veined. *Petal* slightly shorter, ovate. *Lip* stretched forward; hypochile cup shaped, green outside, dark olive-brown, shining inside.

Distribution

Himalayas, 1500-4000 m (Kashmir, Pakistan, Bhutan), Afghanistan, Europe, Iraq, North Africa, Hongkon, Japan, and Upper Burma.

Presently Collected From

Nubra valley (Leh), Suru Valley, Pashkum, Drass Valley (Kargil)

Flowering

July-August

Fruiting

July-August

Threats to Natural Populations

Overgrazing, shifting of land to cultivation, cutting *etc.*

***Epipactis royleana* Lindl.**

Plants erect, up to 90 cm tall. *Rhizome* elongated, creeping, stoloniferous with hairy roots. *Stem* glabrous, leafy, clothed at base with broad loose sheaths. *Leaves* flat, membranous, rarely somewhat folded, ovate or ovate-lanceolate, acute or acuminate, the margins scabrous, 10-15 cm × 2.5-3 cm. *Inflorescence* 10-30 cm long, 20 to many flowered, rachis minutely pubescent. *Flower* drooping, distant, pedicelled, 2.5 cm in diameter, green veined red and a reddish-yellow lip.

Bracts longer than the flowers, lanceolate, acuminate, the lower one large and leaf like. *Sepals* spreading, ovate-lanceolate, concave, upto 20 mm long. *Petal* slightly shorter than the sepals, broadly ovate, oblique. *Lip* longer than the sepals, glabrous, hypochile obovate, ca. 10 mm long, with a cuneate base, 14-20 mm broad, much broader than epichile; epichile narrowly ovate, 6-12 mm long, near the base 5-7 mm broad with two fleshy, wine-red coloured bosses.

Distribution

Himalayas, 2500-4000 m (Kashmir, Pakistan, Bhutan), Afghanistan, East Himalaya, Kirgizstan, Nepal, Tadzhikistan, Tibet, Uzbekistan.

Flowering

July-August

Fruiting

August-September

Presently Collected From

Suru Valley (Kargil)

Threats to Natural Populations

Overgrazing, shifting of land to cultivation, cutting *etc.*

***Herminium monorchis* (L.) R.Br.**

Local name: *Peo*

Plants herbaceous. *Stem* 7.5-15 cm. *Leaves* 2-3, near the base, 2.5-10.0 cm long, oblong-lanceolate, acute, glossy. *Spike* 2.5-5.0 cm long, densely flowered, cylindric or sub-secund. *Flowers* yellowish-green, 4-6 mm in diameter, fragrant. *Bracts* lanceolate, acuminate, short or equal to the ovary. *Sepals* 3 mm long, oblong-obtuse or sub-acute, lateral pair narrower. *Petals* connivent with the sepals and little longer. *Lip* as long as petal concave at base, 3-lobed; lateral lobes half to almost equal to the midlobe, diverging; midlobe obtuse, almost of the same breadth from base to the apex.

Distribution

Himalayas, 3000-4000 m (Kashmir, Pakistan, Arunachal Pradesh), East Tibet, Siberia, West and North China, Korea, and Japan.

Presently Collected From

Nubra valley (Leh), Suru Valley (Kargil)

Flowering

June-August

Fruiting

August-September

Threats to Natural Populations

Overgrazing, shifting of land to cultivation, habitat destruction, cutting *etc.*

Discussion and Conclusion

The occurrence of orchids in Ladakh region of NorthWestern Himalayas is reported earlier by a few explorers (Adhikari *et al.*, 2013; Akhter *et al.*, 2011; Pratibha and Pathak, 2020). A total of 10 species were reported from Ladakh. The present study provides first hand information on 7 species of orchids growing in different regions of Ladakh. These species are used in traditional medical system, Amchi system of medicine, which provides treatment and relief to local indigenous communities. Demand for these plants is increasing at such a high rate that their natural stocks are being destroyed at an alarming rate. Over exploitation of roots/tubers/bulbs for trade may cause rapid depletion of natural populations of these orchids. Therefore, there is an urgent need to create awareness amongst local people about the significance of these medicinally and floriculturally important species. In the present study, densities of species were found to be higher in protected areas than the non protected areas, hence, regular monitoring of populations of these orchids in relation to climate change and habitat degradation is urgently required so as to understand the dynamics of the species. The habitats of orchids investigated were found to be under varied levels of anthropogenic pressures, overgrazing, and over exploitations. Besides natural factors such as avalanches, landslides, decrease in rainfall and snow fall, and rise in minimum and maximum temperature are causing changes in environmental conditions leading to shift in biological cycle and shrinkage of natural habitats of these species. Such conditions are becoming unfavourable for the growth of the species. Changes in habitats may affect the populations of moisture loving orchid species. Bhattacharjee and Dutta (2009) reported that the conservation of habitat is the only way to conserve the orchids. Restoration and protection of the habitats is extremely important for conserving the orchid diversity. There is also a need to develop further strategies for the conservation of these important orchid species. Infact, an integrated conservation approach needs to be adopted for saving their natural population from further depletion. Cultivation of orchids in the surrounding villages and their mass propagation through Plant Tissue Culture techniques could be one of the major and most

suitable alternative tools to minimize the pressure on natural populations of these orchids and to maintain the gene pool of such unique and valuable group of plants for future generations. Mass propagation of medicinal orchids using *in vitro* culture technique has been reported earlier by some workers (Anuprabha and Pathak, 2019, 2020; Anuprabha *et al.*, 2017; Arora *et al.*, 2016; Bhowmik and Rahman, 2022; Chen *et al.*, 2015; Hossain *et al.*, 2009, 2012; Kaur *et al.*, 2017; Kumari and Pathak, 2021; Liu and Zhang, 2010; Mutum, *et al.*, 2022; Pathak, 1989; Pathak *et al.*, 2016, 2017, 2022, 2023; Singh *et al.*, 2006; Sunita *et al.*, 2021; Thakur and Pathak, 2020, 2021; Sembi *et al.*, 2020; Tripura *et al.*, 2022; Vasundhra *et al.*, 2019, 2021). Cost effective protocols for mass propagation of these endangered, threatened, and rare medicinal orchids also need to be developed in order to conserve them. Proper utilization and management of medicinal orchids might be a better alternative of synthetic medicine.

Acknowledgement

The first author gratefully acknowledges the financial support provided by Council of Scientific and Industrial Research (CSIR), New Delhi, India.

References

- Adhikari, B. S., A. Kunzes, J. S. Jalal, and G. S. Rawat. 2013. Rediscovery of *Dactylorhiza kafiriana*, a lesser known orchid from Suru valley, Jammu and Kashmir, India. *Richardiana*, **8**: 220-25.
- Akhter, C., A. A. Khuroo, G. H. Dar, Z. S. Khan, and H. Malik. 2011. An updated checklist of orchids in the Indian Himalayan state of Jammu and Kashmir. *Pleione*, **5**: 1-9.
- Anonymous. 1883-1970. *Index Kewensis Plantarum Phanerogamarum*, Vol. 1-2 and 15 Supplements (1886-1970). Clarendon Press, Oxford, U.K.
- Anuprabha and Promila Pathak. 2019. *In vitro* asymbiotic seed germination and seedling development in *Coelogyne fimbriata* Lindl. *J. Orchid Soc. India*, **33**: 83-89.
- Anuprabha and Promila Pathak. 2020. Micropropagation of *Coelogyne fimbriata* Lindl. using pseudobulb explants. *J. Orchid Soc. India*, **34**: 131-36.
- Anuprabha, Promila Pathak, Ankush Prakash, and Jitender Kumar. 2017. Regeneration competence of *Dendrobium nobile* Lindl. through pseudobulb segments: A study *in vitro*. *J. Orchid Soc. India*, **31**: 71-75.
- Arora, S. K., Promila Pathak, Shivani Verma, Ankush Prakash, Kriti Dhiman, and K. C. Mahant. 2016. Mass propagation of *Dendrobium amoenum* Wall. ex Lindl. through stem nodal explants: A study *in vitro*. *J. Orchid Soc. India*, **30**: 51-55.
- Ballabh, Basant and O. P. Chaurasia. 2007. Traditional medicinal plants of cold desert Ladakh- Used in treatment of cold, cough and fever. *Ethnopharmacol.*, **112**(2): 341-49.

- Ballabh, Basant, O. P. Chaurasia, Zakwan Ahmed, and Shashi Bala Singh. 2008. Traditional medicinal plants of cold desert Ladakh- Used against kidney and urinary disorders. *Ethnopharmacol.*, **118**(2): 331-39.
- Balkrishna, Acharya, Rajesh Juyal, Reema Devi, Jitender Kumar, Ankush Prakash, Promila Pathak, Ved Priya Arya, and Ashwani Kumar. 2020. Ethnomedicinal status and pharmacological profile of some important orchids of Uttarakhand (NorthWestern Himalayas), India. *J. Orchid Soc. India*, **34**: 137-47.
- Bhattacharjee, B. and B. K. Dutta. 2009. *Lagerstroemia reginae* Roxb.- An ideal host supporting orchid species of Barak Valley, Southern Assam. *Indian For.*, **135**(11): 1515-25.
- Bhowmik, T. K. and M. M. Rahman. 2022. Seed germination, protocorm multiplication, and seedling development in *Dendrobium formosum* Roxb. ex Lindl. of Bangladesh- A study *in vitro*. *J. Orchid Soc. India*, **36**: 1-7.
- Blatter, E. 1928. *Beautiful Flowers of Kashmir*. Vol. 2. Staples and Staples Ltd., John Bale, Danielsson, London. U.K.
- Chen, Y., U. M. Goodale, X. L. Fan, and J. Y. Gao. 2015. Asymbiotic seed germination and *in vitro* seedling development of *Paphiopedilum spicerianum*: An orchid with extremely small population in China. *Glob. Ecol. Conserv.*, **3**: 367-78.
- CITES. 2012. *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. Appendices I, II and III. <http://www.cites.org>.
- Coventry, B. O. 1923. *Wild Flowers of Kashmir*. Series-I. Raithby, Lawrence & Co. Ltd., London, U.K.
- Deva, S. and H. B. Naithani. 1986. *The Orchid Flora of NorthWest Himalaya*. Print and Media Associates, New Delhi, India.
- Dhar, U. and P. Kachroo. 1983. *Alpine Flora of Kashmir Himalaya*. Scientific Publishers, Jodhpur, India.
- Dhar, U. and S. S. Samant. 1993. Endemic diversity of Indian Himalaya. I. Ranunculaceae and II. Paeoniaceae. *J. Biogeogr.*, **20**: 659-68.
- Dickore, W. P. and M. Nusser. 2008. *Flora of Nanga Parbat (NW Himalaya, Pakistan)*. Botanischer Garten and Botanischer Museum, Berlin, Germany.
- Dressler, R. L. 1990. The Neottieae in orchid classification. *Lindleyana*, **5**(2): 102-09.
- Duthie, J. F. 1906. *Orchids of the North-Western Himalaya*. Bengal Secretariat Press, Calcutta, India.
- Hossain, M. M., M. Sharma, and Promila Pathak. 2009. Cost effective protocol for *in vitro* mass propagation of *Cymbidium aloifolium* (L.) Sw.- A medicinally important orchid. *Eng. Life. Sci.*, **9**: 444-53.
- Hossain, M. M., M. Sharma, and Promila Pathak. 2012. *In vitro* propagation of *Dendrobium aphyllum* (Orchidaceae)- Seed germination to flowering. *J. Plant Biochem. Biotechnol.*, **22**: 157-67.
- Jalal, J. S. 2012. Distribution pattern of orchids in Uttarakhand, Western Himalayas, India. *Int. J. Plant Biol.*, **3**: 24-26
- Kaur, S., Promila Pathak, Ankush Prakash, Anamika, and Aakanksha Sharma. 2017. *Ex situ* conservation of a floriculturally and medicinally important endangered orchid, *Coelogyne cristata* Lindl. *J. Orchid Soc. India*, **31**: 15-22.
- Kumari, Anamika and Promila Pathak. 2021. *De novo* plantlet regeneration from leaf explants of *Rhynchostylis retusa* (L.) Blume: A study *in vitro*. *J. Orchid Soc. India*, **35**: 47-53.
- Lal, Roshan, Ankush Prakash, and Promila Pathak. 2021. Soil profiling of some endangered terrestrial orchids of Shimla hills (Himachal Pradesh), NorthWestern Himalayas. *J. Orchid Soc. India*, **35**: 9-17.
- Mehra, P. N. and K. S. Bawa. 1970. Cytological observations on some North-West Himalayan Orchids. *Caryologia*, **23**: 273-82.
- Misra, R. 1968. *Ecology Work Book*. Oxford and IBH Publication, New Delhi, India.
- Murti, S. K. 2001. *Flora of Cold Deserts of Western Himalaya*. Vol. 1. Botanical Survey of India, Kolkata, India.
- Mutum, R. D., N. M. Chanu, T. N. Khangnaba, and B. Thongam. 2022. Propagation and conservation of selected orchids of Manipur. *J. Orchid Soc. India*, **36**: 95-101.
- Naqshi, A. R., M. Y. Malla, and G. H. Dar. 1989. Plants of Ladakh-Nubra. *J. Econ. Taxon Bot.*, **13**(3): 539-60.
- Kachroo, P., B. L. Sapru, and U. Dhar. 1977. *Flora of Ladakh: An Ecological and Taxonomic Appraisal*. Bishen Singh Mahendra Pal Singh, Dehradun, India.
- Kapur, S. K. and Y. K. Sarin. 1990. *Flora of Trikuta Hills*. Bishen Singh Mahendra Pal Singh, Dehradun, India
- Kaur, S. and K. Bhutani. 2011. Micropropagation of *Malaxis acuminata* D. Don: A rare orchid of high therapeutic value. *J. Med. Aromat. Plants*, **1**: 29-33.
- Kershaw, K. A. 1973. *Quantitative and Dynamic Plant Ecology*. Edward Arnold Ltd., London, U.K.
- Pathak, Promila, Anamika Kumari, Brent D. Chandler, and Lawrence W. Zettler. 2023. *In vitro* propagation and phytochemical analysis of *Vanda cristata* Wall. ex Lindl.: An endangered medicinal orchid of biopharmaceutical importance. *S. Afr. J. Bot.*, **153**: 109-23.
- Pathak, Promila, Shivani Verma, Ankush Prakash, and K. C. Mahant. 2017. Regeneration competence of an ornamentally important epiphytic orchid, *Rhynchostylis gigantea* (Lindl.) Ridl. through leaf segments: A study *in vitro*. *J. Orchid Soc. India*, **31**: 97-101.
- Pathak, Promila, S. K. Arora, Shivani Verma, Kriti Dhiman, K. C. Mahant, and Raja Jeet. 2016. Mass propagation of a floriculturally and medicinally important epiphytic orchid *Dendrobium amoenum* Wall. ex. Lindl. through asymbiotic seed culture: A study *in vitro*. *Pb. Univ. Res. J. (Sci.)*, **66**: 39-45.
- Pathak, Promila, Sunita, Anamika Kumari, Babita Thakur, Vasundhra, and Madhu. 2022. Regeneration competence of an endangered orchid, *Vanda cristata* Wall. ex Lindl. using leaf explants: A study *in vitro*. *S. Afr. J. Bot.*, **151**: 1018-24.
- POWO. 2023. *Plants of the World Online*. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet; <http://www.plantsoftheworldonline.org/>.

- Prakash, Ankush and Promila Pathak. 2019. Orchids of Water Catchment Wildlife Sanctuary, Shimla (Himachal Pradesh), NorthWestern Himalayas: Their diversity, status, indigenous uses, and conservation status. *J. Orchid Soc. India*, **33**: 65-77.
- Prakash, Ankush and Promila Pathak. 2020a. Ant facilitated pollination of *Herminium lanceum* (Thunb. ex Sw.) Vuijk (Orchidaceae)- An endangered terrestrial orchid of NorthWestern Himalayas. *J. Orchid Soc. India*, **34**: 11-15.
- Prakash, Ankush and Promila Pathak. 2020b. Effects of different concentrations of NPK on vegetative growth parameters of a floriculturally important epiphytic orchid, *Dendrobium chrysanthum* Wall. ex Lindl. *J. Orchid Soc. India*, **34**: 117-21.
- Prakash, Ankush and Promila Pathak. 2022. Bee Pollination in *Calanthe tricarinata* Lindl. (Orchidaceae)- An endangered orchid from NorthWestern Himalayas. *J. Orchid Soc. India*, **36**: 15-20.
- Pratibha and Promila Pathak. 2020. *Dactylorhiza umbrosa* (Kar. & Kir.) Nevski- A new record from Nubra Valley, Ladakh (U.T.), India. *J. Orchid Soc. India*, **34**: 23-25.
- Pridgeon, A. M., P. J. Cribb, M. W. Chase, and F. Rasmussen. 1999. *Genera Orchidacearum*: Volume 1: *Apostasioideae* and *Cypripedioideae* (Vol. 1). Oxford University Press on Demand, England, U.K.
- Polunin, O. and A. Stainton, 1984. *Flowers of the Himalaya*. Oxford University Press, U.K.
- Samant, S. S. 1993. Diversity and status of plants in Nanda Devi Biosphere Reserve. In: *Scientific and Ecological Expedition to Nanda Devi*, pp. 54-85. Army Head Quarters, New Delhi, India.
- Samant, S. S., U. Dhar, and L. M. S. Palni. 1998. *Medicinal Plants of Indian Himalaya: Diversity, Distribution, and Potential Values*. Gyanodaya Prakashan, Nainital, India.
- Sembi, Jaspreet K., Promila Pathak, and Jagdeep Verma. 2020. Regeneration competence of leaf explants in *Cymbidium eburneum* Lindl. (Orchidaceae). *J. Orchid Soc. India*, **34**: 17-21.
- Sharma, B. M. and P. S. Jamwal. 1998. *Flora of Upper Lidder Valley of Kashmir Himalaya*. Vol. 2. Scientific Publishers, Jodhpur, India.
- Sharma, B. M. and P. Kachroo. 1981. *Flora of Jammu*. Bishen Singh Mahendra Pal Singh, Dehradun, India.
- Singh, G. and P. Kachroo. 1976. *Forest Flora of Srinagar*. Bishen Singh Mahendra Pal Singh, Dehradun, India.
- Singh, J. B. and P. Kachroo. 1994. *Forest Flora of Pir Panjal Range (NorthWestern Himalaya)*. Bishen Singh Mahendra Pal Singh, Dehradun, India.
- Singh, K. N., S. K. Samanta, and A. K. Basu. 2006. Asymbiotic seed germination of some orchids. *J. Orchid Soc. India*, **20**(1-2): 11-14.
- Singh, S. K., D. K. Agrawala, J. S. Jalal, S. S. Das, A. A. Mao, and P. Singh. 2019. *Orchids of India: A Pictorial Guide*. Botanical Survey of India, Kolkata, India.
- Stewart, R. R. 1972. *An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir*. Fakhri Printing Press, Karachi, Pakistan.
- Sunita, Promila Pathak, and K. C. Mahant. 2021. Green pod culture of an endangered and medicinally important orchid, *Vanda cristata* Wall. ex Lindl. from Himachal Pradesh. *J. Orchid Soc. India*, **35**: 25-33.
- Swami, A. and R. K. Gupta. 1998. *Flora of Udhampur*. Bishen Singh Mahendra Pal Singh, Dehradun, India.
- Thakur, Babita and Promila Pathak. 2020. *In vitro* propagation of *Herminium lanceum* (Thunb. ex Sw) Vuijk (Orchidaceae), through asymbiotic seed germination: A therapeutically important and endangered orchid from NorthWestern Himalayas. *J. Orchid Soc. India*, **34**: 61-67.
- Thakur, Babita and Promila Pathak. 2021. Application of organic additives for the enhancement of seed germination and seedling development in an endangered and medicinal orchid, *Rhynchostylis retusa* (L.) Blume through asymbiotic culture. *J. Orchid Soc. India*, **35**: 99-107.
- Tripura, A., M. A. Sumi, T. K. Bhowmik, and M. M. Rahman. 2022. *In vitro* seed germination and phytochemical screening of an epiphytic medicinal orchid, *Pholidota imbricata* W. J. Hook. of Bangladesh. *J. Orchid Soc. India*, **36**: 137-45.
- Vasundhra, Promila Pathak, and Anuprabha. 2021. *In vitro* asymbiotic seed germination and regeneration competence of leaf explants in *Satyrium nepalense* D. Don, a medicinally important, and an endangered terrestrial orchid of Kasauli Hills, Himachal Pradesh (NorthWestern Himalayas). *J. Orchid Soc. India*, **35**: 73-82.
- Vasundhra, Promila Pathak, and Ankush Prakash. 2019. *In vitro* shoot induction and regeneration potential of floral buds in *Crepidium acuminatum* (D. Don) Szlach., a medicinal ayurvedic plant from NorthWestern Himalayas. *J. Orchid Soc. India*, **33**: 43-48.
- Vij, S. P., J. Verma, and C. S. Kumar. 2013. *Orchids of Himachal Pradesh*. Bishen Singh Mahendra Pal Singh, Dehradun, India.
- WFO. 2023. *World Flora Online*. Published on the Internet; <http://www.worldfloraonline.org>.