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DIVERSITY, DISTRIBUTION PATTERN, AND INDIGENOUS USES OF HIGH ALTITUDE ORCHIDS OF INDERKILA NATIONAL PARK IN HIMACHAL PRADESH, NORTHWEST HIMALAYAS

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Abstract

The present investigation was carried out for the exploration of orchids in Inderkila National Park, located in Kullu District of the Himachal Pradesh. Eighteen species of the orchids representing 12 genera were recorded during the present investigation. Majority of these orchid species were found to grow between 2815-3800 m amsl. Amongst the presently investigated species, 11 species were native and 4 were near endemic to the Indian Himalayan Region. Eight habitats were identified and majority of the orchid species were reported in shady moist and moist alpine slope habitats. Most of the species were used for curing various diseases by the inhabitants of the valley. *Dactylorhiza hatagirea* and *Malaxis muscifera* are high attitude species. Due to high commercial/medicinal values of *Dactylorhiza hatagirea* and *Malaxis muscifera,* these species are facing high anthropogenic pressure, leading to their rapid population depletion in the area. The conservation of such orchid species underscores the importance of protecting the intricate web of life on earth, acknowledging their ecological significance, and recognizing the need for concerned efforts to ensure their continued existence for the benefits of both nature and mankind. Preserving this remarkable plant family is not only a testament to our commitment to understanding and safeguarding earths diverse ecosystem, but also a key to unlocking potential benefits for science, medicine, and horticulture. Therefore, regular monitoring of populations of orchids in relation to climate scenario has been suggested for understanding the dynamics of the species and develop strategies for conservation.

Introduction

THE FAMILY Orchidaceae is characterised by its unparalleled diversity, exquisite beauty, and ecological significance with cosmopolitan distribution. Orchids have several unique ecological adaptations and characteristics that set them apart such as epiphytic life form, mycorrhizal association, wide range of pollination strategies, deceptive mimicry, unique biodiversity, and high vulnerability (Prakash and Pathak, 2020a, 2022). The orchids prefer to grow on humid and shady environment. One of the reasons behind the most of orchids' population found in Indian Himalayan Region are lies in the fact that India has diverse climatic conditions which are favourable for growth of orchids (Barman *et al*., 2016, 2021; Singh *et al.,* 2019). About 8,000 flowering plants are supported by the IHR and family Orchidaceae is one of the most species rich families of angiosperms (Ramudu and Khasim, 2015; Samant *et al*., 2002; Sharma and Samant, 2017). India represents the 1256 species of orchids in which 757 are epiphytic, 447 terrestrials in habit and some are lithophytic as well (Singh *et al.,* 2019). Orchids are also represented as indicator species of habitat disturbances. They have some ornamental significance as well as they find extensive utility in the traditional systems of medicine (Devi *et al*., 2018; Kumar *et al*., 2019; Prakash *et al*., 2018; Prakash and Pathak, 2020b; Samant, 2009; Singh *et al*., 2019).

Studies on orchid diversity have been carried out in Himachal Pradesh by various workers (Arora, 1986; Deva and Naithani, 1986; Duthie, 1906; Marpa and Samant, 2012; Prakash and Pathak, 2019; Rana *et al*., 2008; Samant, 2009; Sharma *et al*., 2015; Singh and Sharma, 2006; Verma *et al*., 2013; Vij *et al*., 2013). In general, a large number of studies have been carried out on the orchids of IHR (Arora, 1986; Pangtey and Samant, 1991; Samant *et al*., 2002; Vij *et al*., 1983), but very few are available from protected areas. In Himachal Pradesh, very few studies are available for the protected areas (Rana *et al*., 2008; Vij *et al*., 1983). Orchids are occasionally figure in some of the local floras of the state and majority of them are terrestrial in habit (Chowdhery and Wadhwa, 1984; Dhaliwal and Sharma, 1999; Rana *et al*., 2008; Singh and Rawat, 2000).

The protected areas of Himachal Pradesh support rich biodiversity.To explore the orchid diversity in the Inderkila National Park, the present study has been carried out to; i) assess the orchid diversity of Inderkila

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National Park in alpine and sub-alpine region; ii) gather information on indigenous uses; iii) analyse orchid species for nativity, endemism, and threat categories; and iv) suggest management options for the conservation of orchid species.

Material and Methods

Study Area

The Inderkila National Park (32°13'8.45"N to 32°20'25.218"N and 77°14'12.897"E to 77°20'51.738"E) is one of the 5 notified National Parks of the Himachal Pradesh, NorthWestern Himalayas. It is located in the North of Kullu District in Manali Tehsil and covers 104 km^2 area with an altitudinal range, 2800-5200 m amsl (Fig. 1).

The Park around Hamta Pass is known for its glacial features, climatic conditions and unique biodiversity. The area is connected by road upto Sethan and rest is accessible through footpaths, which are developed by the Kullu Forest Department. Certain regions exhibit inaccessibility, thereby rendering them geographically or environmentally restricted for scientific investigations or ecological explorations.

The Hamta Pass is situated in the Northern part of Inderkila National Park. It lies at an altitude of around 4270 m amsl and a popular destination for trekking enthusiasts and researchers who study the Himalayan ecosystem. It offers an opportunity to explore region's geology, ecology, and climatic conditions. Hamta Pass is one of the most beautiful and enormous treks that lies on beautiful Pir Panjal Range and is a small corridor between Spiti and Manali valley of Himachal Pradesh. There is no permanent settlement inside the National Park; however, some villages located in the periphery are dependent on the natural resources of the Park. There are some high-altitude grasslands between Hamta Pass and dry cold desert of Lahaul-Spiti, which are locally called as *Thatches.* These thatches are used as temporary camping sites by Shepherds (*Gaddies*) of the lesser Himalayan region during their voyage in summer. A large number of wildflowers and varieties of

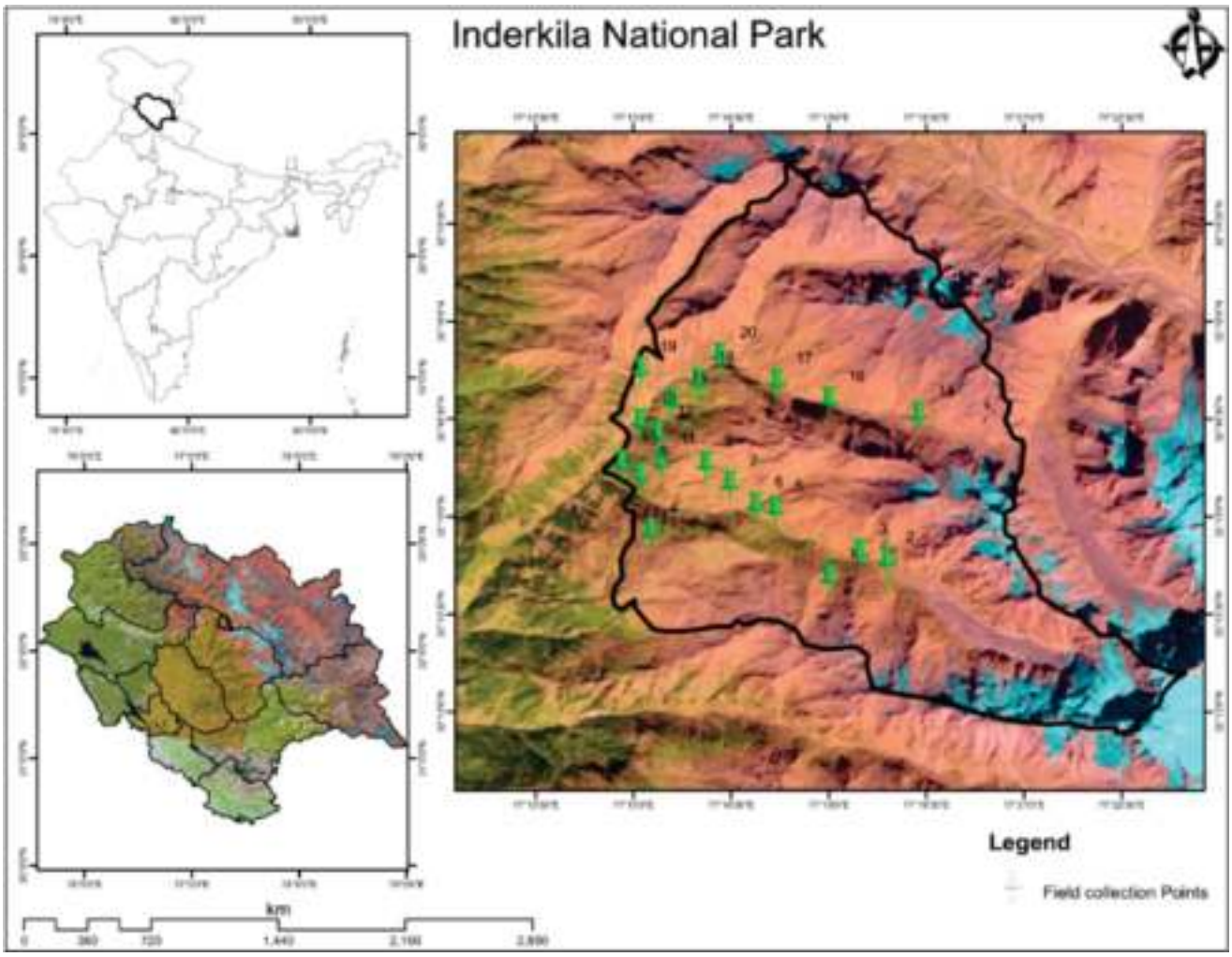

Fig. 1. Map of Inderkila National Park, Kullu, Himachal Pradesh.

orchids can be found at an altitude between 3000 to 3800 m amsl. The vegetation mainly comprises of sub-alpine and alpine types. Sub-alpine forests are mainly dominated by broad leaved and coniferous species, and alpine meadows are dominated by alpine scrubs and herbaceous species.

Survey, Sampling, Identification, and Data Analysis

The accessible sites of the Inderkila National Park were surveyed and sampled for the qualitative and quantitative assessment of the orchids during 2018-2022. For qualitative assessment, rapid sampling was done and the collected samples were identified with the help of local and regional floras and literature (Chowdhery and Wadhwa, 1984; Dhaliwal and Sharma, 1999; Samant, 1993; Singh and Rawat, 2000). For quantitative assessment, quadrat method was followed. Habitats were identified based on the physical features.

Soil samples were collected from each studied site within each plot of 50 × 50 m. Five soil samples, 4 from the corners and 1 from the centre of each plot, up to 20 cm depth were collected, pooled, and mixed properly to make a composite sample. All the samples were mixed together and a composite sample measuring 200 g was stored in airtight polythene bags and brought to the laboratory for the analysis of physico-chemical properties (Singh *et al.,* 2005). Soil pH was measured using a pH meter in 1:5 mixture of soil and distilled water, moisture content was recorded as % difference in fresh and dry soil weight, % organic Carbon, and organic matter were analysed as described by Walkley and Black method (Walkley and Black, 1934), available Nitrogen by Kjeldahl method (Subbiah and Asiijah, 1956), available Phosphorus by Olsen's extraction method (Olsen, 1954) and available Potassium by flame photometer (Jackson, 1958).

Data were analysed for density (Dhar *et al*., 1997; Joshi and Samant, 2004). Species were analysed for nativity, endemism and threat categories. Nativity of the species was identified by following Lal, 2007; Samant, 1993; Samant and Joshi, 2005; Sharma and Samant, 2017. Endemism of the species was identified based on their distribution and following Samant *et al.* (1998). Species confined to the IHR were considered as endemic and those with a distribution extending up to neighbouring countries (*i.e.* Himalayan region of Afghanistan, Pakistan, Baluchistan, Tibet, Nepal, Bhutan, and Adjacent States of the IHR) were considered as near endemic (Samant *et al.,* 1998). For the assessment of threat categories of orchid species, habitat preference, population size, distribution range, and utilization values were collectively used by following Rana and Samant (2010). For indigenous uses local inhabitants, *Gaddis* and *Gujjars* were interviewed and information was gathered (Devi *et al*., 2018; Lal and Samant, 2015; Pandey and Singh, 2016; Samant and Pant, 2006; Samant *et al.,* 1996a; Sharma and Samant, 2017).

Results

Diversity and Distribution

Survey was conducted in the sub-alpine forests and alpine region of the Inderkila National Park. A total of 18 species of orchids representing 12 genera were recorded. Amongst the genera, *Epipactis* (3 spp.), *Herminium,* (3 spp.), and *Cypripedium, Habenaria* (2 spp. each) were dominant. Majority of these orchids grow between 2501-3800 m amsl. Six different habitats were identified and all of the recorded orchid species shared common habitats *i.e.* shady moist and moist alpine slope habitat. *Dactylorhiza hatagirea* was reported from the maximum (5) habitats, which is followed by *Malaxis muscifera* and *Herminium latilabre* (3, each) habitats.

Site Representation and Density of Orchids

Of the total species recorded, 11 species were found in the 20 sites sampled for quantitative assessment of vegetation. *Dactylorhiza hatagirea* was recorded in maximum sites (6 sites), followed by *Malaxis muscifera* (4 sites); *Epipactis gigantea, Calanthe tricarinata,* and *Herminium edgeworthii, H. latilabre, H. monorchis* (2 sites, each), *Spiranthes sinensis, Gymnadenia orchidis, Neottia listeroides,* and *Epipactis helleborine* (1 site, each). The density of *Dactylorhiza hatagirea* was ranged from 0.80-1.40 Ind m^{-2}, *Malaxis muscifera* 0.26- 0.45 Ind m^{-2}, *Epipactis gigantea* 0.50-0.56 Ind m^{-2}, *Herminium edgeworthii* 0.25-0.70 Ind m^{-2}, *H. latilabre* 0.23-0.75 Ind m^{-2}, *Calanthe tricarinata* 0.15-0.37 Ind m^{-2}, *Herminium monorchis* 0.15-0.85 Ind m^{-2}, *Spiranthes sinensis* 0.56-1.00 Ind m^{-2}, *Gymnadenia orchidis* 0.55-0.90 Ind m^{-2}, *Neottia listeroides* 0.28-0.58 Ind m^{-2}, and *Epipactis helleborine* 0.23-0.86 Ind m^{-2} (Fig. 2).

Soil Composition

Chemical properties of soil collected from the representative orchid habitats indicated wide variations in soils with respect to their moisture, Nitrogen, and Carbon contents. The mean values of moisture, Nitrogen, Carbon (%), and pH of all the study sites are represented in Table 1.

Nativity, Endemism, and Threat Categorization

Amongst the presently studied species, 11 species were native and 7 were non-native to the Himalayan region, 4 species were near endemic and 1 was endemic to the Indian Himalayan Region (Table 2).

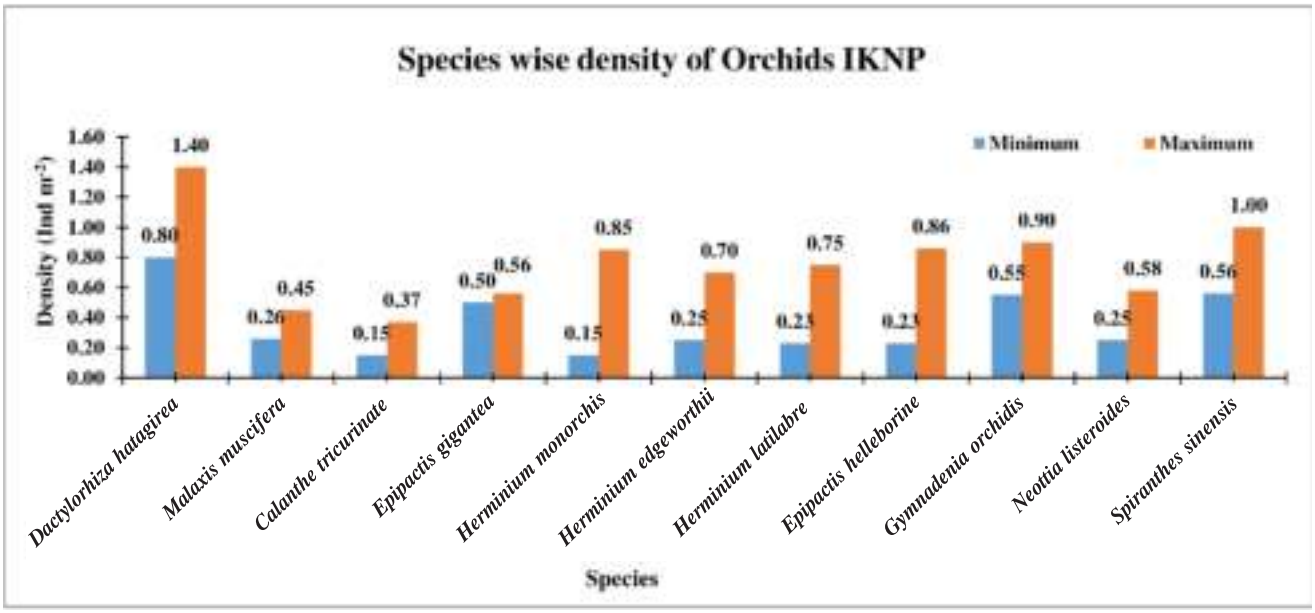

Fig. 2. Species wise density of orchids in Inderkila National Park.

Ethnobotany

Ethnobotany is the way of scientific investigation based on the use of plants species in traditional and cultural practices for food, medicine, religious *etc.* Orchids are the best example of underground drugs. The underground parts (tuber, roots, rhizomes, and bulbs), aerial parts (young stem, flowers, and leaves), and whole plant are used to cure diseases. Amongst the reported species, all were used as medicinal, 2 as ornamental, 1 for fodder, and 1 as religious. Based on plant parts used, the underground parts (57%), aerial parts (25%), and whole plants (18%) contributed the most. After natural sun drying, the underground parts were stored for further use. *Calanthe tricarinata* (leaves), *Dactylorhiza hatagirea* (tubers), *Goodyera repens* (tubers), and *Herminium monorchis* (aerial parts) were used as decoction in cold, cough, and fever. *Cypripedium cordigerum* and *Epipactis helleborine* (rhizomes) were used to cure mental or nervous disorder. *Cypripedium himalaicum* was used as ornamental. The medicinal preparation from orchids includes decoction, tonic, paste, powder, and extract. The most common mode of drug administration was oral, followed by cutaneous and nasal (Table 3; Fig. 3B).

Discussion

India is known for the diversity of orchids, some of them are used as ornamental while some have various medicinal values. Our country is paying attention towards ornamental orchids to bring a revolution in floriculture industry, but orchids in wild having various therapeutic values which is restricted to the particular area. Pharmaceutical industries need to promote such medicinal orchids from wild, which can enhance the

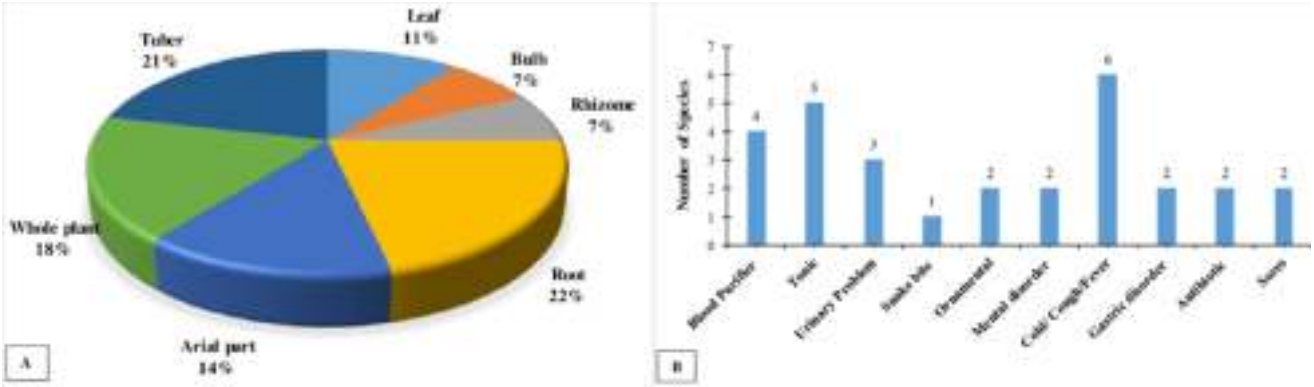

Fig. 3. A-B. A, Percentage of parts used of various medicinally important orchids; B, Medicinal uses of orchids.

Fig. 4. Orchids of Inderkila National Park, Kullu, Himachal Pradesh. A, *Calanthe tricarinata*; B, *Spiranthes sinensis*; C, *Epipactis helleborine*; D, *Gymnadenia orchidis*; E, *Herminium monorchis*; F, *Malaxis muscifera*; G, *Herminium latilabre*; H, *Herminium edgeworthii*; I, *Neottia listeroides*; J, *Dactylorhiza hatagirea;* and K, Sun dried tuber of *Dactylorhiza hatagirea.*

economy and health of many people (Rahamtulla *et al*., 2020).

Most of the orchids found in the Indian Himalayan Region having various medicinal properties, are used in Ayurvedic, Siddha, Unani, and Amchi Systems of medicine especially in the IHR of NorthWestern Himalaya. The above study is an attempt to identify these high value Himalayan medicinal orchids from the Inderkila National Park. Orchids are used as traditional herbs to cure various ailments as a part of traditional medicinal practices (Barman *et al.,* 2016). Buddhist communities in the state Himachal Pradesh uses Tibetan System of Medicine, which is completely based on regional and local herbal plants. During the present investigation, it was found that most of the orchids are the traditionally used ethnomedicinal plants, most of which having high curing capacity, which can be used in pharmaceutical research and studies, and can also be promoted as a cultivated crops among the local inhabitants. All the recorded orchid species were commonly harvested from the study site, but most pressure was on *Dactylorhiza hatagirea* (Devi *et al*., 2018; Singh *et al*., 2019) as the species is under huge market demand and is also used in some religious Buddhist events or ceremonies. The most common use

Table 1. Mean values of various physico-chemical properties of soil from the study sites in Inderkila National Park.

Taxa	pH	Moisture (%)	Nitrogen (%)	Carbon (%)	Phosphorus ($kgha^{-1}$)	Potassium ($kgha^{-1}$)
Calanthe tricarinata	5.96	30.96	0.56	4.66	18.25	89.00
Dactylorhiza hatagirea	5.59	33.52	0.47	3.27	15.50	85.00
Epipactis gigantea	5.62	32.41	0.37	3.32	12.00	155.00
E. helleborine	5.77	33.36	0.47	4.28	15.50	97.00
Gymnadenia orchidis	5.83	32.75	0.51	4.64	18.89	150.00
Herminium monorchis	5.66	27.78	0.61	4.33	17.25	88.00
Malaxis muscifera	5.28	25.52	0.65	4.49	11.55	110.50
Neottia listeroides	5.97	27.11	0.28	4.49	8.12	91.00
Herminium edgeworthii	5.90	30.59	0.23	4.72	11.45	200.00
H. latilabre	5.74	31.44	0.21	3.42	10.50	130.00
Spiranthes sinensis	6.08	32.30	0.47	3.97	12.25	100.50

Table 2. Altitudinal range, habitat, nativity, endemism and status of orchids of Inderkila National Park, Himachal Pradesh.

Taxa	Prevalent species	Altitude (m)	Habitat	Nativity	Status
Calanthe tricarinata Lindl.	*Quercus semecarpifolia, Abies pindrow*	2800-3300	1,4	Reg Himal	LC
*Cypripedium cordigerum** D.Don	*Quercus semecarpifolia*	2800-3200	1,4	Reg Himal	V
C. himalaicum * Rolfe	*Abies pindrow*	3000-3800	1,2,4	China occ., Sikkim, Nepal	EN
Dactylorhiza hatagirea D. Don (Soo')	*Betula utilis, Rhododendron anthopogon*	2800-4000	1,2,4,5,6	Reg Himal, Europe, Afr, Bor Oriens	EN
Epipactis helleborine (L.) Crantz	*Prunus cornuta*	2800-3100	1	Europ, As, Bor	LC
E. gigantea Douglas ex Hook.	*Abies pindrow*	2800-3000	1,3	Am, Bor, As, Temp	NT
E. royleana Lindl.	*Betula utilis*, *Abies pindrow*	2800-3500	1,4	Reg Himal	LC
Goodyera repens (L.) R.Br.	*Abies pindrow, Quercus semecarpifolia*	2800-3000	1,2,3,4	Reg Himal, Bor, Temp	LC
*Gymnadenia orchidis** Lindl.	*Juniper communis*	3500-3800	1	Reg Himal	LC
*Habenaria intermedia*** D.Don	*Acer acuminatum, Abies pindrow*	2800-2900	1	Reg Himal	EN
H. pectinata D.Don	*Abies pindrow, Quercus semecarpifolia*	2800-3500	1	Reg Himal	LC
Herminium lanceum (Thunb. ex Sw.) Vuijk	*Abies pindrow*	2850-3200	4	Ophrys lancea	LC
H. monorchis (L.) R.Br.		2800-3200	1,4	Europe, As, Bor	NT
Malaxis muscifera (Lindl.) Kuntze.	*Acer acuminatum, Abies pindrow*	2800-3200	1, 3, 4	Europe	V
Neottia listeroides Lindl.	*Abies pindrow, Prunus cornuta*	2800-3600	1	Reg Himal	EN
*Herminium edgeworthii** (Hook.f. ex Collett) X.H.Jin, Schuit., Raskoti & Lu Q.Huang	*Abies pindrow*	2800-3300	1, 2	Reg Himal	V
H. latilabre (Lindl.) X.H.Jin, Schuit., Raskoti & Lu Q.Huang	*Abies pindrow*	2800-3500	1,4	Reg Himal	LC
Spiranthes sinensis (Pers.) Ames	*Pinus wallichiana*	2800-3000	1	Europe, As, Aus	LC

Abbreviations used: EN=Endangered, V=Vulnerable, NT=Near Threatened, LC= Least Concern, Reg Himal=Himalayan Region, Bor=Boreal, Afr=Africa, As=Asia, Temp=Temperate, Orient=Oriental, 1=Shady Moist, 2=Riverine, 3=Shrubbery, 4=Moist Alpine Slope, 5= Grassland, 6= Marshy *= Near Endemic and **= Endemic.

of *Dactylorhiza hatagirea* is by the *Khampa* (Buddhist origin) community in their religious ceremony known as *Kurim,* and is used in *Aakha-Mikkha* (to remove evil eye effect). All the studied species are facing tremendous pressure due to anthropogenic activities and habitat degradation, so sustainable harvesting, multiplication, and conservation of such species should be promoted. However, no such activities are yet started to preserve the germplasm of these Himalayan orchids.

Conclusion

The conservation and management of orchids in the Indian Himalayan Region are crucial endeavours to safeguard the rich biodiversity and ecological balance of this unique habitat. Orchids, with their intricate structure and diversity among species, plays a vital role in the pollination dynamics and maintaining overall ecological health.These plants are rich source of alkaloids, flavonoids, glycosides, carbohydrates and phytochemical contents, and are used in indigenous systems of medicine to cure different types of human ailments (Barman *et al.,* 2021).

One key aspect of conservation involves understanding and documenting the diverse orchids present in the region. Establishing a comprehensive inventory becomes a foundational step, providing essential data for targeted conservation efforts. The Indian Himalayan Region boasts a plethora of orchid species, many of which may still be undiscovered, making a thorough assessment imperative. However, the conservation discourse must address the pressing threats faced by factors such as, deforestation, infrastructure development, and climate change pose a significant risk to orchid population. Moreover, illegal trade of some orchid species for medicinal and commercial demand

Table 3. Parts used, Medicinal preparation, Mode of drug administration and indigenous uses of orchids of Inderkila National Park, Himachal Pradesh.

Taxa	Part/s Used	Medicinal preparation	Mode of drug administration	Indigenous Uses
Calanthe tricarinata Lindl.	Leaf, Bulb	Decoction	Orally	Sores, eczema and as aphrodisiac
*Cypripedium cordigerum** D.Don	Rhizome, Aerial part	Tonic	Orally	Mental disorders
*C. himalaicum** Rolfe	Whole plant	-	-	Ornamental
Dactylorhiza hatagirea D.Don (Soo')	Tuber	Extract/ Decoction/ Paste/Tonic	Orally/ Cutaneous	Antibiotic, sexual disability, rheumatism, many Ayurvedic, Unani and Tibetan medicine preparation
Epipactis helleborine (L.) Crantz	Rhizome	Tonic	Orally	Nervous disorder
E. gigantea Douglas ex Hook.	Roots	Tonic	Orally	Used in fever
E. royleana Lindl.	Whole plant	Tonic	Orally	Fodder, food and ornamental
Goodyera repens (L.) R.Br.	Aerial part, Tuber	Decoction/ Paste/Tonic	Orally/ Cutaneous	Plant paste is applied externally in syphilis, blood purifier, menstrual disorder, cold and kidney problems.
*Gymnadenia orchidis** Lindl.	Tuber	Decoction	Orally	Gastric and urinary disorder
*Habenaria intermedia*** D.Don	Tuber	Tonic	Orally	Fever, skin disease and blood disorder
H. pectinata D.Don	Leaf, Tuber	Paste	Orally/ Cutaneous	Snake bites and arthritis
Herminium lanceum (Thunb. ex Sw.) Vuijk	Aerial part	Tonic	Orally	Anti-suppressant properties
H. monorchis (L.) R.Br.	Whole plant	Decoction/Tonic	Orally	Urinary problems
Malaxis muscifera (Lindl.) Kuntze.	Bulb	Decoction/Tonic/ Paste	Orally/ Cutaneous	Cooling, used as refrigerant, febrifuge, aphrodisiac and styptic for curing dysentery, debility, sterility and used in burns.
Neottia listeroides Lindl.	Aerial part	Extract	Orally	Cough
*Herminium edgeworthii** (Hook.f. ex Collett) X.H.Jin, Schuit., Raskoti & Lu Q.Huang	Tuber, Leaf	Tonic	Orally	Blood purifier, rejuvenator and cooling
H. latilabre (Lindl.) X.H.Jin, Schuit., Raskoti & Lu Q.Huang	Leaf	Tonic	Orally/ Cutaneous	Herbal medicine
Spiranthes sinensis (Pers.) Ames	Aerial part, Tuber	Extract	Orally	Anti-inflammatory, cancer, sore throat, debility, cough, tuberculosis

further exacerbates the challenges faced by these delicate species.

To address these threats, effective conservation strategies are essential. Creating protected areas and corridors for orchids, coupled with stringent enforcement against illegal activities can help preserve their natural habitat. Involving local communities in conservation initiatives is equally crucial, as their traditional knowledge can contribute to sustainable orchid management practices. Research initiatives focused on orchid ecology and physiology can provide valuable insights into their specific requirement and aid in the development of targeted conservation measures. Additionally, promoting eco-tourism with a strong emphasis on responsible practices can generate awareness and financial support for orchid conservation. The conservation and management of orchids in the Indian Himalayan Region require a multidimensional approach. Earlier few scientists have worked on the different orchid species including (*Coelogyne fimbriata* (Anuprabha and Pathak, 2019, 2020); *Dendrobium formosum* (Bhowmik and Rahman, 2022); *Pholidota imbricata* (Tripura *et al.,* 2022); *Rhynchostylis retusa* (Kumari and Pathak, 2021; Thakur and Pathak, 2021); *Satyrium nepalense* (Vasundhra *et al*., 2021); *Vanda cristata* (Pathak *et al*., 2022, 2023; Sunita *et al.,* 2021) along with the scientific research, community engagement and policy implementation, it is possible to ensure the survival of these exquisite species and maintain the ecological integrity of this unique and biodiverse landscape.

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