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ECOLOGICAL ASSESSMENT OF SUB-ALPINE AND ALPINE ORCHIDS OF GREAT HIMALAYAN NATIONAL PARK IN HIMACHAL PRADESH, NORTHWESTERN HIMALAYA

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Abstract

The Great Himalayan National Park (GHNP) is one of the World Heritage Sites in the Indian Himalayan Region. It supports representative, natural, unique, and socio-economically important biodiversity. Amongst the flowering plants, family Orchidaceae is unique and highly evolved. But the orchid species are facing tremendous pressure due to over exploitation, habitat degradation, and changing environmental conditions particularly climate change. Also, ecological status of these species is very poorly known. Therefore, the present study has been conducted to assess the orchid diversity of sub-alpine and alpine ecosystems of the Great Himalayan National Park. Rapid sampling and quadrat methods were used for the ecological assessment of the species. The economic importance of the species is based on the interviews of the local inhabitants. The intensive and extensive surveys resulted in the identification of 14 species representing 9 genera. These species were distributed between 2807-4025 m amsl and represented by the moist alpine, bouldary, riverine, rocky, and shady moist habitats. The species were also analyzed for their nativity, indigenous uses, and rarity. Amongst species, 12 species were natives and 02 species non-natives. *Dactylorhiza hatagirea* was recorded in maximum sites (12 sites), followed by *Epipactis helleborine* (11 sites), *Calanthe tricarinata* (04 sites), *Calanthe plantaginea*, *Gymnadenia orchidis* (03 sites, each), *Epipactis royleana*, *Cypripedium cordigerum* (02 sites, each) and *Goodyera repens*, *Goodyera fusca*, *Epipactis gigantea*, *Malaxis muscifera*, *Platanthera edgeworthii*, *Goodyera biflora* and *Dienia cylindrostachya* (01 site, each). Maximum orchids were found in shady moist habitat (21 spp.), followed by alpine moist (08 spp.), riverine and rocky (06 spp., each), and bouldary (02 spp.). The density of *Epipactis helleborine* ranged from 0.20-4.50 Ind m^{-2}, *Dactylorhiza hatagirea* 0.03-3.58 Ind m^{-2}, *Epipactis royleana* 1.90-3.58 Ind m^{-2}, *Calanthe plantaginea* 0.60-0.90 Ind m^{-2}, *Gymnadenia orchidis* 0.60-1.95 Ind m^{-2}, *Cypripedium cordigerum* 0.15-0.60 Ind m^{-2}, *Goodyera fusca* 0.30 Ind m^{-2}, *Epipactis gigantea* 0.23 Ind m^{-2}, *Malaxis muscifera* 0.10 Ind m^{-2}, *Platanthera edgeworthii* 0.30 Ind m^{-2}, *Goodyera biflora* 1.13 Ind m^{-2} , *Dienia cylindrostachya* 0.15 Ind m^{-2}, and *Goodyera repens* 0.83 Ind m^{-2}. Amongst the species, *Calanthe plantaginea*, *Epipactis gigantea, Epipactis helleborine*, *Epipactis royleana*, *Goodyera fusca*, and *Platanthera edgeworthii* were identified as Vulnerable. *Calanthe tricarinata, Goodyera biflora,* and *Dienia cylindrostachya* were identified as Near Threatened, *Cypripedium cordigerum, Dactylorhiza hatagirea,* and *Gymnadenia orchidis* as Endangered, *Malaxis muscifera* was identified as Critically Endengered and *Goodyera repens* was identified as Least Concern. Study on habitat ecology and periodical monitoring populations of these orchids has been suggested for understanding the dynamics and conservation status of their populations.

Introduction

THE ORCHIDS rank amongst the most significant plants, known for their incredibly attractive and beautiful flowers which have an irresistible appeal once anybody comes in contact with them. There are 24,500 species and 800 genera known throughout the world (Chadha, 1992; Dressler, 2005). The orchids belong to the family Orchidaceae which is amongst the largest families of angiosperms in the world. Except Antarctica, orchids are distributed all over the world, and their major diversity occurs in Tropical America, Indo-Malaya, and East Himalaya in India. India is one of the richest orchid habitats with over 1,256 species belonging to 155 genera (Singh *et al.*, 2019). The Indian Himalayan Region (IHR), is one of the richest hotspot of Indian subcontinent, with geographical coverage of over 5.3 lakh km^2 extends over 2,500 km in length between the Indus and Brahmaputra river systems (Fig. 1). It is one of the mega diverse regions of India and supports about 8,000 flowering plants (Samant *et al.,* 1998). The IHR harbours about 876 orchid species in 151 genera (Kumar and Manilal, 1994). The diversity of orchids decreases from North-East to North-West Himalaya because of its unique habitat, large altitudinal range, and diverse weather conditions (Barman *et al*., 2016; Deva and Naithani, 1986; Kumar *et al*., 2017; Marpa and Samant, 2012; Pangtey and Samant, 1991; Samant, 2002, 2009; Samant *et al*., 1995; Verma *et al*., 2009;). Like other parts of IHR, Himachal Pradesh also supports unique orchid diversity. The review of literature revealed that the studies on orchids in Himachal Pradesh have been carried out by various workers (Barman *et al*., 2016; Chaudhary and Agarwal, 2013, Deva and Naithani, 1986; Devi *et al*., 2018; Jalal and Jayanthi, 2015; Kumar *et al*., 2016, 2017, 2018; Marpa and Samant, 2012; Pangtey *et al.,* 1991; Prakash *et al*., 2018, Rana *et al*., 2008; Samant, 2002; Sharma and Samant, 2017;

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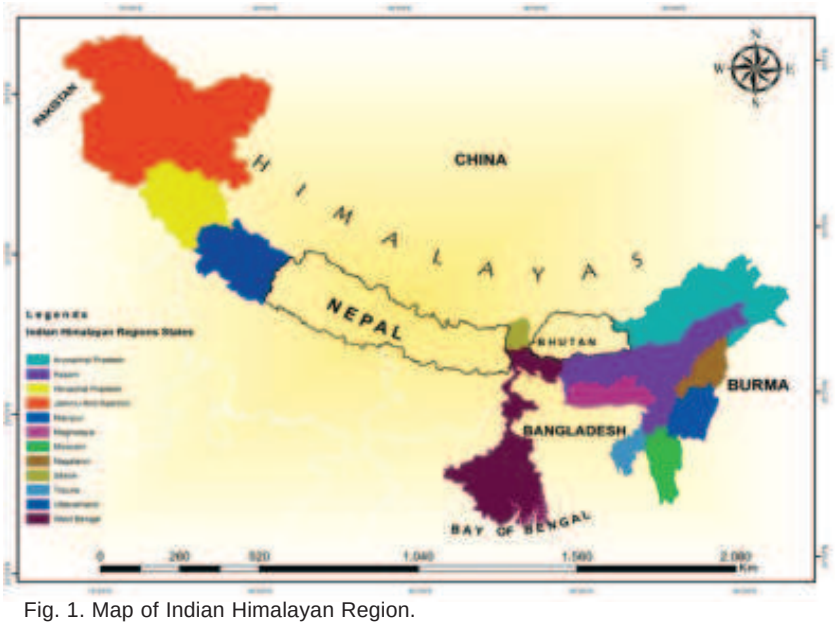

Fig. 1. Map of Indian Himalayan Region.

Sharma *et al*., 2015; Verma *et al*., 2009; Vij *et al*., 2013). In general, systematic study of orchids has also been done by various workers while exploring the flora (Chowdhery and Wadhwa, 1984; Collett, 1902; Dhaliwal and Sharma, 1999; Dhar and Kachroo; 1983; Gaur, 1999; Murthy, 2011; Naithaini, 1984; Polunin and Staintion, 1984; Rai *et al*., 2017; Rana *et al.,* 2008; Sharma, 2013; Singh and Rawat, 2000; Singh and Sharma, 2006; Staintion, 1988). These studies are totally based on the qualitative assessment of the species (Rana and Samant, 2010). However, ecological study of orchids following quadrat method has been attempted by a few workers (Rana *et al*., 2008; Rana and Samant, 2010). In view of this, the present study has been carried out in sub-alpine and alpine ecosystems of the GHNP to; i) assess the diversity and status of orchids in the sub-alpine and alpine ecosystems; ii) analyze orchid species for nativity, endemism, and threat categories; and iii) suggest management options for the conservation of orchid diversity.

Material and Methods

Study Area

The present study was conducted in the sub-alpine and alpine ecosystems of Great Himalayan National Park located in the Banjar tehsil of Kullu district in Himachal Pradesh, India (Fig. 2). Initially constituted in 1984, it covers an area of 1171 km^2 lying between 31°38'28" N to 31°51'58" N latitudes and 77°20'11" E to 77°45'52" E longitudes. Final notification of the Park was done in the year 1994. The GHNP, a natural site was inscribed into the UNESCO World Heritage list during the session of the 38th World Heritage Committee in Doha (Qatar), on 23rd June, 2014. The GHNP is surrounded from all directions by Sanctuaries. Administratively, the area has been divided into different management zones. These are Eco-development Zone (EZ) in the SouthWest, Tirthan Wildlife Sanctuary (TWLS) in the South, GHNP in the North and Sainj Wildlife Sanctuary (SWS) lying between West to East directions. The Park is bordered by Rupi Bhava Wildlife Sanctuary in the East, Pin Valley National Park in the NorthEast and Kanawar Wildlife Sanctuary in the NorthWest. The major vegetation types include broad leaved forests, coniferous forests, and mixed conifer forests. It is known for its rich faunal and floral diversity (Mathur and Naithani, 1999). The altitudinal range (1344-6248 m) supports representative, natural, unique, and socio-economically important biodiversity. According to biogeography classification, GHNP falls under NorthWestern Himalayan biotic province. The temperature ranges between -10° to 35°C and rainfall ranges 1000-2000 mm annually. The underlying rocks found in the area are largely quartzite, schist, phyllite,

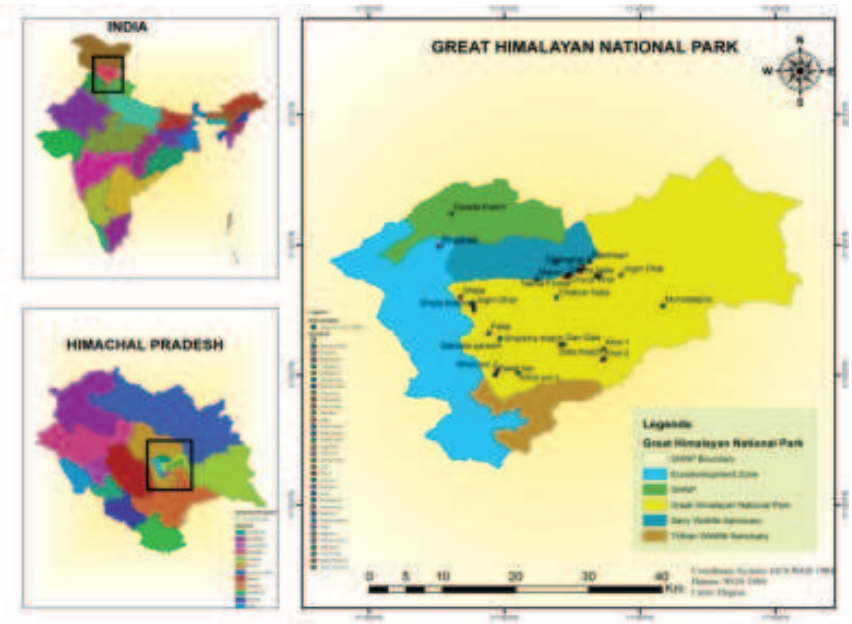

Fig. 2. Map of Great Himalayan National Park, District Kullu, Himachal Pradesh.

dolomites, limestone, shale, slate, gneiss, and granites. The GHNP areas show complex geography along an altitudinal gradient which supports diverse vegetation *i.e*., sub-tropical, temperate, sub-alpine, and alpine types.

Survey, Sampling, Identification, and Data Analysis

The site representing orchid species selected along an altitudinal gradient between 2624-4025 m amsl. Observations on habitat type, aspect, altitude, slope, latitudes, and longitudes of every sampled plot was obtained with the help of GPS. Slope was measured with the help of clinometer. Habitats were identified based on the physical characters and dominance of vegetation. Sites having closed canopy with high proportions of humus and moisture content were considered as moist habitat. The sites having >50% boulders of the ground cover were considered as bouldary habitat, sites with rocks, and cliffs were considered as rocky habitat and site located on the river banks were considered as riverine habitat. The field surveys and samplings were conducted during the summer and rainy seasons in the years 2015-2018.

For qualitative assessment, rapid sampling was done and sample of each species was collected and identified with the help of local and regional floras, and literature (Aswal and Mehrotra, 1994; Chowdhery and Wadhwa, 1984; Dhaliwal and Sharma, 1999; Pangtey and Samant, 1991; Singh and Rawat, 2000). For the assessment of economically important orchids, local *Vaidyas* and knowledgeable persons from the study area were interviewed. The information was compiled and analyzed for the utilization pattern following Samant *et al*. (2007). For quantitative assessment, quadrat method was followed. In each site, a plot of 50×50 m was laid and within this plot 20 quadrats of 1×1 m were placed randomly. For the data collection, standard ecological methods were used (Curtis and McIntosh, 1950; Dhar *et al*., 1997; Greig-Smith, 1957; Joshi and Samant, 2004; Kershaw, 1973; Mishra, 1968; Mueller-Dombois and Ellenberge, 1974). Species were analyzed for nativity, endemism, and threat categories. The species with its origin or firstly reported from the Himalayan region were considered as natives (Samant *et al*., 1998), whereas remaining species were considered as non-natives. The species restricted to IHR were considered as endemic, whereas those extending their distribution to neighbouring countries/states were considered as near endemic (Dhar and Samant, 1993; Samant *et al*., 1996, 1998). For the assessment of threat categories of orchid species, habitat preference, population size, altitudinal range, and utilization values were collectively used following Rana and Samant (2010).

Results

Distribution and Spatial Pattern of Orchids

Total 35 sites representing 05 major habitats and 08 directional aspects between 2807-4025 m amsl were selected and sampled from the sub-alpine and alpine ecosystems of GHNP. Maximum sites (14) were represented by shady moist habitat, followed by alpine moist (09), rocky (05), riverine (05), and bouldary (02) habitats. In term of directional aspect, 08 sites were represented in NorthWest, 07 in North, 04 in West, SouthWest, and East, each, 03 in South and NorthEast and 02 in SouthEast aspects. The slope varied from 15°-68°. Site/habitat characteristics, dominant species, aspect, altitude and slope are presented on Table 1.

A total of 14 species representing 09 genera (Fig. 5) were recorded from the sub-alpine and alpine ecosystems of the GHNP, of these, 14 species of orchids were recorded between 2800-3200 m, 11 species between 3201-3600 m, 07 species between 3601-4000 m and 02 species above 4000 m (Fig. 3). The study concluded that sub-alpine ecosystems of GHNP supported maximum number of orchids.

Density

In the presently studied area, *Dactylorhiza hatagirea* was recorded in maximum sites (12 sites), followed by *Epipactis helleborine* (11 sites), *Calanthe tricarinata* (04 sites), *Calanthe plantaginea*, *Gymnadenia orchidis* (03 sites, each), *Epipactis royleana, Cypripedium*

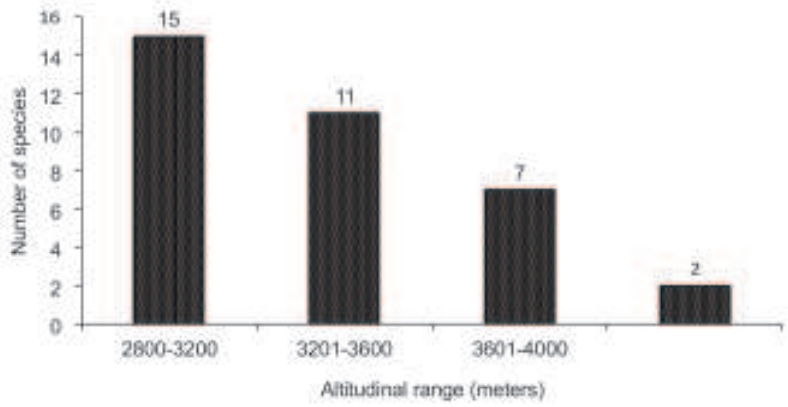

Fig. 3. Altitudinal distribution of orchids in sub-alpine and alpine zones of GHNP.

Table 1. Physical characteristics of the sites assessed in Great Himalayan National Park.

Site name	Habitat type	Aspect	Altitude (m)	Slope (°)	Dominant species
Dhela	SM	NW	2836	40	*Picea smithiana, Quercus semecarpifolia*
Dhela thatch 1	AM	SW	3518	60	*Quercus semecarpifolia*
Dhela thatch 2	RO	W	3711	68	*Rhododendron anthopogon, Juniperus recurva*
Jogni Dhar	AM	N	3610	35	*Cassiope fastigiata, Rhododendron anthopogon*
Maror	RI	NW	2824	25	*Abies pindrow*
Chyos Khol	RI	N	2852	20	*Pinus wallichiana*
Brahmachuli	SM	SW	2862	45	*Pinus wallichiana*
Kaili thatch	RO	NE	3000	35	*Prunus cornuta*
Chyos thatch	AM	NW	3157	15	*Rosa sericea*
Ratidwari	B	SW	3452	45	*Juniperus indica*
Chakrer thatch	AM	NW	3821	30	*Poa pratens, Aconitum heterophyllum*
Chakrer Nala	R	W	4025	55	*Rhododendron anthopogon*
Chainghar 1	RI	SE	3370	40	*Abies pindrow*
Chainghar 2	AM	E	3329	20	*Betula utilis*
Parkachi thatch	SM	NW	3124	15	*Abies pindrow, Betula utilis*
Upper Parkachi 1	RO	NW	3242	56	*Betula utilis, Abies pindrow*
Upper Parkachi 2	SM	N	3194	30	*Betula utilis, Abies pindrow*
Jogni Dhar	SM	SW	3239	20	*Betula utilis, Abies pindrow*
Kamba Forest	SM	N	2900	30	*Taxus wallichiana, Abies pindrow*
Telan Forest	SM	N	2829	15	*Taxus wallichiana, Betula utilis*
Chyos Nala	SM	NW	2924	40	*Abies pindrow, Betula utilis*
Naina Forest	RI	NW	2807	20	*Betula utilis, Taxus wallichiana*
Mundatapra	B	S	4010	30	*Rosa macrophylla*
Dwada thatch	SM	S	3225	30	*Quercus semecarpifolia, Abies pindrow*
Bhujaradi	SM	E	3330	40	*Quercus semecarpifolia*
Banadapareshi	SM	SE	3513	28	*Juniperus communis*
Patal	AM	E	3706	40	*Geum elatum, Bromus javanicus*
Paadi top	AM	N	3537	30	*Rhododendron campanulatum, Rosa sericea*
Kholi poi 1	SM	W	2877	40	*Acer acuminatum, Quercus semecarpifolia*
Kholi poi 2	SM	W	2862	42	*Abies pindrow, Picea smithiana*
Shankha thatch	RI	NE	3212	30	*Betula utilis, Quercus semecarpifolia*
Khol 1	AM	NE	3801	35	*Carex setigera, Fastuca rubra*
Sitto thatch	RO	E	3970	40	*Salix lindleyana*
Khol 2	AM	N	3810	45	*Rosa sericea,*
Dari Gad	SM	S	3206	60	*Quercus semecarpifolia, Prunus cornuta*

AM, Alpine moist; SM, Shady Moist; RI, Riverine; B, Bouldary; RO, Rocky; SE, South East; NE, NorthEast; S, South; E, East; SW, SouthWest; W, West; N, North; NW, NorthWest.

cordigerum (02 sites, each), *Epipactis gigantea, Goodyera biflora, Goodyera fusca, Goodyera repens, Platanthera edgeworthii, Dienia cylindrostachya,* and *Malaxis muscifera* represented in 01 site each. Highest density was recorded for *Epipactis helleborine,* ranged from 0.20-4.50 Ind m^{-2} and *Epipactis royleana* 1.90-3.58 Ind m^{-2} which is followed by *Dactylorhiza hatagirea* 0.03-3.58 Ind m^{-2}, *Gymnadenia orchidis*

Fig. 5. A-I. Orchids of Great Himalayan National Park in Himachal Pradesh, NorthWestern Himalaya. A, *Dactylorhiza hatagirea;* B, *Gymnadenia orchidis*; C, *Goodyera repens*; D, *Calanthe tricarinata*; E, *Calanthe plantaginea*; F, *Goodyera fusca*; G, *Platanthera edgeworthii*; H, *Dienia cylindrostachya*; I, *Epipactis helleborine*.

0.60-1.95 Ind m^{-2}, *Calanthe plantaginea* 0.60-0.90 Ind m^{-2}, *Cypripedium cordigerum* 0.15-0.60 Ind m^{-2}, *Calanthe tricarinata* 0.05-1.00 Ind m^{-2}, *Goodyera fusca* 0.30 Ind m^{-2}, *Epipactis gigantea* 0.23 Ind m^{-2}, *Dienia cylindrostachya* 0.15 Ind m^{2}, *Malaxis muscifera* 0.10 Ind m^{-2}, *Platanthera edgeworthii* 0.30 Ind m^{-2}, *Goodyera biflora* 1.13 Ind m^{-2}, and *Goodyera repens* 0.83 Ind m^{-2} (Fig. 4).

Nativity and Endemism

Eight species namely, *Calanthe plantaginea*, *Calanthe tricarinata*, *Epipactis helleborine*, *Epipactis royleana*, *Dienia cylindrostachya, Malaxis muscifera*, *Goodyera biflora*, and *Goodyera fusca* were natives and 02 species *Epipactis gigantea* and *Goodyera repens* were non-natives. Amongst the species, *Dactylorhiza hatagirea*,

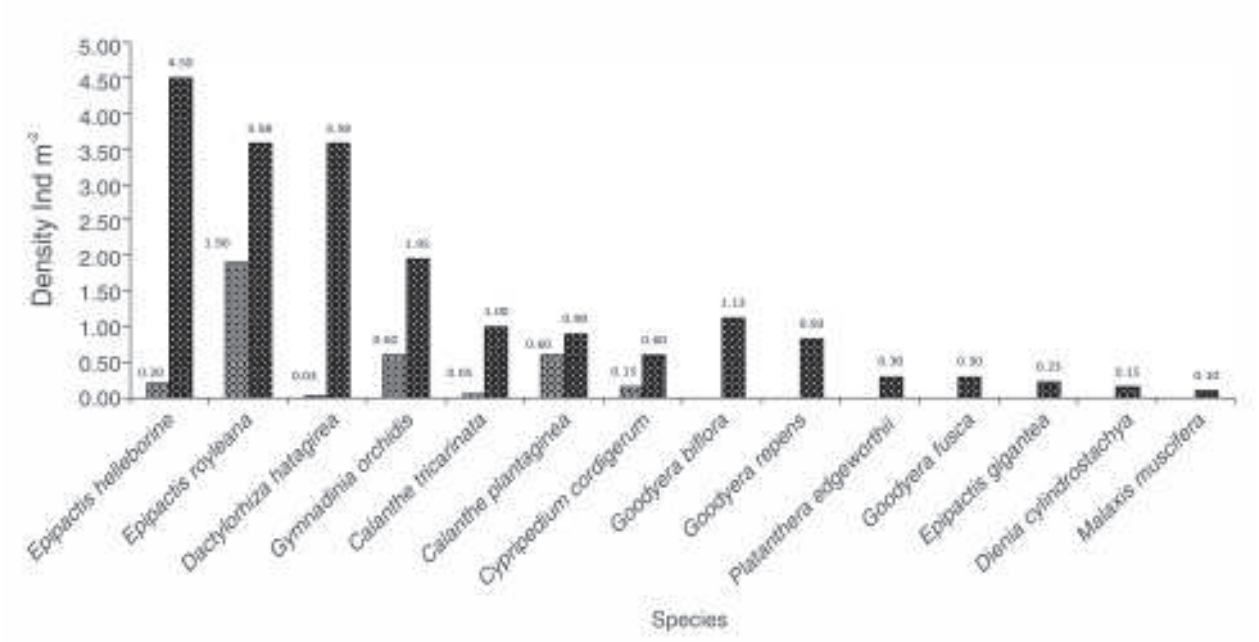

Fig. 4. Density of Orchid species in the Sub-alpine and Alpine zones of GHNP.

Cypripedium cordigerum, and *Gymnadenia orchidis* were near endemic and one species *Platanthera edgeworthii* was endemic to the Indian Himalayan Region (Table 2).

Threat Categorization

The investigation on threat categorization revealed that *Calanthe plantaginea*, *Epipactis gigantea, Epipactis*

Table 2. Site representation, habitat, directional aspect, altitudinal range, nativity and status of Sub-alpine and Alpine ecosystems of GHNP.

Taxa	Site representation	Habitat(s)	Directional aspect(s)	Altitudinal range (m)	Nativity	Status
Calanthe plantaginea Lindl.	03	SM	NW, SE, W	2500-3100	Reg Himal	VU
Calanthe tricarinata Lindl.	04	RI, SM	N, NW	2500-3300	Reg Himal	NT
Dactylorhiza hatagirea (D.Don) Soó	13	AM, BL, RI, RO, SM	E, N, NE, NW, S, SE, SW, W	2800-4000	Reg Himal	EN
Epipactis gigantea Douglas ex Hook.	01	SM	SW	2800-3200	N. Amer	VU
Epipactis helleborine (L.) Crantz	11	RI, RO, SM,	N,NE, NW, SW	2800-3200	Reg Himal	VU
Epipactis royleana Lindl.	02	SM	SW	3000-3300	Reg Himal	VU
Goodyera biflora (Lindl.) Hook.f.	01	SM	N	2800-3000	Reg Himal	NT
Goodyera fusca (Lindl.) Hook.f.	01	AM, RO	SW, W	3200-3700	Reg Himal	VU
Goodyera repens (L.) R.Br.	01	SM	E	3000-3400	N. Amer	LC
Platanthera edgeworthii (Hook.f. ex Collett) R.K.Gupta	01	BL	SW	3000-3500	Reg Himal	VU
Malaxis muscifera (Lindl.) Kuntze	01	SM	SW	2800-3500	Reg Himal	CR
Dienia cylindrostachya Lindl.	01	SM	N	2800-3000	Reg Himal	NT
Cypripedium cordigerum D.Don	02	AM, RO	E, NW	3000-3300	Reg Himal	EN
Gymnadenia orchidis Lindl.	03	RO, SM	E, S, SE	3200-3900	Reg Himal	EN

SM, Shady Moist; RI, Riverine; AM, Alpine moist; BL, Bouldary; RO, Rocky; VU, Vulnerable; NT, Near Threatened; EN, Endangered; CR, Critically Endangered; LC, Least Concern; Reg Himal, Himalayan Region; N. Amer, North America; NW, NorthWest; SE, SouthEast; W, West; N, North; E, East; NE, NorthEast; S, South; SW, SouthWest.

helleborine, *Epipactis royleana*, *Goodyera fusca*, and *Platanthera edgeworthii* were identified as Vulnerable. *Calanthe tricarinata, Goodyera biflora,* and *Dienia cylindrostachya* were identified as Near Threatened, *Cypripedium cordigerum, Dactylorhiza hatagirea,* and *Gymnadenia orchidis* as Endangered, *Malaxis muscifera* was identified as Critically Endengered and *Goodyera repens* was identified as Least Concern. (Table 2).

Discussion and Conclusion

The NorthWestern Himalaya is mostly known for the terrestrial orchids (Vij *et al*., 2013). The habitats of orchids investigated in Great Himalayan National Park were found to be under varied levels of anthropogenic pressures, forest fire, overgrazing, and over exploitations. Besides, natural factors such as avalanches, landslides, decrease in rain fall and snow fall, rise in minimum and maximum temperature are causing changes in environmental conditions leading to shift in biological cycle and shrinkage of natural habitats. Such conditions are becoming unfavourable for the growth of the species. In the present study, majority of the orchids were found in shady moist forests. Changes in habitats may affect the populations of moisture loving orchid species. Over exploitation of roots/tubers/bulbs for trade may cause rapid depletion of populations of these orchids. The orchid seeds do not germinate without an appropriate fungal stimulus in nature, therefore, soil and climatic conditions have to be favourable for the growth of their mycorrhizal partner. The degradation of soil may result changes in above and below ground diversity.

In Great Himalayan National Park, the inhabitants largely depend on forests for grazing and collection of fuel, fodder, timber, medicine, wild edible, and other economically important plants. Some of the orchid species namely, *Dactylorhiza hatagirea*, *Malaxis muscifera*, *Platanthera edgeworthii*, and *Gymnadenia orchidis* are extensively used in Traditional System of Medicine and are commercially exploited in the area. If over exploitation and habitat degradation continues, these species may become extinct from the wild in future. Therefore, long term habitat monitoring using standard ecological methods is essentially required to understand the response of the orchid species under anthropogenic and climate change scenarios. In addition, mass multiplication of the species following conventional and *in vitro* propagation methods (Bhatti *et al.,* 2017; Decruse and Gangaprasad, 2018; Kaur *et al.,* 2017; Pathak *et al.,* 2001) and their establishment in the *in situ* and *ex situ* conditions with the participation of local communities and Forest Department; and conservation education programmes for the local inhabitants and officials of Forest Department have been suggested.

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