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Therapeutic Himalayan herbs: Folklore uses, bioactive phytochemicals, and biological activities of medicinal orchids used by Nomads

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Natural products have bioactive properties which have been exploited for human and animal use for hundreds of years. Orchids are one of the largest, diverse, and most evolved groups of plants within monocot angiosperms. Different species under this category have been recognized as the most threatened plants due to poor seed germination, the need for endophytic mycorrhizal partners, and habitat destructions coupled with climate change. The majority of orchid taxa are known to have therapeutic potential due to the presence of bioactive substances, such as alkaloids, bibenzyls, phenanthrenes, phenanthrenequinones, glycosides, carbohydrates, flavonoids, and stilbenoids. In this study, twenty-eight indigenous Himalayan orchids were documented from six Himalayan states and one union territory of India *viz*., *Acampe ochracea, Aerides odorata, A. multiflora, Anoectochilus setaceus*, *Arundina graminifolia*, *Bulbophyllum odoratissimum*, *Coelogyne corymbosa*, *C. punctulata*, *Crepidium acuminatum*, *Cymbidium aloifolium*, *C. elegans*, *Dendrobium densiflorum*, *D. fimbriatum*, *D. fugax*, *D. nobile*, *Eulophia graminea*, *Habenaria dentata*, *H. marginata*, *Herminium lanceum*, *Liparis nervosa*, *Papilionanthe teres*, *Phaius tankervilleae*, *Pholidota imbricata*, *P. pallida*, *Porpax muscicola*, *Rhynchostylis retusa*, *Vanda coerulea* and *V. cristata* familiar to nomadic tribes for use as medicine in their daily life. Data collected on species identity and nomenclature, local names, uses, bioactive constituents, pharmacological bioactivities, and phenology are presented. These findings will help in preserving Himalayan traditional knowledge, conservation of endangered plants, and research and development associated with wild orchids or similar taxa elsewhere in the globe.

Keywords: Distribution, Eco-taxonomy, Ethnobotany, Himalayas, Pharmacology.

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Introduction

Herbs are the reservoirs of a wide variety of bioactive compounds which have been exploited for human use in the medicine and culinary for thousands of years[1,2]. Natural products are substances produced by living organisms, such as microbes, plants, and animals[3]. Plants continue to be examined for research studies, and the past few decades have witnessed a tremendous resurgence in interest and use of ethnomedicinal plant products[4-5]. Himalayan regions are fascinating as they form a unique repository of biological diversity and contain a high number of endemic taxa[6], and orchids are interesting groups of plants from the ethnomedicinal point of view[7-8]. Orchids are a classic angiosperms model for understanding biotic pollination[5] and their diversity is represented by approximately 10% of the world's flowering plants[9]. They are characterized by distinct flower morphology, unique association with fungal partners, velamen, minuscule seeds, pollination system, and represent one of the greater diversity in colour, shape, size, and flowers perfume[10-12]. Having diversified into 27,801 species of 899 genera, orchids are capable of occupying almost all conceivable ecological niches, except marine environments and habitats characterised by snow[13]. Endemic plant species are the most valuable component of any flora and deserve a high regional and global conservation priorities[14]. The Orchidaceae members deserve proper conservation priorities for their existence in nature[15]. Orchid species in India are represented by 1,331 species and 186 genera reported from tropical, subtropical, temperate and alpine climates[16-18].

Members of orchids are recognized as medicinal herbs used by millennia to treat different types of diseases[19]. *Calanthe* R.Br., *Coelogyne* Lindl., *Cymbidium* SW., *Crepidium* Blume, *Dendrobium*

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Sw., *Ephemerantha* P.F.Hunt & Summerh., *Eria* Lindl., *Galeola* Lour., *Gastrodia* R.Br., *Gymnadenia* R.Br., *Habenaria* Willd., *Ludisia* A.Rich., *Luisia* Gaudich., *Nervilia* Comm. ex Gaudich., and *Thunia* Rchb.f. are reported as the frequently used genera in medicine. Several bioactive compounds such as alkaloids (dendrobine, jebantine), bibenzyl (gigantol, moscatilin), phenanthrene (nudol, agrostophyllinone, isoagrostophyllol, nidemin), phenanthrenequinone (cypripedin), glycosides (loroglossin, melianin, kinsenoside), carbohydrates, flavonoids, stilbenoids (arundinan, orchinol, 6-methoxycoelonin, imbricatin, flaccidin, oxoflaccidin, isooxoflaccidin, flaccidinin, agrostophyllin, callosin, callosinin, callosumin, callosuminin and callosumidin) have been reported from several orchid species[20-23]. These orchid compounds are useful in healing fractures, seminal weakness, fever, abnormal thirst, curing cancer, and diabetic conditions[23-24]. Several bioactive compounds found in orchids have been shown to possess various pharmacological properties such as anti-microbial, anti-inflammatory, anti-tumour, and anti-viral[24]. Due to human activities, these groups of plants have a higher proportion of threatened and endangered species.

Keeping in view the importance of traditional knowledge associated with plants in drug discovery programs, an investigative study was carried out to document the medicinal orchids of the Himalaya regions used by nomadic people.

Methodology

Study area

Indian Himalaya (26°20' to 35°40'N, 74°50' to 95°40'E) with 250 to 300 km is spread over 2,500 km stretch from union territory Jammu & Kashmir (J&K) in the west to Arunachal Pradesh in the east[6,18]. It borders Pakistan on the west, Myanmar in the Eastern Himalaya, touching parts of Nepal and Bhutan. The region partially/full covers 11 states Himachal Pradesh, Uttaranchal, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam, West Bengal, and 1 union territory J&K. The region has a total geographical area of approximately 5,33,604 km^2 and is home to 3,69,28,311 people[18]. The region supports unique cultural, ethnic, and biological diversity and there are several glaciers such as Siachen, Rulung, Neh-Nar, Braham Sar, and Harmukh originating from the high hills mountains of the Indian Himalaya[18]. Climate is characterized by tropical/subtropical climatic conditions from the foothill region of the mountains to permanent ice and snow-covered peaks at higher altitudes[11,12]. The species of plants and animals of the Himalayas vary with climate, rainfall, altitude, and soils. The amount of annual rainfall increases from west to east along the southern front of the range. The valleys experience a mean summer temperature between 15 and 25 °C and a much colder winter; the north-western peaks of Himalaya typically experience dry conditions, with surface temperatures ranging between 3 and 35 °C in summer and −20 and −35 °C in winter together with heavy snowfall[16,18]. The mountains have rich forests abode with thousand of species of trees, shrubs, herbs, lianas and more than 40% of the species are endemics. Many medicinal species are growing in the Himalayas which have high demand in the international trade such as species of *Aconitum* L., *Allium* L., *Angelica* L., *Cinnamomum* Schaeff., *Panax* L., *Paris* L., *Podophyllum* L., *Saussurea* DC., *Terminalia* L., and *Zanthoxylum* L.[13,18].

Field survey and ethnobotanical documentation

Field surveys, investigations, and plant collection tours for studying medicinal orchids were conducted between 2015 and 2018. Few pockets of Himalaya regions were selected based on their known cultural and botanical richness. Before the field-works, relevant information and literature[25-35] were reviewed with reference to local indigenous knowledge on people, topography, and climate of the study areas. Field studies were undertaken during the growing season by interviewing members of the local nomadic communities inhabiting the Indian Himalayas. Medicinal information on orchid plants was collected from 146 individuals (81 males and 65 females) (Table 1). The data collected were from headmen, heads of the family, and herbal practitioners, through direct observation, and individual discussions. The plant materials collected as voucher samples were prepared in the usual way[36] and stored in the ASSAM herbarium. The acronym of the herbarium names is in accordance with Thiers[37].

Plant authentication and certification

All local plant names recorded during field were scientifically authenticated using keys and descriptions from literature (regional floras, manuals, monographs), research articles and by matching the collected samples with that of deposited vouchers at herbaria of the Botanical Survey of India, Eastern Regional Centre, Shillong; The Herbarium of Forest

Table 1 — Surveyed area and informants involved in documentation of traditional knowledge of Himalayan orchids

Surveyed Area	Year of survey	Sex and number of informants			GPS Coordinates		
		Male	Female	Total	Latitude (N)	Longitude (E)	Altitude (m amsl)
Jammu & Kashmir	2015 (July, September)	9	4	13	34°38′14.06″	74°52′07.04″	2692
Himachal Pradesh	2012 (April)	10	1	11	32°03'42.12"	77°15'40.68"	3029
Uttarakhand	2011 (June)	7	1	8	30°05'12.84"	78°16'03.36"	2189
Sikkim	2010 (August)	3	14	17	27°37'57.07"	88°45'15.01"	2700
Arunachal Pradesh	2013 (September)	13	16	29	27°15'53.00"	92°25'28.00"	2507
Meghalaya	2011 (March)	18	20	38	25°31'60.01"	90°06'60.08"	1050
Assam	2011 (January)	21	9	30	26°34'39.00"	93°10'15.96"	354
Total		81	65	146			

Research Institute, Dehradun; Janaki Ammal Herbarium, Jammu; Gauhati University, Guwahati for Indian Himalayan species. Valid botanical names along with the author citations were verified from Plants of the World Online (http://www.plantsoftheworldonline.org/). All vouchers were deposited in ASSAM herbarium at Botanical Survey of India, Eastern Regional Centre Shillong.

Data analysis

Informed consent was obtained verbally from all the informants prior to the semi-structured interviews. The data collected through discussions and interviews while surveying the localities were analyzed using quantitative index use frequency (Fq), which is expressed in percentage and calculated by multiplying the use-value mentioned by informants with 100. This gives the overall percentage of use reports of the particular species of the study area.

Results and Discussion

Population structure of informants

Table 1 shows the area surveyed, period of field trips, number of informants, and GPS coordinates recorded during the investigations of the traditional knowledge associated with orchids growing in the Himalaya regions. The Meghalaya state recorded the largest number of informants (38) having the indigenous knowledge on the use of orchid species as medicine, followed by informants of Assam (30) and Arunachal Pradesh (29). The state of Uttarakhand recorded the smallest number of informants (8). In total, 146 informants (81 males and 65 females) were interviewed from the different study sites. Respondents belong to all age groups (I: 15-30 yrs, II: 31-45 yrs, III: 46-60 yrs, IV: 60 yrs and above), but the majority of informants (~35%) were above 60 years of age. These local people come from various ethnic cultures and poor educational backgrounds.

Table 2 — Informants, age group, and education level considered for documentation of traditional knowledge

Informants		Male	Female	Total
	Total number	81	65	146
	Percentage	55.48%	44.52%	
Age group	15-30 yrs	7	12	19 (13.01%)
	31-45 yrs	24	17	41 (28.08%)
	46-60 yrs	19	16	35 (23.97%)
	Above 60 yrs	31	20	51 (34.93%)
Education level	Illiterate	24	29	53 (36.30%)
	Attended school upto 5 classes	11	13	24 (16.44%)
	Attended school for 6-10 classes	22	11	33 (22.60%)
	Intermediate (12^{th} class) onwards	24	12	36 (24.66%)

Large proportions of the informants (~36%) were illiterate, while around ~64% of people had a secondary or a college level of education (Table 2).

Life-Forms, habit, habitat, and traditional uses

The ethnobotanical surveys revealed 28 indigenous Himalayan orchid species used as folklore medicine to be widely distributed in six Himalayan Indian states and one union territory, *viz.*, Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Meghalaya, and Assam. These orchid plants are familiar with nomadic tribal people such as *Gujjars, Bakarwal, Himachaali, Garos, Khasis, Assammes, Arunchalis, Bhotiyas,* and *Jaunsari* residing in and around the hilly/mountainous regions of the study areas, and frequently employed in local preparation of ethnomedicine. These orchid species includes *Acampe ochracea* (Lindl.) Hochr., *Aerides odorata* Lour., *A. multiflora* Roxb., *Anoectochilus setaceus* Blume*, Arundina graminifolia* (D.Don) Hochr.*, Bulbophyllum odoratissimum* (Sm.)

Lindl. ex Wall., *Coelogyne corymbosa* Lindl., *C. punctulata* Lindl., *Crepidium acuminatum* (D.Don) Szlach., *Cymbidium aloifolium* (L.) Sw., *C. elegans* Lindl., *Dendrobium densiflorum* Lindl., *D. fimbriatum* Hook., *D. fugax* Rchb.f., *D. nobile* Lindl., *Eulophia graminea* Lindl., *Habenaria dentata* (Sw.) Schltr., *H. marginata* Colebr., *Herminium lanceum* (Thunb. ex Sw.) Vuijk, *Liparis nervosa* (Thunb.) Lindl., *Papilionanthe teres* (Roxb.) Schltr., *Phaius tankervilleae* (Banks) Blume, *Pholidota imbricata* Hook., *P. pallid* Lindl., *Porpax muscicola* (Lindl.) Schuit., Y.P.Ng & H.A.Pedersen, *Rhynchostylis retusa* (L.) Blume, *Vanda coerulea* Griff. ex Lindl. and *Vanda cristata* Wall. ex Lindl. (Fig. 1). Most of these orchid species are either epiphytic or terrestrial. As far as the use of plant parts is concerned, leaves, rhizomes, tubers, pseudobulbs, and stems are the most common parts used as medicine. Leaves of the majority of the species are used in the treatment of diseases. Bones fracture, tuberculosis, cuts, boils, wounds, reptile bites, cancer, and several other diseases get cured by using plant parts of these orchids growing in the Himalaya. The details of orchid species, mode of use, citation, plant parts used, major active chemical constituents, and associated biological function are given in Table 3.

Quantitative Frequency (Fq)

To find out the relative importance of various ethnomedicinal orchid species effective in the treatment of various human-associated problems, a quantitative index frequency (%) was employed. The results of the study are presented in Table 3 which indicates that the frequency ranges from 5.63 to 52.11%. On the basis of frequency, the most important orchid species investigated includes *L. nervosa* (Fq=52.11%), *C. aloifolium* (Fq=50.70%), *D. nobile* (Fq=47.89%), *P. muscicola* (Fq=46.48%), *A. odorata* (Fq=45.07%), *H. dentata* (Fq=40.85%), *D. densiflorum* (Fq=39.44%), *R. retusa* (Fq=26.76%), and *A. setaceus* (Fq=26.76%). The least medicinal orchids investigated were *A. graminifolia* (Fq=5.63%) and *Herminium lanceum* (Fq=9.86%) (Table 3).

Fig. 1 — Orchids used in traditional system of medicine in Indian Himalaya. a) *Arundina graminifolia* (D.Don.) Hochr., b) *Aerides odorata* Lour., c) *Aerides multiflora* Roxb., d) *Cymbidium elegans* Lindl., e) *Coelogyne punctulata* Lindl., f) *Dendrobium densiflorum* Wall., g) *Dendrobium fimbriatum* Hook., h) *Dendrobium nobile* Lindl., i) *Habenaria dentata* (Sw.) Schltr., j) *Herminium lanceum* (Thunb. ex Sw.) Vuijk, k) *Phaius tankervilleae* (Banks) Blume, l) *Pholidota imbricata* Lindl., m) *Rhynchostylis retusa* (L.) Blume, n) *Vanda coerulea* Griff. ex Lindl.

Table 3 — Morphology, part(s) used, traditional therapeutic uses, phytochemicals and biological properties of Himalayan orchids

Botanical name/Voucher number	Life form	Mode of Use	Part(s) used	Citation	Frequency (%)	Traditional therapeutic uses	Active chemical constituents	Biological properties
Acampe ochracea (Lindl.) Hochr. /116699	annual	paste	Lv	12	16.90	Fresh paste used in the treatment of the bone fracture.	praemorsin	Antimicrobial efficacy against kanamycin and ampicillin resistant strains of *E. coli*[20].
Aerides odorata Lour. / 118277	perennial	powder	Wp	32	45.07	Dried powder used in the treatment of tuberculosis.	ascorbic acid, apigenin, catechin, *p*-coumaric acid, ferulic acid, gallic acid, kaempferol, myricetin, naringin, quercetin, sinapic acid, syringic acid, rutin	Antimicrobial efficacy against kanamycin and ampicillin resistant strains of *E. coli*[20].
Aerides multiflora Roxb. /59292	perennial	paste	Tb, St	17	23.94	Paste used to heal wounds, boils and skin infections.	apigenin, catechin, p-coumaric acid, gallic acid, p-hyroxy, myricetin, rutin	Antibacterial properties[20].
Anoectochilus setaceus Blume / 50095	annual	powder	Wp	19	26.76	Dried powdered used as herbal tea, and decoction used in treatment of fever, pleurodynia, snake bike, lung infection, and hypertension.	flavonoids	Antimicrobial properties; *Xylaria*, isolated from leaves has helvolic acid, which is active against *Bacillus subtilis* and methicillin-resistant to *Staphylococcus aureus*[24].
Arundina graminifolia (D.Don.) Hochr. /64516	perennial	paste/ extract	Rz, Lv, St	4	5.63	Paste used to cure wounds and cuts; fresh juice obtained from young leaves and stems used in treatment of ear troubles.	arundinan, brundinaol, arundinoside A-G, arundiquinone & arundigramin rac-syringaresinol, astragalin, batatasin III, coelonin, densiflorol B, ephemeranthoquinone, flavanthrin, gramniphenol H, lusian-thridin, orchinol, quercetin	polyphenols and flavonoids show antioxidant activity; Gramniphenol H shows cytotoxicity property against five tumor cell lines[2,20].
Bulbophyllum odoratissimum (Sm.) Lindl. ex Wall. /116613	perennial	paste	Wp	12	16.90	Paste used in treatment of tuberculosis, chronic inflammation and fractured bones.	batatasin III, bulbobiphenantrene-bulbophythrins A and B coelonin, densiflorol B, gigantol, moscatin, 7-hydroxy-2,3,4-trimethoxy-9,10-dihydrophenanthrene, 1-monolinolein, syringaldehyde, syringing, tristin	Anticancerous; bulbobiphenantrene shows inhibition on human leukemia cell HL-60 and K562, human lung cancer cell strain A549 and human gastric carcinoma SGC-7901; densiflorol B and bulbobiphen-antrene used as anticancerous drugs[24].
Coelogyne corymbosa Lindl. /116786	annual	paste	Pb, St	12	16.90	Paste of pseudobulbs used on burns; stem paste applied on forehead to get relieve from headache.	coeloginone	data deficient.

(*Contd*.)

Table 3 — Morphology, traditional therapeutic uses, phytochemicals and biological properties of Himalayan orchids (*Contd*.)

Botanical name/Voucher number	Life form	Mode of Use	Part(s) used	Citation	Frequency (%)	Traditional therapeutic uses	Active chemical constituents	Biological properties
Coelogyne punctulata Lindl. /60130	perennial	extract	Wp	9	12.68	Juice extract used to make vomits in case of poison.	coeloginone, coelogin, quabain, batatasin III	Data deficient.
Crepidium acuminatum (D.Don) Szlach. /64415	annual	extract/ decoction	Pb	14	19.72	Decoction used to cure fever, tuberculosis, bleeding diathesis and phthisis.	flavonoids, caryophyllene, eugenole, gallic acid, humulene, linoleic acid	Antioxidant activity against a long lived 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical[32].
Cymbidium aloifolium (L.) Sw. / 116709	perennial	paste/ extract	Wp	36	50.70	Roots paste plastered tightly to cure bones fractures; seeds useful in healing wounds and boils; leaves juice dropped in ears to cure otitis.	batatasin III, aloifol II, coumarin, cymbinodin A & B, methoxycoelonin.	Antibacterial; ethanol extracts show antinociceptive and anti-inflammatory activity against carrageenin induced paw oedema in mice[42.]
Cymbidium elegans Lindl./ 116719	perennial	extract	Tb, Fl	12	16.90	Fresh extract obtained from tubers and flowers used for vomit in poison or toxic substances.	cymbinodin	Data deficient.
Dendrobium densiflorum Wall. /116701	perennial	paste	Lv	28	39.44	Paste used in treatment of bones fractures and considered as calcium supplying plant.	dendroflorin, gigantol, scopoletin, moscatilin, scoparone, densiflorol A & B, moscatin, confusarin, dendrodensiflorol, cypripedin	Antimicrobial, anti-inflammatory activities; exhibits *in vitro* ant-platelet aggregation activity[48].
Dendrobium fimbriatum Hook. /101135	perennial	paste/ extract	Wp	17	23.94	Leaves juice used in liver upsets and for curing nervous debility; paste used in setting bones fractures.	moscatilin, gigantol, defuscin, chrysotoxine, 2,5-phenanthrenediol, 9-10-dihydro-7-methoxy, fimbriadimerbibenzyls	Cytotoxic properties against five human cell lines with IC_{50} value ranges from 2.2 to 21.2 μM.
Dendrobium fugax Rchb.f. /118587	perennial	powder	Tb	12	16.90	Taken as aphrodisiac, and used to cure insomnia.	salutaridine, thebaine	Data deficient.
Dendrobium nobile Lindl./28416	perennial	powder	Se	34	47.89	Grinded power applied on cuts, boils and wounds for quick healing; also taken in case of dry mouth and menstrual pains.	gigantol, denbinobine, dendramine, copacamphane, picrotoxane, cyclococamphane, nobiline, dendrophenol	Antioxidant activity; highly effective against Sarcoma 180 *in vivo* and HL-60 *in vitro*, showing antitumerous activity; denbinobine shows anticancer activity in human myelogenous K562 leukemia cells[22].
Eulophia graminea Lindl. /53021	annual	extract	Rz	16	22.54	Juice extract used as tonic, and effective in curing cough and paralysis.	linalool, ferulic acid	Data deficient.

(*Contd*.)

Table 3 — Morphology, traditional therapeutic uses, phytochemicals and biological properties of Himalayan orchids (*Contd*.)

Botanical name/Voucher number	Life form	Mode of Use	Part(s) used	Citation	Frequency (%)	Traditional therapeutic uses	Active chemical constituents	Biological properties
Habenaria dentata (Sw.) Schltr. /63928b	annual	extract	Wp	29	40.85	Extract used in urinary problems; used as analgesic, disinfectant, aphrodisiac and antirheumatic.	habenariol, gastrodigenin	Apparently less explored; habenariol isolated used as anti-inflammatory agent[22].
Habenaria marginata Colebr. /29138	annual	extract/ decoction	Tb	14	19.72	Decoction of fresh boiled tubers along with honey consumed daily in empty stomach to cure malignant ulcer.	diterpenes, hecogenin.	Data deficient.
Herminium lanceum (Thunb. ex Sw.) Vuijk /63928	annual	extract	Lv, St	7	9.86	Decoction prepared from green leaves and stems used to cure diabetes, fever and nose bleeding.	alkaloids	Data deficient.
Liparis nervosa (Thunb.) Lindl. /53324	annual	extract	Lv	37	52.11	Juice extract used in treatment of burns and ulcers.	linoleic acid, p-hydroxybenzaldehyde, swertisin, 6,8-di-C-α-L-arabinopyranosyl genkwanin, apigenin.	Data deficient.
Papilionanthe teres (Roxb.) Schltr. /42661	perennial	paste	Lv. St	10	14.08	Paste applied on forehead to keep brain cool during malaria fever, and also taken to protect body from cold and cough.	butanenediol, vandateroside I, II, III	Data deficient.
Phaius tankervilleae (Banks ex L'Her.) Blume / 61429	perennial	extract	Pb	13	18.31	Paste used to cure bones fractures, and extract taken to get relief from dysentery.	alkaloids, flavonoids	Data deficient.
Pholidota imbricata Lindl. /59456	perennial	extract	Tb	11	15.49	Paste used in treatment of stomach and rheumatic pains.	phoimbrtol A, loddigesiinol B, shanciol B, quercetin, luteolin, platycaryanin D, imbricatin.	Data deficient.
Pholidota pallida Lindl. / 116891	perennial	extract	Rz	8	11.27	Paste of fresh part used to cure finger abscess.	loddigesiinol B, luteolin, phenanthrene, phoimbrtol A, platycaryanin D, shanciol B.	Data deficient.
Porpax muscicola (Lindl.) Schuit., Y.P.Ng & H.A.Pedersen /53838	perennial	extract	Wp	33	46.48	Extract taken to get relief from chest, heart and lungs pain; juice of fresh leaves used to cure eye problems.	flavonoids, alkaloids	Data deficient
Rhynchostylis retusa (L.) Blume /116697	perennial	extract	Rt, Lv	19	26.76	Fresh juices applied on cuts, boils and wounds; also taken orally in empty stomach to cure blood dysentery.	gigantol, flavidin,	Extract indicated positive antibacterial activity against *Pseudomonas aeruginosa, Staphylococcus aureus, E. coli* and *Salmonella typhi*[20].

(*Contd.*)

Table 3 — Morphology, traditional therapeutic uses, phytochemicals and biological properties of Himalayan orchids (*Contd*.)

Botanical name/Voucher number	Life form	Mode of Use	Part(s) used	Citation	Frequency (%)	Traditional therapeutic uses	Active chemical constituents	Biological properties
Vanda coerulea Griff. ex Lindl. /11872	perennial	extract	Lv	16	22.54	Fresh juice used in treatment of diarrhea and dysentery.	imbricatin, methoxycoelonin, gigantol, flavidin, coelonin, stilbenoids; stilbenoids (1-3) are the best stem biomarkers.	Hydro-alcoholic stem extract displayed DPPH/(•)OH radical scavenging activity[20].
Vanda cristata Wall. ex Lindl. /22523	perennial	extract	Lv	13	18.31	Fresh juice extracted used as a tonic and helps in body growth and to cure cough and cold.	gigantol, flavidin, coelonin	Data deficient.

(Lv-Leaves, Wp-Whole plant, St-Stem, Tb-Tuber, Rz-Rhizome, Pb- Pseudobulbs, Fl-Flower, Se-Seed)

Active phytochemicals constituents

Similar to other higher angiosperms, plant parts of orchid species do synthesize innumerable phytochemicals. Due to restrictions in a wide collection of orchid species, research on only a few species has been undertaken to investigate their biological properties and thousands of species are still unknown. Alkaloids, anthocyanins, carotenoids, flavonoids, and sterols are major groups of chemical constituents present in orchid species, and usually, alkaloids and flavonoids groups are most important for biological functions[20]. The genus *Dendrobium* is a well-recognised genus studied for its phytochemical content and dendrobine was the first alkaloid investigated from Himalayan orchid *Dendrobium nobile*[38]. *Dendrobium* is known to produce a variety of secondary metabolites in the form of alkaloids, bibenzyls, fluorenones, phenanthrens, and sesquiterpenes[32], and these active phytochemical constituents are responsible for biological properties in human and animal health care. Several phenanthrene constituents (amoenumin, crepaditin, cumulatin dihydrophenanthrene), denfigenin, defuscin, dendrophenol, ephemeranthoquionone, gigantol, moscatilin, moscatin, shihunidine, shihunine and rotundatin reported from orchids[21-23]. The genus *Anoectochilus* Blume*, Arundina* Kunth*, Bulbophyllum* Thouars*, Bletilla* Rchb.f.*, Cypripedium* L.*, Eria* Lindl.*, Eulophia* C. Agardh*, Gastrodia* R.Br.*, Habenaria* Willd.*, Malaxis* Sol. ex Sw.*, Vanda* Jones ex R.Br. and *Vanilla* Mill. are enriched with different important phytochemicals[38]. However, alkaloids present in orchids were studied by many researchers[39-42].

Lüning[43] studied the alkaloid content of 525 orchid species and recorded 214 species belonging to sixty four genera contain 0.1% or more alkaloids. Approximately, 8% of *Dendrobium*, 18% of *Eria* and 42% of *Liparis* have this degree of alkaloid content. Zhang *et al.*[44] studied 42 species of *Dendrobium* having 100 compounds including 31 alkaloids, 6 coumarins, 15 bibenzyls, 4 fluorenones, 22 phenanthrenes, and 7 sesquiterpenoids. According to Hossain[20] more than 2000 species of orchid have been screened for their chemical constituents mostly rich in alkaloids and flavonoids contents. A study has shown that flavonol glycosides are mostly reported from Neottioid orchid species, whereas flavone glycosides are commonly found in the Epidendroid and Vandoid subfamily distributed in tropical and sub-tropical regions[20]. The major active phytochemical constituents present in orchid species having a high demand in the pharmaceutical companies for medicine development are given in Fig. 2. Literatures[2,39,45] screening showed pharmacological bioactivities for *A. multiflora, A. setaceus*, *A. gramnifolia, B. odoratissimum, C. corymbosa, C. acuminatum, C. aloifolium*, *C. elegans, D. nobile*, *D. fimbriatum*, *E. graminea, F. fugax, H. marginata, H. lanceum, L. nervosa, P. teres, P. tankervilleae, P. imbricata, P. pallida, P. muscicola, R. retusa, V. Coerulea*, and *V. cristata*. This may be due to the shortage of planting materials for chemistry and pharmacological activities as most of the endemic orchids are categorized under the endangered category by IUCN, and wild collection from nature is strictly prohibited by State Forest Departments[15].

The present investigation identifies the tribal applications of twenty-eight Himalayan orchids that occur in Himalayan belts. Chemical analyses indicate orchids are loaded with several commercially important bioactives in the form of alkaloids

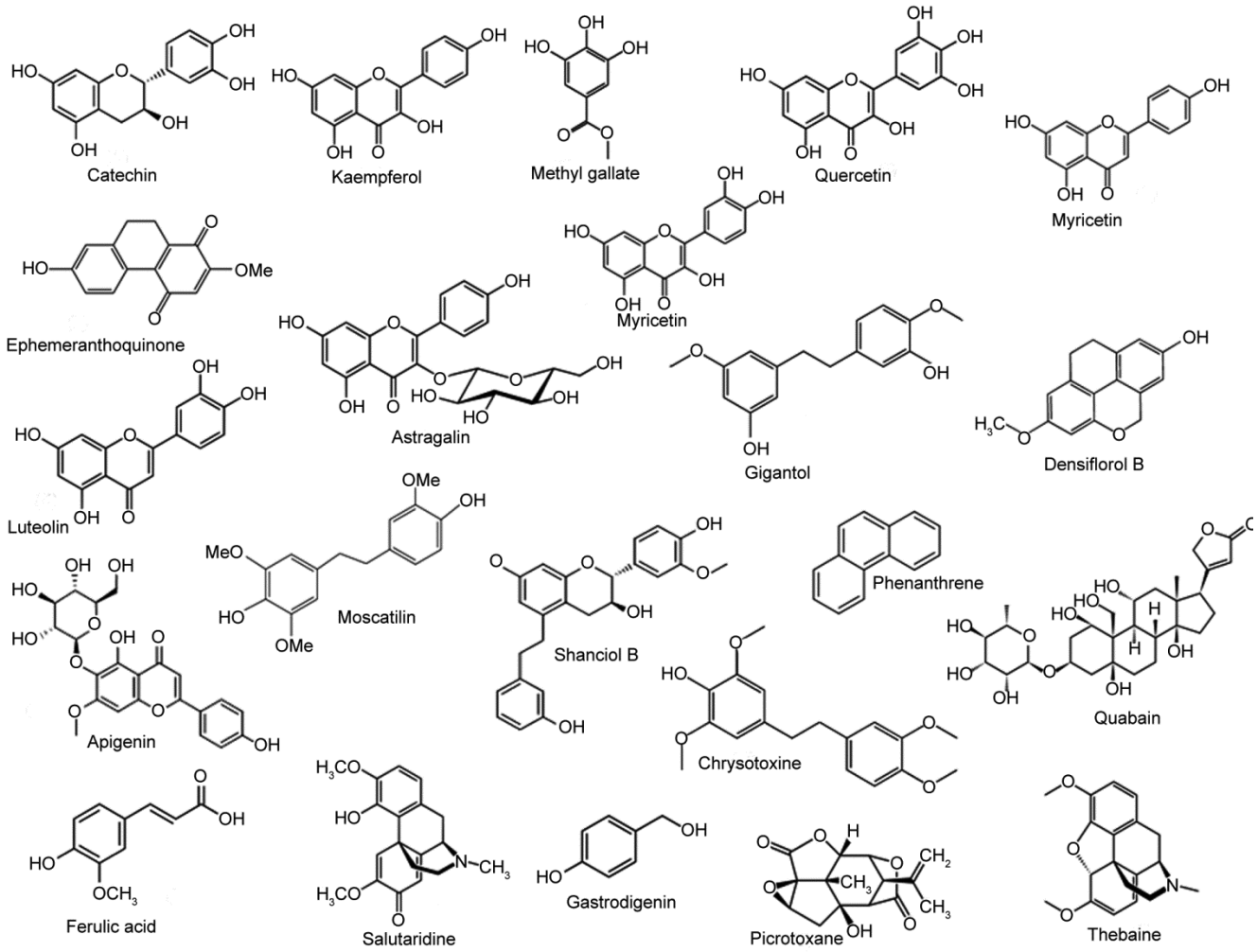

Fig. 2 — Major bioactive phytochemicals of Himalayan orchids.

(dendrobine, jebantine), bibenzyls (gigantol, moscatilin), phenanthrenes (nudol, vllinol, agrostophyllinone, isoagrostophyllol, nidemin), 1-4 phenanthrenequinone (cypripedin), glycosides (loroglossin, melianin, kinsenoside), carbohydrates flavonoids, phenolic compounds (esters, glycosides) and stilbenoids (arundinan, orchinol, 6-methoxycoelonin, imbricatin, flaccidin, oxoflaccidin, isooxoflaccidin, flaccidinin, agrostophyllin, callosin, callosinin, callosumin, callosuminin, callosumidin). Major commercially important compounds isolated and described from the Himalayan orchids includes agrostophyllin, agrostophyllinone, apigenin, arundinan, astragalin, callosin, callosinin, callosumidin, callosumin, callosuminin, catechin, chrysotoxine, cypripedin, dendrobine, densiflorol B, ephemeranthoquinone, flaccidin, flaccidinin, ferulic acid, gastrodigenin, gigantol, imbricatin, isoagrostophyllol, isooxoflaccidin, jebantine, kaempferol, kinsenoside, loroglossin, luteolin, 6-methoxycoelonin, melianin, moscatilin, nidemin, nudol, orchinol, oxoflaccidin, phenanthrene, picrotoxane, quabain, quercetin, methyl gallate, myricetin, shanciol B, salutaridine, and thebaine. Many more compounds have been extracted from different parts (leaves, pseudobulbs, roots, stems, flowers, fruits) of the orchids[46-48]. *Dendrobium* and *Cymbidium* species have been used in traditional medicines in Taiwan, Korea, and Japan for the treatment of stomachache, healing fractures, kidney strengthening, fever, cancer treatment, and diabetic[49-50]. Several Ayurvedic medicines and nutraceutical products such as chyavanprasha, sudarshana churna, balarishtha, and amritprasha ghritam are available in the Indian markets whose formulations were prepared by using orchid species[51-53].

Conclusion

The ethnobiological investigations of the medicinal plant species of Himalayan regions and their uses among various tribal populations have proven that the medicinal potential of shared species were not dependent on geography, but depending on how frequently these species are used in the treatment of various diseases. Human-induced climate change has led to accelerated warming of the Himalayas in the recent past decade, which might have led to a decrease in the population of the biodiversity abode in different pockets of the regions. The orchids are a valuable source of bioactive compounds and are to believed to possess medicinal properties that can help to treat many diseases. There is a need for inventory work for wild orchids from the conservation point of view, and this will help in the preservation of traditional knowledge associated with this group of plants, and for planning future research and developmental science associated with orchids or similar taxa.

Conflict of interest

Author declares no conflict of interest.

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