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FLORAL DIVERSITY ALONG SUB-ALPINE AND ALPINE ECOSYSTEMS IN TUNGNATH AREA OF KEDARNATH WILDLIFE SANCTUARY, UTTARAKHAND

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ABSTRACT

Extensive floristic surveys were carried out at Tungnath area in Kedarnath Wildlife Sanctuary during 2007-2011. During the survey a total of 433 plant species belonging to 234 genera under 71 families were recorded along the sub-alpine and alpine region (2800-3680m amsl). Of which 349, 42, 18, 13, 5, 6 and species were herbs, shrubs, grasses, trees, sedges and climbers, respectively. Among dicotyledonous families Asteraceae was the largest family represented by 42 species followed by Rosaceae (30 species), Ranunculaceae (25 species), Polygonaceae (24 species), Scrophulariaceae (17 species) and Apiaceae (17 species), whereas Orchidaceae (29 species), Poaceae (19 species) and Liliaceae (13 species) were the major families among the monocotyledons. Some uncommon species *viz., Balanophora involucrata, Cypripedium* spp., *Calanthe manii* and *Eleutherococcus cissifolius* were recorded for the first time from the area. The species categorised under various threat categories (rare, endangered and threatened) *e.g.*, *Cyananthus integer*, *Dactylorhiza hatagirea, Balanophora involucrata, Fritillaria roylei*, *Jurinea macrocephala* were also recorded during the survey.

Key words : Floral diversity, Ecosystem, Kedarnath Wildlife Sanctuary, Uttarakhand

Introduction

High altitude landscapes in the Western Himalaya are of particular importance as they play a vital role in the ecological balance and provide several ecosystem services. Due to enchanting, picturesque landscape they attract ecologists, naturalists and pilgrims from time immemorial. Kedarnath Wildlife Sanctuary (KWS) is one of the important protected areas in the Western Himalayan due to its high ecosystem diversity with varying plant communities across the altitudinal gradient and topography. The herbaceous diversity increases considerably whereas tree and shrub species were limited up to the timberline ecotone. In the higher altitudes alpine meadows harbour a great diversity of flowering). Pastoral migratory communities stay around the timberline zone for about 6 months and these high altitude transition zones under high anthropogenic pressure (Singh *et al.,* 2010).

The Garhwal region of the Western Himalaya has been extensively surveyed considerably by number of workers in the latter half of twentieth century, *viz.,* Rau (1963); Semwal and Gaur (1981); Kala and Gaur (1982); Naithani (1984); Kala *et al*. (1998) and Gaur (1999). Recently the floral diversity from the lower region (temperate to sub-alpine zone) has been documented by Singh *et al. (*2008). Semwal and Gaur (1981) extensively worked on the flora of Tungnath area and subsequently added 53 more species (Semwal and Gaur, 1983) to the region. Present study deals with the thorough floristic survey along the sub-alpine and alpine habitat in the Tungnath area inside the Kedarnath Wildlife Sanctuary with addition to the 112 plant species in the existing literature for the area and many species of which are categorised under various threat categories.

Material and method

Study site

The survey was carried out in Tungnath area (30°29'22"N, 79°12'47"E) within Kedarnath Wildlife Sanctuary (Fig. 1). It lies in the Chamoli and Rudraprayag districts and covers a large area of the upper catchments of river Alaknanda, a major tributary of the river Ganga. Four prominent seasons were observed at the high altitude region (>3000m), *viz.,* short summer (May-June), Monsoon (July-mid September) and autumn (mid-September-October) and long winter (November-April). The summer is generally drier and monsoon season is characterized by incessant rains, while heavy snowfall during winter, followed by frequent hail storms during April-May is the characteristic feature of the study area. The snow cover lasted for about 3 months and melts during April-May, resulting high soil moisture that favours initiation of plant growth. Mean Annual Temperature (MAT) during present study at 3300m

Plant wealth of 433 species in sub-alpine - alpine ecosystems in Tungnath, Kedarnath Wildlife Sanctuary include 349 herbs and 42, 18, 13, 5 and 6 species as shrubs, grasses, trees, sedges and climbers respectively.

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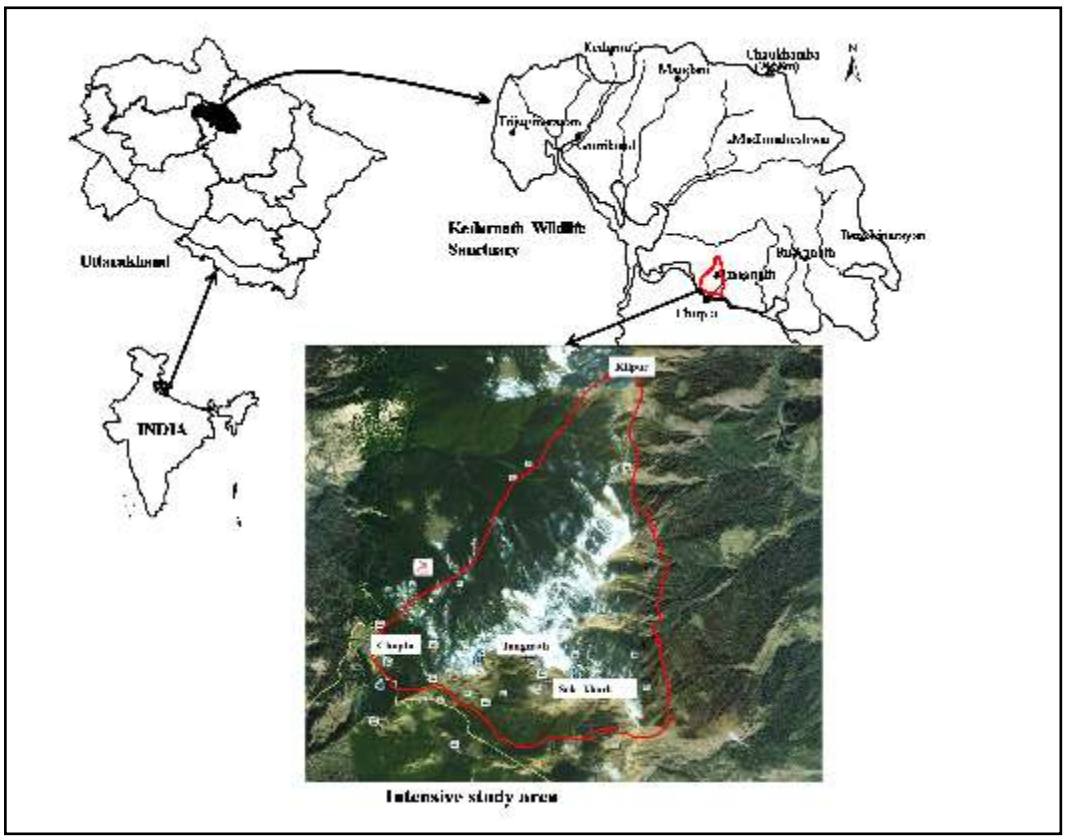

Fig. 1 : Location of Kedarnath Wildlife Sanctuary in the state of Uttarakhand and Google Earth image showing intensive study area.

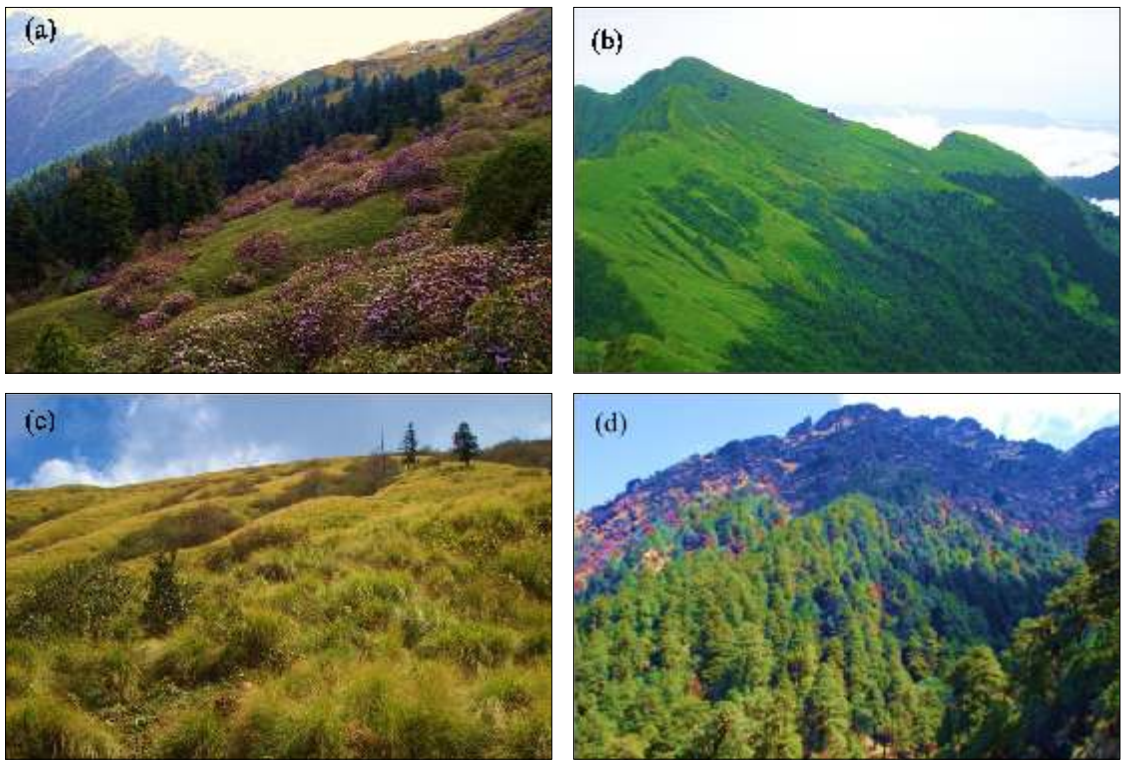

Fig. 2 : Different habitat types in the study area. a: Timberline ecotone formed by *Abies spectabilis* and *R. Campanulatum,* b: Alpine meadow, timberline ecotone and sub-alpine forest, c: *Danthonia* grassland in gentle slope and d: Sub-alpine forest dominated by *Quercus semecarpifolia* and forest edge (timberline) by *R. arboreum.*

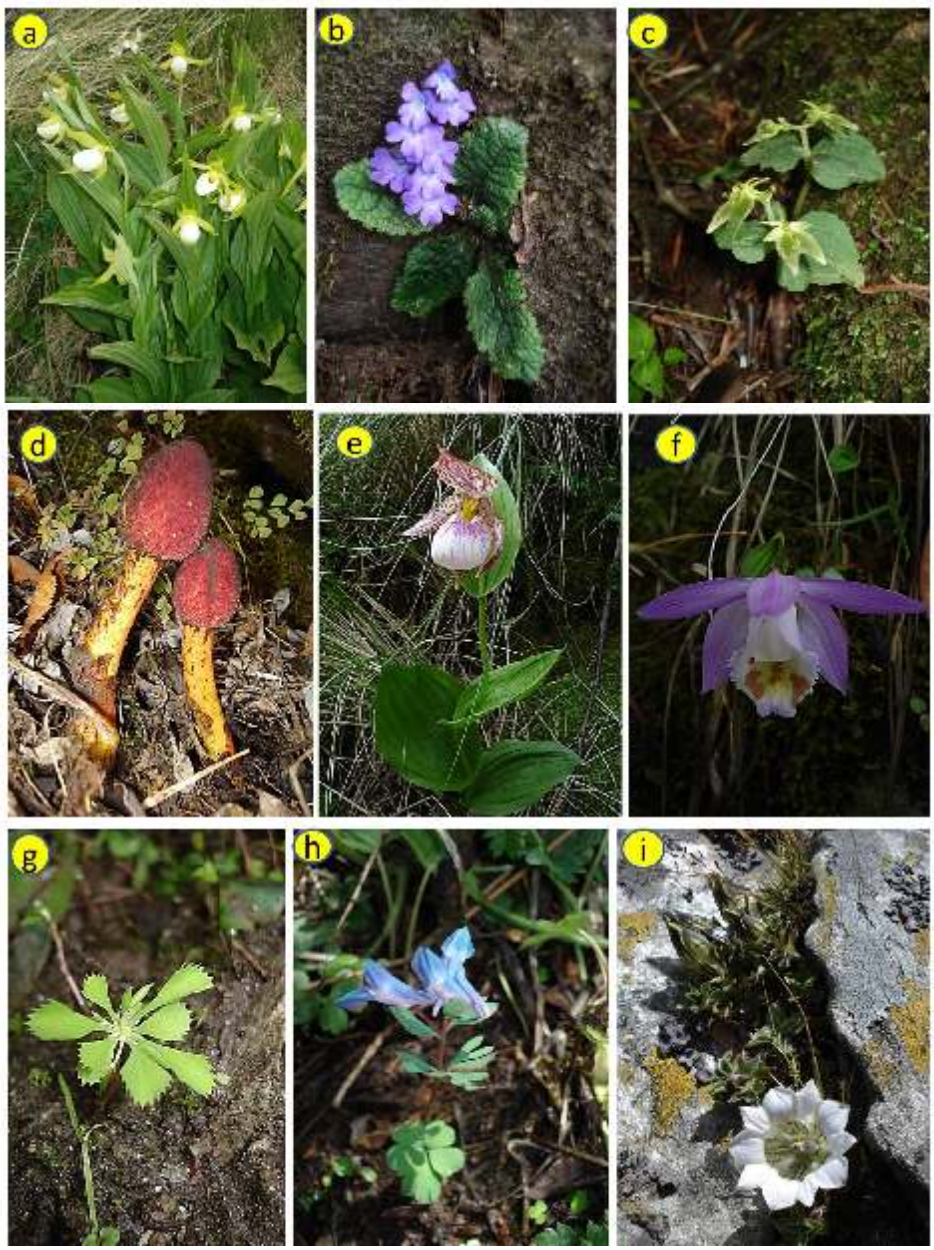

Fig. 3 : Some important plant species of the study area; a: *Cypripedium cordigerum,* b: *Falconeria himalaica,* c: *Neottia pinetorum,* d: *Balanophora involucrata,* e: *Cypripedium himalaicum,* f: *Pleione hookeriana,* g: *Circaeaster agrestis,* h: *Corydalis cashmeriana* and i: *Gentiana stipitata.*

elevation (timberline) was 6.65°C and daily temperature ranged between -8.91 to 25.6°C at the timberline ecotone (3300m), while it had higher variation in alpine area (-11.2 to 27.9°C) at 3600m. The average annual precipitation was about 2410 mm, of which 90% received during June to September.

Forest types and vegetation

According to Champion and Seth's (1968) classification the study area falls in sub-alpine forest and alpine scrubs. Some typical habitats are shown in Fig. 2. The description of the vegetation types of the area is as follow:

Sub-alpine forest: The sub-alpine forest is formed by *Quercus semecarpifolia*, *Betula utilis, Abies spectabilis* with other tree species *viz., Acer caesium, Prunus cornuta, Taxus wallichiana, Rhododendron arboreum* and *Sorbus foliolosa*. The shrub layer is dominated by *R. campanulatum, R. barbatum* and *Viburnum grandiflorum* with scattered individuals of *Rosa, Rubus, Salix* and *Skimmia*. The herb layer in forest gaps is mainly dominated by *Trachydium roylei*, *Cirsium verutum*, *Plantago brachyphylla*, *Rumex nepalensis*, *Persicaria wallichii* etc., whereas in undisturbed areas, which were naturally protected from the anthropogenic pressure

due to rock, steep slope or other topographic barriers, various herbaceous communities are present. In lower elevation zone *Thamnocalamus spathiflorus* is a major shrub species and local community largely depends on this for various purposes *e.g.,* making basket, broom and other products for daily use and sometime for earning also. The high anthropogenic pressure in the subalpine zone is evident in the form of large forest gaps in between.

Timberline ecotone : Timberline in the study area ranges between 3250-3350m which is formed by *Betula utilis* and *Abies spectabilis* in the north to north-west facing slopes, while south to south west facing slopes dominated by *Q. Semecarpifolia* and *R. arboreum*. In the steep rocky slopes timberline is dominated by climatically modified dwarf and stunted individuals of *R. arboreum*, which grow very slowly in harsh climatic conditions. Other major shrub species in this zone are *Lonicera* spp., *Rubus niveus*, *Salix denticulata*, *Rosa sericea*, *Berberis jaeschkeana* and *Viburnum grandiflorum*, while in drier slopes and rocky outcrops *Cotoneaster microphylla* and *Juniperus indica*. *Cypripedium elegans, C. cordigerum, Neottia pinetorum* and *Platanthera leptocaulon* are some rare orchid taxa of the area which are mainly recorded at timberline zone.

Krummholz layer : The '*krummholz*' layer under the tree canopy is formed by *Rhododendron campanulatum*, a dominant shrub species of the region and facing high pressure in the form of fuelwood collection all along the edges of alpine meadows in the entire Western Himalaya.

Alpine meadow and scrubs : The ground layer vegetation consists of cushionoid herb, grasses and sedges. The herbaceous flora represented by some unique species such as *Cypripedium himalaicum, Impatiens sulcata, Satyrium nepalense, Caltha palustris, Geranium wallichianum, Potentilla atrosanguinea, Trachydium roylei* and *Epilobium royleanum.* Early flowering species are *Gentiana capitata, Oxygraphis polypetala, Ranunculus hirtellus* and *Primula denticulata* in the initial growing period; *and Danthonia cachemyriana* is the common grass species, while Carex and Kobresia are the major sedge species in the area. Beyond timberline ecotone other two dwarf species of *Rhododendron viz., R. anthopogon* and *R. lepidotum* forms the community and provide micro-habitat to several other herbaceous species.

Data collection

Intensive survey of the vegetation was carried out during 2007-2011 covering all the seasons of the year as a part of the study of the ecological attributes of timberline ecotone. The vegetation surveys were conducted for entire growth period (March-October) in all the seasons, as each species has its own seasonality for 4 years. The areas Chopta, Tungnath, Kilpur and Sok-Khark were thoroughly surveyed all along the altitudinal gradient between 2800-3680m. During field surveys collections were made and photographs of most of the plant species with their characteristic features were taken along with field notes on habitat characteristics and identification features of the species. The plants were identified with the help of specimens existing in WII herbarium from Kedarnath WS, Flora of Chamoli (Naithani, 1984), Flora of District Garhwal (Gaur, 1999) and other available literature (Semwal, 1981; Semwal and Gaur, 1984; Singh *et al*., 2009). The list is arranged according to Bentham and Hooker's classification (1862-1883) and gymnosperms are placed in between the dicots and monocots. The nomenclature has been updated as far as possible with the help of available recent taxonomic literature, floras and web based digital herbariums (www.kew.org; www.eflora.org) and checklists (www.theplantlist.org).

Results and discussion

Species diversity: In the present survey a checklist of 433 plant species (430 angiosperms and 3 gymnosperms) is prepared from Tungnath region (Tungnath, Kilpur, Sok-Khark and Chopta area), a part of Kedarnath WS (Appendix I). While compared with the other extensive floral survey in the region in Valley of Flowers NP and adjacent area, Kala *et al*. (1998) recorded 521 species in which number of angiosperm taxa was 499 and 4 gymnosperms. In the present study 430 angiosperms and 3 gymnosperms are recorded. Asteraceae is largest family followed by Rosaceae in both the studies, which indicates prevalence of these families across the sub-alpine and alpine region in valley as well as open hill slopes. Orchidaceae is third major family (29 species) in the present study, whereas only 24 orchid species were recorded in the Valley of Flowers NP. The high heterogeneity in the forest structure and composition, which were distributed in the different aspects and slope categories may be the region for the high orchid diversity in the present study area.

Species distribution : Alpine meadows were dominated by various plant species depends on the disturbance regimes, such as in undisturbed areas *Danthonia* tussocks (Fig. 2c) form community with large number of herbaceous species, whereas in camping areas and grazing sites nitrophilous species were dominant (*Persicaria wallichii* (Synonym: *Polygonum polystachyum*), *Trachydium roylei*, *Impatiens sulcata*, *Cirsium verutum, Rumex nepalens*is). The extensive *krummholz* of *Rhododendron campanulatum* in

subalpine and alpine transition zone and scrub formation by *Rhododendron anthopogon* and *R. lepidotum* in alpine meadows are unique with distribution of many herbaceous species under their canopies.

Addition to the existing flora : The survey reveals the addition of 111 species in the previous list published by Semwal and Gaur (1983; 322 plant species), while 11 species distributed above 4000 m are excluded in the present survey, because during present study the upper elevation limit of the study was 3680 m. Eighteen orchid species were added to the existing species under Orchidaceae in the checklist of the Tungnath area. Some important plant species are shown in Fig. 3, which are not very common in the area and are under various threat categories (IUCN, 2011).

Conclusion

The presence of 433 species in a small area (*ca.* 30 km^2) indicates rich floral diversity. In the present scenario, there is loss of habitats due to high anthropogenic pressure and excessive grazing which facilitate the growth of many nitrophilous species *viz*., *Persicaria wallichii, Circium verutum*, *Impatiens sulcata* and *Rumex nepalensis.* These species are growing vigorously and dispersing especially around the camping sites and invading natural alpine pastures, may led to the restricted distribution or elimination of many sensitive taxa (*viz*., orchids). The study area needs a well-managed conservation plan from the management authorities to protect the rich floral diversity of the region.

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केदारनाथ वन्य प्राणि अभयारण्य, उत्तराखण्ड के तुंगनाथ क्षेत्र में उप-एल्पाइन और एल्पाइन पारितंत्रों के साथ-साथ पादपी विविधता

ईश्वरी डी. राय, भूपेन्द्र एस. अधिकारी और गोपाल एस. रावत

सारांश

केदारनाथ वन्यप्राणि अभयारण्य में तुंगनाथ क्षेत्र में 2007-2011 के दौरान गहन पादपी सर्वेक्षण किया गया। सर्वेक्षण के दौरान, उप-एल्पाइन और एल्पाइन क्षेत्र (2800-3680 m amsl) के साथ-साथ 71 कुलों के तहत 234 वंश से संबंधित कुल 433 पादप प्रजातियां अभिलिखित की गई। जिसमें से 349, 42, 18, 13, 5, 6 और प्रजातियां क्रमशः शाक, झाड़ी, घासें, वृक्ष, नरकट और आरोही हैं। द्विबीजपत्रीय कुलों में एस्टीरेसीया 42 प्रजातियों के प्रतिनिधित्व के साथ सबसे बड़ा कुल है, इसके बाद रोसेसीया (30 प्रजाति), रेनूनकूलेसीया (25 प्रजाति), पॉलीगोनेसीया (24 प्रजाति), स्क्रोफूलेरिएसीया (17 प्रजाति) और एपिएसीया (17 प्रजातियां) हैं ; जबकि आर्किडेसीया (29 प्रजातियां), पोएसीया (19 प्रजातियां) और लिलिएसीया (13 प्रजातियां) एक बीज पत्रियों में प्रमुख कुल हैं। कुछ असामान्य प्रजातियां उदा. - *बेलेनोफोरा इन्वोलूक्रेटा, सीप्रिवीडियम प्रजातियां, केलेन्थी* मानि और *ईलीयूथीरोकोकस सिसिफोलियस* क्षेत्र से पहली बार अभिलिखित की गई हैं। विभिन्न संकट श्रेणियों (दुर्लभ, संकटापन्न एवं संकटस्थ) के अन्तर्गत श्रेणीकृत प्रजातियों, यथा-*साइएनेन्थस इन्टीगर, डेक्टीलोरहिजा हटैजिरीया, बलैनोफोरा इन्वोलूक्रेटा, फ्रिटिलेरिया रायली, जूरिनीया मैक्रोसीफाला,* को भी सर्वेक्षण के दौरान अभिलिखित किया गया है।

References

Champion, H.G. and S.K. Seth (1968). *A revised survey of forest types of India.* Delhi: Manager of Publications, Government of India. 404 p.

Bentham, G. and J.D. Hooker (1862-1883). *Genera Planterum*, 3 vols., London.

Gaur, R.D. (1999). *Flora of the District Garhwal, North West Himalaya (with Ethnobotanical Notes)*. Transmedia, Srinagar, Garhwal.

IUCN (2011). *IUCN Red List of Threatened Species. Version 2011.2.* Electronic Database accessible at http://www.iucnredlist.org/ accessed on 28 November 2011.

Kala, C.P., G.S. Rawat and V.K. Uniyal (1998). *Ecology and Conservation of the* Valley of Flowers *National Park*, Garhwal Himalaya. Wildlife Institute of India, Dehradun.

Kala, S.P. and R.D. Gaur (1982). A Contribution to the flora of Gopeshwar (Chamoli-Garhwal). In (ed.) Paliwal, G.S. *The vegetation wealth of Himalaya*. Puja publisher.

Naithani, B.D. (1984). *Flora of Chamoli*, 2vols, Botanical Survey of India, Dehradun.

Rau, M.A. (1963). The vegetation around Jumnotri in Tehri Garhwal, U.P. *Bulletin of Botanical Survey of India,* 5: 277-280.

Semwal, J.K. and R.D. Gaur (1981). Alpine flora of Tungnath in Garhwal Himalaya. *Journal of Bombay Natural History Society*, 78: 498-512.

Semwal, J.K. and R.D. Gaur (1983). Addition to the alpine flora of Tungnath, *Journal of Bombay Natural History Society*, 83: 267-271.

Singh, G., H.B. Naithani and G.S. Rawat (2009). Observations on the Flora of Mandal Forests, Garhwal Himalaya, India, *Indian Forester*, 135: 162-179.

Singh, G., G. S. Rawat and D. Verma 2010. Comparative study of fuelwood consumption by villagers and seasonal ''Dhaba owners'' in the tourist affected regions of Garhwal Himalaya, India, *Energy Policy,* 38(4):1895-1899.

Appendix I : The checklist of plants along subalpine, timberline ecotone and alpine zones in Tungnath area inside Kedarnath Wildlife Sanctuary.

Family/ Species	Habit[a] (Threat status)	Habitat[b]
Ranunculaceae		
Aconitum balfourii Stapf	H (VU)	TL
Aconitum heterophyllum Wall. ex Royle	H (CR)	A
Actaea spicata L.	H	SF
Anemone polyanthes D.Don	H	TL, A
Anemone obtusiloba D.Don	H	SF, A
Anemone rivularis Buch.-Ham.	H	SF, A
Anemone tetrasepala Royle	H	TL, A
Anemone vitifolia Buch.-Ham. ex DC.	H	TL, A
Aquilegia pubiflora Wall. ex Royle	H	SF
Caltha palustris L.	H	SF, TL
Clematis barbellata Edgew.	C	SF
Clematis buchananii DC.	C	SF
Clematis montana Buch.-Ham. ex DC.	C	SF
Delphinium vestitum Wall. ex Royle	H	TL, SF
Oxygraphis polypetala (Royle) Hook. f. & Thomson	H	SF, A
Ranunculus diffusus DC.	H	TL
Ranunculus hirtellus Royle	H	SF, A
Ranunculus hyperboreus Rottb.	H	SF
Thalictrum alpinum L.	H	SF, A, R
Thalictrum chelidonii DC.	H	SF
Thalictrum minus L.	H	SF,
Thalictrum dioicum L.	H	SF
Thalictrum punduanum Wall.	H	SF
Thalictrum reniforme Wall.	H	SF
Thalictrum virgatum Hook. f. & Thomson	H	SF
Circaeasteraceae		
Circaeaster agrestis Maxim.	H	A
Paeoniaceae		
Paeonia emodi Royle	H	SF
Schisandraceae		
Schisandra grandiflora Hook.f. & Thomson	S	SF
Berberidaceae		
Berberis aristata DC.	S	SF, TL
Berberis chitria Buch.-Ham. ex Lindl.	S	SF
Berberis jaeschkeana C.K.Schneid.	S	SF, A
Berberis kumaonensis C.K. Schneid.	S	SF, TL
Podophyllaceae		
Podophyllum hexandrum Royle	H (EN)	SF, A
Papaveraceae		
Meconopsis aculeata Royle	H (EN)	A, BA
Meconopsis robusta Hook. f. & Thomson	H	SF
Meconopsis paniculata (D. Don) Prain	H	SF
Fumariaceae		
Corydalis cashmeriana Royle	H (EN)	A
Corydalis cornuta Royle	H	SF, A
Corydalis falconeri Hook. f. & Thomson	H	SF
Corydalis govaniana Wall.	H	SF, A
Corydalis rutifolia (Sm.) DC.	H	SF
Corydalis vaginans Royle	H	SF
Brassicaceae		
Arabidopsis himalaica (Edgew.) O.E. Schulz	H	SF, A
Arabis amplexicaulis Edgew.	H	SF
Arcyosperma primulifolium (Thomson) O.E. Schulz	H	SF, A
Cardamine impatiens L.	H	TL
Cardamine scutata Thumb.	H	SF

Draba gracillima Hook f.& Thomson	H	A
Capsella bursa-pastoris (L.) Medik.	H	SF, A
Megacarpaea polyandra Benth. ex Madden	H	SF, A
Thlaspi cochleariforme DC.	H	SF,A
Violaceae		
Viola biflora L.	H	SF, A
Viola canescens Wall.	H	SF
Caryophyllaceae		
Cerastium cerastoides (L.) Britton	H	SF, A
Cerastium holosteoides Fries	H	SF
Gypsophila cerastoides D.Don	H	SF, A
Pseudostellaria himalaica (Franch.) Pax	H	SF
Sagina saginoides (Linn) Karsten	H	SF
Silene indica (Roxb.) Roxb. ex Otth	H	SF
Silene laxantha Majumdar	H	SF
Silene setisperma Majumdar	H	TL, A
Silene vulgaris (Moench) Garcke	H	SF
Stellaria cherleriae (Fisch. ex Ser.) F.N.Williams	H	SF
Stellaria decumbens Edgew.	H	A
Stellaria patens D.Don.	H	SF
Stellaria uliginosa Murray	H	SF
Hypericaceae		
Hypericum hookerianum Wight & Arn.	H	SF
Hypericum japonicum Thunb.	H	A
Hypericum nepalense Hort. ex K.Koch	S	SF
Malvaceae		
Malva rotundifolia L.	H	SF
Geraniaceae		
Geranium nepalense Sweet	H	SF
Geranium paludosum R.Knuth	H	A
Geranium polyanthes Edgew. & Hook. f.	H	SF, A
Geranium wallichianum D.Don ex Sweet	H	SF, A
Oxalidaceae		
Oxalis acetosella L.	H	SF
Oxalis corniculata L.	H	SF
Balsaminaceae		
Impatiens brachycentra Kar. & Kir.	H	SF
Impatiens glandulifera Royle	H	SF
Impatiens racemosa DC.	H	SF
Impatiens scabrida DC.	H	SF
Impatiens sulcata Wall.	H	SF, A
Rutaceae		
Skimmia anquitilia N.P. Tayler & Airy Shaw	S	SF, A
Aquifoliaceae		
Ilex dipyrena Wall.	T	SF
Celastraceae		
Euonymus tingens Wall.	T	SF
Aceraceae		
Acer acuminatum Wall. ex D.Don	T	SF
Acer caesium Wall. ex Brandis	T (VU)	SF
Acer pictum Thunb.	T	SF, TL
Fabaceae		
Astragalus chlorostachys Lindl.	H	SF, A
Astragalus himalayanus Klotzsch	H	SF, A
Parochetus communis Buch. -Ham. ex D.Don	H	SF
Piptanthus nepalensis (Hook.) D.Don	S	SF, TL, R
Trifolium repens L.	H	SF
Rosaceae		
Aruncus dioicus (Walter) Fernald	H	SF, TL
Cotoneaster acuminatus Lindl.	S	SF, A
Cotoneaster microphyllus Wall. ex Lindl.	S	TL
Filipendula vestita (Wall. ex G. Don) Maxim.	H	TL, A

Fragaria daltoniana J. Gay	H	SF, TL
Fragaria nubicola (Hook. f.) Lindl. ex Lacaita	H	SF, TL
Geum elatum Wall ex G.Don	H	SF, A
Geum urbanum Linn.	H	SF
Potentilla argyrophylla Wall. ex Lehm.	H	SF, A
Potentilla atrosanguinea Lodd. ex Lehm.	H	SF, A
Potentilla eriocarpa Wall. ex Lehm.	H	SF, R
Potentilla gelida C.A. Mey.	H	SF
Potentilla leuconota D.Don	H	SF
Potentilla lineata Trevir.	H	A
Poten tilla microphylla D.Don	H	A
Potentilla multifida L.	H	A
Potentilla polyphylla Wall. ex Lehm.	H	SF, A
Potentilla fruticosa L.	S	A
Prunus cornuta (Wall. ex Royle) Steud.	T	SF, TL
Rosa macrophylla Lindl.	S	TL
Rosa sericea Lindl.	S	SF, TL
Rubus nepalensis (Hook. f.) Kuntze	H	SF
Rubus pedunculosus D.Don	S	SF
Rubus niveus Thunb.	S	SF, TL
Sibbaldia cuneata Hornem. ex Kuntze	H	SF, A
Sibbaldia micropetala (D. Don) Hand.-Mazz.	H	TL, A
Sorbus cuspidata (Spach) Hedl.	T	SF
Sorbus foliolosa (Wall.) Spach	T	SF, TL
Spiraea bella Sims.	S	TL
Spiraea canescens D.Don	S	SF, A
Saxifragaceae		
Astilbe rivularis Buch.-Ham. ex D.Don	H	SF
Bergenia stracheyi (Hook.f. & Thomson) Engl.	H (NT)	SF, TL, B
Chrysosplenium tenellum Hook.f. & Thomson	H	A
Saxifraga asarifolia Sternb.	H	A
Saxifraga brachypoda D.Don var. *fimbriata* (Wall.) Engl. & Irmsch.	H	A
Saxifraga brunonis Wall. ex Ser.	H	A
Saxifraga diversifolia Wall. ex Ser.	H	A
Saxifraga filicaulis Wall. ex DC.	H	A
Saxifraga flagellaris Willd. ex Sternb.	H	A
Saxifraga hirculus L.	H	A
Saxifraga hispidula D.Don	H	A
Saxifraga pallida Wall. ex Ser.	H	A
Saxifraga parnassifolia D.Don	H	A
Saxifraga pseudopallida Engl. & Irmsch.	H	TL, A
Parnassiaceae		
Parnassia nubicola Wall. ex Royle	H	TL, A
Parnassia pusilla Wall. ex Arn.	H	A
Parnassia laxmannii Pall. ex Schult.	H	A
Grossulariaceae		
Ribes glaciale Wall.	S	SF, A
Ribes himalense Royle ex Decne.	S	SF
Crassulaceae		
Crassula campestris (Eckl. & Zeyh.) Endl.	H	SF
Rhodiola sinuata (Royle ex Edgew.) S.H. Fu	H	SF, A
Rhodiola trifida (Hook. f. & Thomson) Jacobsen	H	SF, TL
Rosularia alpestris (Kar. & Kir.) Boriss.	H	SF, A
Sedum quadrifidum Pall.	H	SF
Onagraceae		
Circaea alpina subsp. *imaicola* (Asch. & Magnus) Kitam.	H	TL, A
Epilobium royleanum Hausskn.	H	SF, A
Epilobium wallichianum Hausskn.	H	SF, A
Apiaceae		
Acronema hookeri (C.B.Clarke) H.Wolff	H	SF, A
Angelica archangelica L.	H	SF, TL
Angelica glauca Edgew.	H (EN)	SF, TL

Bupleurum hamiltonii N.P.Balakr.	H	SF, H
Bupleurum longicaule Wall. ex DC.	H	SF
Chaerophyllum reflexum var. *acuminatum* (Lindl.) Hedge & Lamond	H	SF
Heracleum canescens Lindl.	H	SF, A
Osmorhiza aristata (Thunb.) Rydb.	H	SF
Pimpinella diversifolia DC.	H	SF
Pleurospermum brunonis (DC.) C.B.Clarke	H	A
Pleurospermum angelicoides (Wall. ex DC.) Benth. ex C.B. Clarke	H (VU)	SF
Selinum candollei DC.	H	SF, A
Selinum vaginatum C.B. Clarke	H	SF, A
Selinum wallichianum (DC.) Raizada & H.O. Saxena	H	SF, A
Tordyliopsis brunonis DC.	H	SF
Trachydium roylei Lindl.	H	SF, A
Vicatia coniifolia DC.	H	SF, A
Araliaceae		
Eleutherococcus cissifolius (Griff. ex C.B.Clarke) Nakai	S	SF, TL
Aralia leschenaultii (DC.) J.Wen	S	SF
Caprifoliaceae		
Lonicera myrtillus Hook f. & Thomson	S	SF, A, R
Lonicera obovata Royle ex Hook.f.& Thomson	S	SF
Leycesteria formosa Wall.	S	SF
Triosteum himalayanum Wall.	S	SF
Viburnum foetens Decne.	S	SF
Viburnum grandiflorum Wall. ex DC.	S	SF, TL
Viburnum stellatum (Oerst.) Hemsl.	S	SF
Rubiaceae		
Galium aparine L.	H	SF, A
Galium asperuloides Edgew.	H	SF, A
Galium mollugo L.	H	SF
Galium rotundifolium L.	H	SF
Leptodermis lanceolata Wall.	S	SF
Rubia cordifolia L.	H	SF
Valerianaceae		
Nardostachys jatamansi (D. Don) DC.	H (CR)	A
Valeriana hardwickii Wall.	H	TL, A
Dipsacaceae		
Dipsacus mitis D.Don.	H	SF
Triplostegia glandulifera Wall.ex DC.	H	SF, TL
Morinaceae		
Morina longifolia Wall. ex DC.	H	SF, A
Asteraceae		
Adenocaulon bicolor Hook.	H	SF
Ainsliaea aptera DC.	H	SF
Ainsliaea latifolia (D.Don) Sch.Bip.	H	SF
Anaphalis cinnamomea (DC.) C.B.Clarke	H	SF
Anaphalis contorta (D.Don) Hook.f	H	SF, A
Anaphalis cuneifolia (DC.) Hook.f.	H	SF
Anaphalis royleana DC.	H	SF, A
Aster methodorus (Benth.) Govaerts	H	A
Carpesium cernuum L.	H	SF, A
Carpesium nepalense Less.	H	SF, A
Cicerbita cyanea (D.Don) Beauv.	H	TL, A
Cicerbita macrorhiza (Royle) Beauv	H	A
Cicerbita violaefolia (Decne.) Beauv.	H	A
Cirsium verutum (D.Don) Spreng.	H	SF, A
Cremanthodium arnicoides (DC. ex Royle) R.D. Good	H (EN)	A, R
Doronicum roylei DC.	H	A, R, B
Erigeron alpinus L.	H	SF, A
Erigeron multiradiatus (Lindl. ex DC.) Benth. ex C.B.Clarke	H	SF, A
Galinsoga parviflora Cav.	H	SF
Gerbera gossypina (Royle) Beauverd	H	SF, A

Gerbera kunzeana A.Braun & Aschers	H	SF
Gerbera lanuginosa Benth.	H	SF
Jurinea macrocephala DC.	H (EN)	A
Ligularia amplexicaulis DC.	H	A
Myractis nepalensis Less.	H	SF, A
Myractis wallichii Less.	H	SF, A
Prenanthes brunoniana Wall. ex DC.	H	SF
Saussurea auriculata (DC.) Sch.Bip.	H	SF
*Saussurea leontodontoides (*DC.) Sch.Bip.	H	SF, A
Saussurea nepalensis Spreng.	H	A
Saussurea piptathera Edgew.	H	A
Saussurea taraxacifolia Wall.ex DC.	H	A
Senecio candolleanus Wall.	H	SF
Senecio graciliflorus (Wall.) DC.	H	SF, TL
Senecio kunthianus Wall.	H	A
Senecio laetus Edgew.	H	SF, A
Senecio levingii C.B.Clarke	H	SF
Senecio rufinervis DC.	H	SF
Solidago virgaurea L.	H	SF
Synotis alata (Wall. ex Wall.) C.Jeffrey & Y.L.Chen	H	SF
Tanacetum longifolium Wall.ex.DC.	H	A
Taraxacum officinale Webb	H	SF, A
Campanulaceae		
Campanula argyrotricha Wall.ex DC.	H	A
Codonopsis rotundifolia Benth.	H	TL, A
Cyananthus lobatus Wall.ex Benth.	H	A
Cyananthus microphyllus Edgew.	H	A
Cyanathus integer Wall.ex Benth.	H	A, R
Ericaceae		
Cassiope fastigiata (Wall.) D.Don	S	A
Gaultheria nummularioides D.Don	H	A
Gaultheria trichophylla Royle	H	A
Rhododendron anthopogon D.Don	S (NT)	A
Rhododendron arboreum Sm.	T	SF, TL
Rhododendron barbatum Wall.ex G.Don	S	SF
Rhododendron campanulatum D.Don	S (NT)	SF, A
Rhododendron lepidotum Wall.ex G.Don	S (NT)	A, R
Primulaceae		
Androsace lanuginosa Wall.	H	A, R
Androsace sarmentosa Wall.	H	SF, R
Lysimachia japonica Thunb.	H	SF
Lysimachia prolifera Klatt.	H	SF
Primula denticulata Sm.	H	SF, A
Primula edgeworthii Pax	H	SF, A, B
Primula petiolaris Wall.	H	A
Primula reidii Duthie	H	SF, A, R
Primula sessilis Roxb. ex Steud.	H	A
Oleaceae		
Syringa emodi Wall. ex Royle	S	SF
Jasminum humile L.	C	SF, TL
Gentianaceae		
Gentiana albicalyx Burkill	H	A
Gentiana argentea Royle ex D.Don	H	SF, A
Gentiana carinata Griseb.	H	A
Gentiana leucomelaena Maxim.	H	A
Gentiana pedicellata (D.Don) Wall.	H	A
Gentiana stipitata Edgew.	H	A, R
Halenia elliptica D.Don	H	SF, TL
Lomatogonium carinthiacum (Wulfen) Rchb.	H	A
Swertia alata Royle ex D.Don	H	TL, A
Swertia ciliata (D. Don ex G. Don) B.L.Burtt	H	TL, A
Swertia cuneata Wall. ex D. Don	H	SF, A

Swertia speciosa D.Don	H	TL, A
Swertia tetragona R.H. Miao	H	A
Boraginaceae		
Cynoglossum wallichii G.Don	H	A
Cynoglossum zeylanicum (Lehm.) Brand	H	A
Eritrichium canum (Benth.) Kitam.	H	A
Hackelia uncinata (Benth.) C.E.C.Fisch.	H	SF, A
Lindelofia longiflora (Benth.) Bail.	H	SF
Maharanga emodi (Wall.) A. DC.	H	A, R
Mertensia racemosa Benth. ex C.B.Clarke	H	SF
Myosotis sylvatica Ehrh. ex Hoffm.	H	SF
Scrophulariaceae		
Euphrasia himalayica Wettst.	H	A
Euphrasia platyphylla Pennell	H	A
Falconeria himalaica HooK.f.	H	A, R
Hemiphragma heterophyllum Wall.	H	SF, A
Lindernia crustacea (L.) F.Muell.	H	SF
Pedicularis gracilis Wall. ex Benth.	H	A
Pedicularis hoffmeisteri Klotzsch	H	A
Pedicularis pectinata Wall. ex Benth.	H	A
Pedicularis siphonantha D.Don	H	A, R
Pedicularis porrecta Wall. ex Benth.	H	A
Pedicularis rhinanthoides Schr. ssp. *labellata* (Jacq.) Prain	H	A
Picrorhiza kurrooa Royle ex Benth.	H (CR)	SF, A, R
Scrophularia calycina Benth.	H	SF, A, B
Scrophularia himalensis Royle ex Benth.	H	SF, A, B
Veronica cana Wall. ex Benth.	H	SF, A
Veronica macrostemon Bunge	H	SF, A
Wulfenia amherstiana Benth.	H	SF, B
Orobanchaceae		
Boschniakia himalaica Hook.f. & Thomson	H	TL, A
Lentibulariaceae		
Utricularia striatula Sm.	H	A
Acanthaceae		
Strobilanthes atropurpureus Nees	H	SF, TL
Lamiaceae		
Ajuga brachystemon Maxim.	H	SF, A
Clinopodium umbrosum (M.Bieb.) Kuntze	H	SF
Clinopodium vulgare L.	H	SF
Elsholtzia strobilifera Benth.	H	TL, A
Lamium album L.	H	SF
Leonurus cardiaca L.	H	SF
Nepeta govaniana (Wall. ex Benth.) Benth.	H	SF, TL
Phlomis bracteosa Royle ex Benth.	H	SF, A
Plectranthus coetsa Buch.-Ham. ex D.Don	H	SF
Prunella vulgaris L.	H	SF, A
Salvia hians Royle ex Benth.	H	A
Salvia nubicola Wall. ex Sweet	H	SF
Stachys melissifolia Benth.	H	SF, A
Stachys sericea Cav.	H	SF, A
Teucrium royleanum Wall. ex Benth.	H	SF
Plantaginaceae		
Plantago brachyphylla Edgew.	H	A
Polygonaceae		
Aconogonon rumicifolium (Royle ex Bab.) H.Hara	H	A
Aconogonon tortuosum (D.Don) H.Hara	H	A
Bistorta affinis (D.Don) Greene	H	A, B
Bistorta emodi (Meisn.) H.Hara	H	SF, A, R
Bistorta macrophylla (D.Don) Soják	H	SF, A
Bistorta purpusilla (Hook. f.) Greene	H	A
Koenigia islandica L.	H	A, B

Oxyria digyna (L.) Hill	H	A, B
Persicaria alpina (All.) H.Gross	H	A
Persicaria amplexicaulis (D.Don) Ronse Decr.	H	SF, A
Persicaria chinensis (L.) H. Gross	H	TL, A
Persicaria nepalensis (Meisn.) Miyabe	H	SF, A
Persicaria sinuata (Royle ex Bab.) K. R. Rajbhandari & R. Joshi	H	A, R
Persicaria vivipara (L.) Ronse Decr.	H	A
Persicaria wallichii Greuter & Burdet	H	SF, A
Polygonum delicatulum Meisn.	H	SF, A
Polygonum filicaule Wall. ex Meisn.	H	SF, A
Polygonum glaciale (Meisn.) Hook. f.	H	SF
Polygonum recumbens Royle ex Bab.	H	SF, A, R
Polygonum sphaerocephalum Wall. ex Meissn.	H	SF, A
Polygonum vaccinifolium Wall. ex Meissn	H	SF, A, R
Rheum australe D. Don	H	A, R, B
Rheum webbianum Royle	H (VU)	A, R, B
Rumex nepalensis Spreng.	H	SF, A
Eleagnaceae		
Hippophae salicifolia D.Don	S (NT)	SF, R
Balanophoraceae		
Balanophora involucrata Hook. f. & Thomson	H (LC)	TL
Euphorbiaceae		
Euphorbia pilosa L.	H	SF
Euphorbia stracheyi Boiss.	H	A
Buxaceae		
Sarcococca saligna (D. Don) Maell.- Arg.	S	SF
Urticaceae		
Chamabainia cuspidata Wight	H	SF, TL
Elatostema monandrum (Buch.-Ham. ex D.Don) H.Hara	H	SF
Parietaria debilis G.Forst.	H	SF
Pilea wightii Wedd.var. *roylei* Hook.f.	S	SF
Urtica dioica L.	S	SF
Betulaceae		
Betula utilis D. Don	T (NT)	SF, TL
Fagaceae		
Quercus semecarpifolia Sm.	T	SF, TL
Salicaceae		
Salix denticulata Andersson	S	TL
Salix elegans Wall. ex Anderss.	H	A
Salix lindleyana Wall. ex Andersson	H	A
Pinaceae		
Abies spectabilis Spach	T	SF, A
Cupressaceae		
Juniperus indica Bertol.	S	A, R, B
Taxaceae		
Taxus wallichiana Zucc.	T (EN)	SF
Orchidaceae		
Aorchis spathulata (Lindl.) Verm.	H	A
Aphyllorchis parviflora King & Pantl.	H	SF, TL
Calanthe mannii Hook.f.	H	SF
Calanthe tricarinata Lindl.	H	SF, TL
Cypripedium cordigerum D.Don	H	TL
Cypripedium elegans Reichb.f.	H	TL, A
Cypripedium himalaicum Rolfe	H	TL, A
Dactylorhiza hatagirea (D.Don) Soó	H (CR)	TL, A
Goodyera fusca (Lindl.) Hook.f.	H	SF, A
Goodyera repens (L.) R. Br.	H	SF, TL
Gymnadenia orchidis Lindl.	H	A
Herminium lanceum (Thunb. ex Sw.) Vuijk	H	SF, A
Herminium mackinonii Duthie	H	SF, A
Herminium monophyllum (D.Don) P.F.Hunt & Summerh.	H	A

Liparis rostrata Rchb.f.	H	TL
Malaxis muscifera (Lindl.) Kutze.	H	A
Neottia pinetorum (Lindl.) Szlach.	H	TL
Oreorchis indica (Lindl.) Hook.f.	H	SF, TL
Peristylus duthiei (Hook.f.) Deva & H.B.Naithani	H	A
Peristylus elisabethae (Duthie) R.K.Gupta	H	A
Peristylus fallax Lindl.	H	A
Platanthera latilabris Lindl.	H	TL
Platanthera leptocaulon (Hook.f.) Soó	H	TL
Platanthera leptocaulon (Hook.f.) Soó	H	TL
Pleione hookeriana (Lindl.) J.Moore	H	SF, R
Ponerorchis chusua (D.Don) Soó	H	A
Ponerorchis renzii Deva & H.B.Naithani	H	A
Satyrium nepalense D.Don	H	SF
Satyrium nepalense var. *ciliatum* (Lindl.) Hook.f.	H	A
Zingiberaceae		
Roscoea alpina Royle	H	SF, A
Iridaceae		
Iris kemaonensis Wall. ex G. Don	H	SF, A
Amaryllidaceae		
Allium stracheyi Baker	H	TL, A
Allium wallichii Kunth	H	TL, A
Nartheciaceae		
Aletris pauciflora (Klotzsch) Hand.-Mazz	H	A
Haemodoraceae		
Ophiopogon intermedius D.Don.	H	SF
Liliaceae		
Clintonia udensis Trautv. & Mey.	H	SF, TL
var. *alpina* (Kunth ex Baker) Hara		
Fritillaria roylei Hook.	H (EN)	A
Gagea lutea (L.) Ker Gawl.	H	SF
Lilium nanum Klotzsch	H	A
Lloydia alpina (Mill.) Salisb.	H	A, R
Lloydia longiscapa Hook.	H	A, R
Notholirion macrophyllum (D.Don) Boiss.	H	SF
Polygonatum geminiflorum Decne	H	A
Polygonatum leptophyllum Royle	H	A
Polygonatum verticillatum (L.) All.	H (VU)	SF, A
Smilacina purpurea Wall.	H	SF, A
Streptopus simplex D.Don	H	SF
Trillium govanianum Wall. ex D.Don	H	SF, A, B
Smilacaceae		
Smilax elegans Wall.	C	SF, TL
Juncaceae		
Juncus concinnus D.Don	H	A
Juncus himalensis Klotzsch	H	A
Juncus membranaceus Royle ex D.Don	H	A
Luzula multiflora (Retz.) Lejeune	H	A
Areceae		
Arisaema intermedium Blume	H	SF, A
Arisaema jacquemontii Blume	H	SF, A
Arisaema propinquum Schott	H	SF, A
Typhonium sagittariifolium Gagnep.	H	SF
Cyperaceae		
Carex inanis Kunth.	Sd	SF, A
Carex setigera D.Don	Sd	SF, A
Carex setosa Boott	Sd	SF, A
Kobresia esenbeckii (Kunth) Noltie	Sd	A
Kobresia nepalensis (Nees) Kukenthal	Sd	A
Kobresia nitens C.B.Clarke	Sd	A
Poaceae		
Agrostis canina L.	G	SF, A

Agrostis munroana Aitch. & Hemsl.	G	SF, A
Agrostis pilosula Trin.	G	SF, A
Agrostis stolonifera L.	G	SF, A
Danthonia cachemyriana Jaub. & Spach	G	SF, A
Calamagrostis lahulensis G.Singh	G	SF, A
Calamagrostis scabrescens Griseb.	G	SF, A
Festuca gigantea (L.) Vill.	G	SF, A
Festuca kashmiriana Stapf	G	SF, A
Festuca rubra L.	G	SF, A
Festuca valesiaca Schleich. ex Gaudin	G	SF, A
Helictotrichon junghuhnii (Buse) Henrard	G	SF, A
Poa alpina L.	G	SF, A
Poa annua L.	G	SF, A
Poa nepalensis (Wall. ex Griseb.) Duthie	G	SF, A
Poa pagophila Bor	G	SF, A
Poa supina Schrad.	G	SF, A
Thamnocalamus spathiflorus (Trin.) Munro	G	SF
Trisetum clarkei (Hook.f.) R.R. Stewart	G	SF, A

[a] Habit and IUCN threat categories: C- Climber, H- Herb, S- Shrub, T- Tree, G- Grass, Sd- Sedge; CR- Critically Endangered, EN- Endangered, LC- Least Concerned, NT- Near Threatened, VU- Vulnerable

[b] Habitat: SF- Subalpine forest; TL- Timberline ecotone; A- Alpine meadow; R- Rocky edges and slopes; B- Bouldery areas