



Plant Species Diversity in Ropa - Giavung Valley in Cold Deserts of District Kinnaur, Himachal Pradesh

R.K. Verma and K.S. Kapoor

Himalayan Forest Research Institute Conifer Campus, Panthaghathi, Shimla, (HP)

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ABSTRACT : A study was conducted to understand the plant diversity along an altitudinal gradient with elevations varying from 3000m to 5000m above msl in Ropa- Giavung valley falling in cold desert area of Pooh sub division of district Kinnaur, Himachal Pradesh during 2008. The total number of plant species was 160 belonging to 51 families and 119 genera. The dominant families were Asteraceae, Polygonaceae, Rosaceae and Ranunculaceae. The number of tree species at 3000-3500m was 12 with the dominance of *Pinus gerardiana*. The number of shrub species were 20 and 15 in the elevations of 3000-3500m and 3500-4000m respectively. *Rosa webbiana* and *Juniperus indica* taking shape of the dominant shrub at 3000-3500m and 3500-4000m elevations respectively. The number of herb species were 83, 46, 44 and 30 at 3000-3500m, 3500-4000m, 4000-4500m and 4500-5000m elevational ranges respectively. On the basis of Importance Value Index (IVI), *Ephedra gerardiana*, *Artemisia brevifolia*, *Bistorta affinis* and *Potentilla argyrophylla* were the dominant herbs dotting different elevational ranges and distribution pattern of plant species was mostly contiguous in all the altitudes. Index of diversity for herb species in different elevational ranges was 3.97, 3.54, 3.16 and 2.98. Index of similarity for herb species between different altitudes was low indicating more dissimilarity of species between different altitudes.

Keywords : Dominance, distribution pattern, diversity index, similarity index, IVI.

INTRODUCTION

Himalayas are one of the largest and youngest mountain chains in the world and cover roughly 10% of India total land surface. Variations in terms of its size, climate and altitudinal ranges have created environments those are unique and characteristic to this region only. The diverse climate and the varied environmental conditions prevailing in Himalayas support diverse habitat and ecosystems with equally diverse life forms. It provides an important habitat to the flora and fauna including 9,000 species of angiosperms and hence, is considered as the hot spot of biodiversity. There are about 3,470 species considered exclusively endemic to the Himalayas. The cold deserts in India occur in Ladakh region of Jammu & Kashmir, Spiti valley of Lahaul and Spiti district and Pooh sub division of Kinnaur district of Himachal Pradesh. The total area under cold deserts in Himachal Pradesh is about 11,000 sq.km., out of which 3,400 sq.km. area is in Kinnaur district. Human pressure on natural ecosystems is intensifying, some being incompatible with survival of certain species of plants.

In cold desert areas, continuous removal of plant species for various uses and overgrazing by migratory livestock have resulted in desertification and loss of biodiversity. If these naturally occurring plant resources are not timely conserved then they may soon become extinct. In cold desert this genetic erosion coupled with soil erosion may retard prospects of future economic development and welfare of the people. The assessment of plant wealth in this harsh cold arid belt may provide a key for its

conservation. Keeping these aspects in view, a study was undertaken to know the plant diversity in Ropa-Giavung valley of cold desert in Kinnaur district of Himachal Pradesh.

MATERIALS AND METHODS

The present study was conducted in Ropa- Giavung valley of cold desert area of Pooh sub division of district Kinnaur, Himachal Pradesh during, 2007 at an elevation of 3000 m to 5000 m. The study site was situated 31°42' 93.6" to 31°43' 98.7" N latitude and 78° 23' 94.1" to 78° 31' 72.8"E longitudes. The whole area of the valley was divided into four altitudes *i.e.* 3000-3500m, 3500-4000m, 4000-4500m and 4500-5000 m for conducting the phyto-sociological study. Quadrats of size 10 × 10m, 3 × 3m and 1 × 1m laid out randomly for enumerating trees, shrubs and herbs + regeneration respectively. The seedlings were considered as herb while saplings as shrubs. The vegetation data was analysed for density, frequency and abundance according to formulas given by Curtis and McIntosh (1950). The relative values of density, frequency and dominance were summed to get Importance Value Index (IVI) of individual species. The abundance to frequency ratio (A/F) of different species was determined for eliciting the distribution pattern. This ratio indicates regular (<0.025), random (0.025 to 0.050) and contiguous (>0.050) distribution (Curtis and Cottam, 1956). The plant species diversity was calculated by using Shannon-Wiener diversity Index (*H*) (Shannon-Wiener, 1963).

$$H = \sum_{i=1}^S (N_i / N) \ln(N_i / N)$$

Concentration of dominance (C) was measured by Simpson's Index (Simpson, 1949).

$$C = \sum_{i=1}^S (N_i / N)^2$$

where N_i = importance value of species i and N = total importance value of all the species in both the indices.

Index of similarity and dissimilarity between different altitudes were calculated by using following formula (Misra, 1989).

$$\text{Index of similarity, } S = 2C/A + B$$

where A = number of species in community A , B = number of species in community B , C = number of species common to both communities.

$$\text{Index of dissimilarity} = 1 - S$$

Richness Index was estimated as per Margalef (1958) i.e. $R = S - 1/\ln N$

Evenness Index was calculated as per Hill (1973) i.e. $E = H/\ln S$

where S = total number of species, N = total number of individuals of all the species, H = Index of diversity.

RESULTS AND DISCUSSION

The total number of plant species was 160 belonging to 51 families and 119 genera. The dominant families were Asteraceae, Polygonaceae, Rosaceae and Ranunculaceae. At elevation 3000-3500 m, total number of tree species was 12 (Table 1). *Pinus gerardiana* was dominant species having maximum density, frequency and abundance. This was followed by *Salix alba*, *Cedrus deodara* and *Populus ciliata* in term of density. For a particular species, higher frequency indicates its more frequent distribution at a particular site. *Pinus gerardiana* recorded highest value in term of IVI (101.96) followed by *Salix alba* (36.32) and *Cedrus deodara* (33.98). The community identified was *Pinus gerardiana-Salix alba* in this elevation. The ratio of abundance to frequency (A/F) indicates the distribution pattern of all the species except *Populus ciliata*, *Pinus gerardiana*, *Juglans regia* and *Cedrus deodara* was contiguous. The contiguous distribution is the commonest pattern in nature, random distribution is found in very uniform environment. The general preponderance of contiguous distribution in vegetation has been reported by several workers (Kershaw, 1973; Singh and Yadava, 1974; Kunhikannan *et al.*, 1998).

Among the 20 species of shrub including saplings (Table 2), *Rosa webbiana* was the dominant species having maximum density and frequency. It was followed by *Colutea nepalensis*, *Myricaria germanica* and *Sorbaria tomentosa* in term of density. In term of abundance, *Colutea nepalensis* observed maximum value followed by *Myricaria germanica*, *Fraxinus xanthoxyloides* and *Rosa webbiana*. *Rosa webbiana* recorded highest value of IVI (79.23) followed

by *Colutea nepalensis* (26.97) and *Salix denticulata* (20.49). The ratio of abundance to frequency (A/F) showed that distribution pattern of all the species was contiguous.

In case of herbs including regeneration, total number of species was 83 at elevation of 3000-3500m (Table 3). *Ephedra gerardiana* was the dominant species having maximum density followed by *Artemisia brevifolia*, *Rumex nepalensis* and *Polygonum paronychioides*. In term of abundance, *Bergenia stracheyi* noted maximum value followed by *Ephedra gerardiana*, *Artemisia brevifolia* and *Polygonum paronychioides*. *Ephedra gerrardiana* recorded highest value of IVI (28.96) followed by *Cirsium wallichii* (20.55), *Polygonum paronychioides* (16.69) and *Rumex nepalensis* (14.94). The distribution pattern of all species except *Heracleum candicans* was contiguous.

At elevation 3500-4000m, total number of shrub species including saplings was 15 (Table 4). *Juniperus indica* was dominant species having maximum density and abundance. It was followed by *Rosa webbiana*, *Juniperus polycarpus* and *Lonicera quinquelocularis* in term of density. *Juniperus indica* recorded highest value of IVI followed by *Rosa webbiana*, *Juniperus polycarpus* and *Juniperus communis*. The distribution pattern of all the species was contiguous.

In case of herbs, total number of species was 46 at 3500-4000m elevation (Table 5). *Artemisia brevifolia* was dominant herb having maximum density and abundance followed by *Bergenia stracheyi*. The value of frequency was maximum for *Stellaria media* followed by *Artemisia brevifolia*. On the basis of IVI, *Artemisia brevifolia* was dominant species followed by *Hyoscyamus niger*, *Bergenia stracheyi* and *Thymus linearis*. The distribution pattern of all the species was contiguous.

At elevation 4000-4500 m, total number of herb species was 44 (Table 6). *Bistorta affinis* was dominant species having maximum density followed by *Arenaria festuroides*, *Bergenia stracheyi* and *Potentilla parviflora*. On the basis of abundance, *Arenaria festuroides* recorded maximum value followed by *Galium acutum*, *Bistorta affinis* and *Arenaria griffithii*. *Bistorta affinis* recorded highest value of IVI followed by *Bergenia stracheyi*, *Arenaria festuroides* and *Potentilla parviflora*. The distribution pattern of all species was contiguous.

At elevation 4500-5000 m, total number of herb species was 30 (Table 7). *Potentilla argyrophylla* was the dominant species having maximum density and frequency followed by *Bistorta affinis*, *Androsace mucronifolia* and *Sibbaldia parviflora* in term of density. In term of abundance, *Bistorta affinis* noted maximum value followed by *Sibbaldia parviflora*, *Thymus linearis* and *Androsace mucronifolia*. *Potentilla argyrophylla* recorded highest value of IVI (53.39) followed by *Bistorta affinis* (26.99), *Sibbaldia parviflora* (26.67) and *Androsace mucronifolia* (25.42). The distribution pattern of all the species was contiguous.

Table 1: Distribution of tree species in Ropa -Giavung area of district Kinnaur at 3000-3500 m elevation.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Cedrus deodara</i> (Roxb. ex D. Don) G.Don	105	45	2.33	0.05	33.98
2.	<i>Fraxinus xanthoxyloides</i> (Wall. ex G. Don) DC	25	20	1.25	0.06	8.84
3.	<i>Juglans regia</i> Linn	20	20	1.00	0.05	12.35
4.	<i>Juniperus polycarpos</i> C. Koch	45	20	2.25	0.11	11.70
5.	<i>Pinus gerardiana</i> Wall ex Lambert	275	85	3.24	0.04	101.96
6.	<i>Pinus wallichiana</i> A.B. Jackson	45	20	2.25	0.11	16.24
7.	<i>Populus ciliata</i> Wall ex Royle	80	40	2.00	0.05	27.09
8.	<i>Populus alba</i> Linn	60	35	1.71	0.05	19.61
9.	<i>Populus nigra</i> Linn	55	25	2.20	0.09	16.94
10.	<i>Prunus armeniaca</i> Linn	15	5	3.00	0.60	3.45
11.	<i>Robinia pseudoacacia</i> Linn	40	20	2.00	0.10	11.52
12.	<i>Salix alba</i> Linn.	120	45	2.67	0.06	36.32

Table 2: Distribution of shrub species in Ropa-Giavung area of district Kinnaur at 3000-3500 m elevation.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Abelia triflora</i> R. Br ex Wall.	2333	25	8.40	0.34	14.50
2.	<i>Ailanthus excelsa</i> * Roxb.	389	15	2.33	0.16	6.03
3.	<i>Caragana brevispina</i> Royle	833	20	3.75	0.19	7.29
4.	<i>Cedrus deodara</i> * (Roxb ex D. Don) G. Don	389	20	1.75	0.09	7.31
5.	<i>Colutea nepalensis</i> Sims	5278	35	13.57	0.39	26.97
6.	<i>Cotoneaster bacillaris</i> Wall ex Lindley	500	15	3.00	0.20	5.78
7.	<i>Cotoneaster microphyllus</i> Wall ex Lindley	667	15	4.00	0.27	6.73
8.	<i>Fraxinus xanthoxyloides</i> (Wall. ex G. Don) DC	1667	15	10.00	0.67	12.26
9.	<i>Hippophae rhamnoides</i> Linn	1333	20	6.00	0.30	10.25
10.	<i>Juniperus polycarpos</i> * C. Koch	667	20	3.00	0.15	8.67
11.	<i>Lonicera alpigena</i> Linn.	1111	15	6.67	0.44	7.30
12.	<i>Lonicera quinquelocularis</i> Hardw.	1222	25	4.40	0.18	9.05
13.	<i>Myricaria germanica</i> (L.) Desv.	3500	30	10.50	0.35	20.28
14.	<i>Pinus gerardiana</i> * Wall. ex Lambert	1111	35	2.86	0.08	14.29
15.	<i>Populus ciliata</i> * Wall ex Royle	389	20	1.75	0.09	6.56
16.	<i>Ribes orientale</i> Desf.	1278	15	7.67	0.51	7.28
17.	<i>Rosa webbiana</i> Wall ex Royle	8111	85	8.59	0.10	79.23
18.	<i>Salix alba</i> * Linn.	1111	20	5.00	0.25	9.94
19.	<i>Salix denticulata</i> Andersson	2222	25	8.00	0.32	20.49
20.	<i>Sorbaria tomentosa</i> (Lindl.) Rehder	3389	40	7.63	0.19	19.68

*Sapling

Table 3: Distribution of herb species in Ropa-Giavung area of district Kinnaur at 3000-3500 m elevation.

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Amaranthus caudatus</i> Linn.	0.13	8	1.60	0.192	0.82
2.	<i>Anaphalis triplinervis</i> (Sims) C.B. Clarke	0.73	13	5.50	0.413	2.81
3.	<i>Arabidopsis thaliana</i> (L.) Heynh	0.37	8	4.40	0.528	1.38
4.	<i>Arenaria griffithii</i> Boiss	0.42	8	5.00	0.600	1.40
5.	<i>Artemisia brevifolia</i> Wall	6.42	55	11.66	0.212	14.67
6.	<i>Artemisia dracunculus</i> L. Tarragon	2.13	27	8.00	0.300	6.34
7.	<i>Artemisia vestita</i> Wall ex. DC	1.73	18	9.45	0.516	4.62
8.	<i>Astragalus rhizanthus</i> Royle ex Benth	1.32	32	4.15	0.131	5.27
9.	<i>Bergenia stracheyi</i> (Hook.f. & Thoms.) Engl.	1.37	8	16.40	1.968	4.04
10.	<i>Bupleurum falcatum</i> Linn.	0.37	13	2.75	0.206	1.72
11.	<i>Cannabis sativa</i> L. Hemp	0.87	27	3.25	0.122	4.86
12.	<i>Capparis spinosa</i> Linn.	0.42	18	2.27	0.124	2.11
13.	<i>Capsella bursa pastoris</i> (Linn.) Medik.	0.18	5	3.66	0.733	0.64
14.	<i>Chenopodium album</i> Linn.	0.95	37	2.59	0.071	5.84
15.	<i>Chenopodium ambrosioides</i> Linn.	0.13	13	1.00	0.075	1.32
16.	<i>Chenopodium botrys</i> Linn.	0.27	8	3.20	0.384	1.56
17.	<i>Chenopodium foliosum</i> (Moench) Asch	0.23	13	1.75	0.131	1.58
18.	<i>Cicer microphyllum</i> Benth	0.18	13	1.37	0.103	1.25
19.	<i>Cirsium wallichii</i> DC	1.13	42	2.72	0.065	20.55
20.	<i>Clematis orientalis</i> Linn.	0.37	13	2.75	0.206	1.79
21.	<i>Convolvulus arvensis</i> Linn	0.27	13	2.00	0.150	1.34
22.	<i>Conyza japonica</i> (Thunb.) Less ex DC.	1.00	18	5.45	0.298	2.97
23.	<i>Conyza stricta</i> Willd.	0.27	8	3.20	0.384	1.06
24.	<i>Cousinia thamsonii</i> C.B.Clarke	0.23	8	2.80	0.336	1.55
25.	<i>Cynoglossum micranthum</i> Desf.	0.58	27	2.18	0.082	4.42
26.	<i>Datisca cannabina</i> Linn.	1.13	13	8.50	0.638	6.63
27.	<i>Datura stramonium</i> Linn.	0.18	13	1.37	0.103	1.85
28.	<i>Echinops cornigerus</i> DC	0.37	18	2.00	0.109	2.02
29.	<i>Ephedra gerardiana</i> Wall ex Stapf	7.13	50	14.26	0.285	28.96
30.	<i>Epilobium laxum</i> Royle	1.13	18	6.18	0.337	3.38
31.	<i>Epilobium royleanum</i> Hausskn	0.32	13	2.37	0.178	1.53
32.	<i>Equisetum arvense</i> Linn.	0.45	13	3.37	0.253	1.64
33.	<i>Erigeron alpinus</i> Linn	0.27	13	2.00	0.150	1.36
34.	<i>Fagopyrum dibotrys</i> (D. Don) Hara	0.27	13	2.00	0.150	1.36
35.	<i>Galinsoga parviflora</i> Cav	1.00	13	7.50	0.563	2.73
36.	<i>Galium asperuloides</i> Edgew	1.13	18	6.18	0.337	3.17
37.	<i>Geranium pratense</i> Linn	0.32	13	2.37	0.178	1.42
38.	<i>Heracleum candicans</i> Wall ex DC	0.50	32	1.57	0.050	6.73
39.	<i>Hippophae rhamnoides</i> Linn	0.13	8	1.60	0.192	0.86
40.	<i>Hyoscyamus niger</i> Linn	1.45	23	6.21	0.266	4.72
41.	<i>Impatiens glandulifera</i> Royle	0.23	8	2.80	0.336	1.24
42.	<i>Lactuca dissecta</i> D. Don	0.23	13	1.75	0.131	1.29
43.	<i>Lotus corniculatus</i> Linn	1.27	13	9.50	0.713	3.09
44.	<i>Malva rotundifolia</i> Linn	0.77	27	2.87	0.108	3.80
45.	<i>Medicago falcata</i> Linn	0.87	23	3.71	0.159	3.22
46.	<i>Melilotus alba</i> Medik. ex Desr.	0.45	13	3.37	0.253	1.66

47.	<i>Mentha longifolia</i> (L.) Hudson	2.50	45	5.55	0.123	8.27
48.	<i>Nepeta erecta</i> Royle ex Benth	0.37	13	2.75	0.206	1.72
49.	<i>Oplismenus compositus</i> Linn. Beauv.	0.92	18	5.00	0.273	2.83
50.	<i>Origanum vulgare</i> Linn	1.00	23	4.28	0.184	4.04
51.	<i>Orobanche alba</i> Stephen ex Willd	0.23	8	2.80	0.336	1.03
52.	<i>Oxalis corniculata</i> Linn	0.87	18	4.72	0.258	2.56
53.	<i>Oxytropis lapponica</i> (Wahlenb.) Gay	0.42	13	3.12	0.234	1.67
54.	<i>Polygonum capitata</i> Buch.Ham. ex D. Don	0.42	13	3.12	0.234	1.57
55.	<i>Pinus gerardiana</i> ** Wall ex Lambert	0.18	13	1.37	0.103	1.25
56.	<i>Plantago lanceolata</i> Linn	1.63	27	6.12	0.230	4.84
57.	<i>Plantago tibetica</i> Hook. f. &Thoms	0.18	5	3.66	0.733	0.66
58.	<i>Polygonum nepalense</i> Meissner	0.45	18	2.45	0.134	5.30
59.	<i>Polygonum paronychioides</i> C.Meyer. ex. Hohen	2.37	23	10.14	0.435	16.69
60.	<i>Polygonum polystachya</i> Wall ex Meissner	0.95	13	7.12	0.534	4.31
61.	<i>Populus ciliata</i> ** Wall.	0.18	13	1.37	0.103	1.95
62.	<i>Potentilla argrophylla</i> Wall ex Lehm	0.23	8	2.80	0.336	0.95
63.	<i>Prangos pabularia</i> Lindley	0.23	13	1.75	0.131	1.34
64.	<i>Rheum webbianum</i> Royle	0.18	5	3.66	0.733	1.01
65.	<i>Rorippa nasturtium aquaticum</i> (L.) Hayek.	0.82	8	9.80	1.176	2.27
66.	<i>Rosa webbiana</i> ** Wall ex Royle	0.13	8	1.60	0.192	1.24
67.	<i>Rumex hastatus</i> D. Don	0.87	13	6.50	0.488	2.65
68.	<i>Rumex nepalensis</i> Sprengel	2.58	50	5.16	0.103	14.94
69.	<i>Salvia nubicola</i> Wall ex Sweet	0.92	13	6.87	0.516	3.38
70.	<i>Scorzonera virgata</i> DC	0.42	13	3.12	0.234	1.61
71.	<i>Scutellaria prostrata</i> Jacq ex Benth.	0.27	13	2.00	0.150	1.36
72.	<i>Senecio chrysanthemoides</i> DC	1.13	23	4.85	0.208	3.46
73.	<i>Silene gonosperma</i> (Rupr) Bocquet	0.68	18	3.72	0.203	2.62
74.	<i>Sisymbrium brassiforme</i> Linn.	0.18	5	3.66	0.733	0.64
75.	<i>Solanum nigrum</i> Linn	0.18	13	1.37	0.103	1.19
76.	<i>Sorbaria tomentosa</i> ** (Lindl.) Rehder	0.37	13	2.75	0.206	2.22
77.	<i>Stellaria media</i> Linn.	0.55	13	4.12	0.309	1.89
78.	<i>Tagetes minuta</i> Linn	0.68	18	3.72	0.203	2.46
79.	<i>Taraxacum officinale</i> Wigg.	0.45	23	1.92	0.083	2.40
80.	<i>Thalictrum elegans</i> Wall. ex Royle	0.58	18	3.18	0.174	2.35
81.	<i>Thalictrum foliolosum</i> Linn.	0.42	23	1.78	0.077	2.31
82.	<i>Urtica dioica</i> Linn.	1.58	27	5.93	0.223	5.11
83.	<i>Verbascum thapsus</i> Linn.	0.37	27	1.37	0.052	4.94

**Regeneration

Table 4: Distribution of shrub species in Ropa- Giavung area of district Kinnaur at 3500-4000 m elevation.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Abelia triflora</i> R.Br. ex Wall.	3056	25	11.00	0.440	12.33
2.	<i>Betula utilis</i> * D. Don.	639	18	3.29	0.188	6.60
3.	<i>Colutea nepalensis</i> Sims	2778	25	10.00	0.400	11.32
4.	<i>Cotoneaster bacillaris</i> Wall ex Lindley	3250	33	9.00	0.277	17.07
5.	<i>Juniperus communis</i> Linn.	3694	25	13.30	0.532	20.24
6.	<i>Juniperus indica</i> Bertol	10639	43	22.53	0.530	60.50
7.	<i>Juniperus polycarpus</i> * C. Koch	6583	58	10.30	0.179	40.97
8.	<i>Lonicera orientalis</i> Lamk.	1111	25	4.00	0.160	7.96
9.	<i>Lonicera myrtillus</i> Hook. f. & Thoms.	917	25	3.30	0.132	7.85
10.	<i>Lonicera quinquelocularis</i> Hardw.	3250	25	11.70	0.468	12.88
11.	<i>Myricaria germanica</i> (L.) Desv.	2306	18	11.86	0.678	9.29
12.	<i>Ribes orientale</i> Desf.	2972	33	8.23	0.253	13.29
13.	<i>Rosa webbiana</i> Wall ex Royle	9250	83	10.09	0.122	50.40
14.	<i>Salix alba</i> Linn.	2028	33	5.62	0.173	12.89
15.	<i>Salix denticulata</i> Andersson	2778	25	10.00	0.400	16.33

*Sapling

Table 5: Distribution of herb species in Ropa -Giavung area of district Kinnaur at 3500-4000 m elevation.

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Allium carolinianum</i> DC	0.41	18	2.27	0.124	2.52
2.	<i>Anaphalis triplinervis</i> (Sims) C.B. Clarke	2.23	47	4.78	0.103	8.69
3.	<i>Anemone rivularis</i> Buch. Ham ex DC	2.76	35	7.90	0.226	9.54
4.	<i>Arenaria festucoides</i> Benth	4.11	47	8.82	0.189	12.31
5.	<i>Artemisia brevifolia</i> Wall	8.41	53	15.78	0.296	25.55
6.	<i>Artemisia dracunculus</i> L.Tarragon	0.81	18	4.45	0.243	3.43
7.	<i>Astragalus rhizanthus</i> Royle ex Benth	0.88	35	2.52	0.072	5.24
8.	<i>Bergenia stracheyi</i> (Hook. f. Thoms) Engl.	5.58	42	13.40	0.322	21.24
9.	<i>Bistorta affinis</i> (D. Don) Greene	4.00	42	9.60	0.230	11.06
10.	<i>Caltha palustris</i> Linn.	1.11	23	4.78	0.205	3.78
11.	<i>Chenopodium ambrosioides</i> Linn.	0.30	18	1.63	0.089	2.37
12.	<i>Cirsium wallichii</i> DC	1.65	47	3.53	0.076	10.44
13.	<i>Conyza japonica</i> (Thunb.) Less ex DC	0.53	18	2.90	0.159	2.62
14.	<i>Cousinia thomsonii</i> C.B.Clarke	0.30	18	1.63	0.089	2.88
15.	<i>Cuscuta reflexa</i> Roxb.	1.06	23	4.57	0.196	3.53
16.	<i>Cynoglossum micranthum</i> Desf.	0.35	23	1.50	0.064	2.52
17.	<i>Dianthus angulatus</i> Royle	1.23	23	5.28	0.227	4.09
18.	<i>Echinops cornigerus</i> DC	0.11	12	1.00	0.086	1.17
19.	<i>Ephedra gerardiana</i> Wall ex Stapf.	1.65	23	7.07	0.303	10.32
20.	<i>Epilobium latifolium</i> Linn.	0.88	23	3.78	0.162	3.66
21.	<i>Eremurus himalaicus</i> Baker	0.53	23	2.28	0.098	2.80
22.	<i>Galium acutum</i> Edgew	2.23	23	9.57	0.410	6.91
23.	<i>Geranium wallichianum</i> D. Don ex Sweet	0.93	30	3.11	0.104	3.96
24.	<i>Hyoscyamus niger</i> Linn	4.41	35	12.61	0.361	21.56
25.	<i>Impatiens glandulifera</i> Royle	0.65	18	3.54	0.193	3.56
26.	<i>Malva rotundifolia</i> Linn	0.41	23	1.78	0.077	2.74

27.	<i>Medicago falcata</i> Linn	0.58	18	3.18	0.174	2.52
28.	<i>Mentha longifolia</i> (L.) Hudson	1.35	30	4.50	0.150	5.31
29.	<i>Nepeta glutinosa</i> Benth	0.76	18	4.18	0.228	2.77
30.	<i>Oxyria dignya</i> (L.) Hill	3.18	35	9.09	0.260	7.67
31.	<i>Plantago tibetica</i> Hook. f. & Thoms.	0.65	23	2.78	0.119	2.97
32.	<i>Plantago lanceolata</i> Linn	0.35	18	1.90	0.104	2.05
33.	<i>Potentilla parviflora</i> Desf.	1.58	30	5.27	0.176	7.15
34.	<i>Rheum webbianum</i> Royle	1.76	35	5.04	0.144	8.85
35.	<i>Rhodiola heterodonta</i> (Hook.f. Thoms) Boriss	1.46	23	6.28	0.269	4.67
36.	<i>Rumex nepalensis</i> Sprengel	1.00	30	3.33	0.111	6.89
37.	<i>Salvia nubicola</i> Wall ex Sweet	0.46	18	2.54	0.139	2.27
38.	<i>Saussurea albescens</i> (DC) Sch. Bip	0.53	30	1.77	0.059	3.18
39.	<i>Sibbaldia parviflora</i> Edgew	3.06	47	6.57	0.141	9.45
40.	<i>Stellaria media</i> Linn.	2.65	58	4.54	0.078	9.19
41.	<i>Tanacetum tibeticum</i> Hook. f. Thoms ex C.B. Clarke	0.93	23	4.00	0.171	3.20
42.	<i>Thermopsis barbata</i> Royle	0.65	18	3.54	0.193	2.37
43.	<i>Thalictrum foliolosum</i> DC.	0.35	23	1.50	0.064	2.94
44.	<i>Thymus linearis</i> Benth ex Benth	4.06	47	8.71	0.187	14.21
45.	<i>Urtica dioica</i> Linn.	1.46	18	8.00	0.436	11.30
46.	<i>Verbascum thapsus</i> Linn	0.30	23	1.28	0.055	2.54

Table 6: Distribution of herb species in Ropa-Giavung area of district Kinnaur at 4000-4500 m elevation.

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Aconitum ferox</i> Wall ex Seringe	0.18	5	3.66	0.733	1.44
2.	<i>Allium carolinianum</i> DC	0.21	12	1.85	0.159	2.68
3.	<i>Anaphalis triplinervis</i> (Sims) C.B. Clarke	1.38	15	9.22	0.615	8.13
4.	<i>Androsace mucronifolia</i> Watt.	1.25	12	10.71	0.918	6.40
5.	<i>Androsace sarmentosa</i> Wall	0.88	12	7.57	0.649	5.21
6.	<i>Anemone obtusiloba</i> D. Don	0.18	7	2.75	0.413	1.68
7.	<i>Anemone rivularis</i> Buch-Ham ex DC	0.18	7	2.75	0.413	1.63
8.	<i>Arenaria festucoides</i> Benth	6.91	40	17.29	0.432	29.67
9.	<i>Arenaria griffithii</i> Boiss	2.11	18	11.54	0.630	9.15
10.	<i>Bergenia stracheyi</i> (Hook. f. & Thoms.) Engl.	6.78	67	10.17	0.153	35.20
11.	<i>Bistorta affinis</i> (D. Don) Greene	7.98	68	11.68	0.171	35.27
12.	<i>Chenopodium album</i> Linn	0.61	8	7.40	0.888	5.12
13.	<i>Cirsium wallichii</i> DC	0.08	7	1.25	0.188	1.73
14.	<i>Conyza japonica</i> (Thunb.) Less ex DC	0.40	7	6.00	0.900	2.02
15.	<i>Corydalis govaniana</i> Wall	0.15	7	2.25	0.338	1.31
16.	<i>Euphorbia stracheyi</i> Boiss	0.48	7	7.25	1.088	2.17
17.	<i>Fragaria vesca</i> Linn	0.13	8	1.60	0.192	1.45
18.	<i>Galium acutum</i> Edgew	1.00	8	12.00	1.440	3.71
19.	<i>Gentiana tubiflora</i> (G. Don.) Griseb	0.21	7	3.25	0.488	1.58
20.	<i>Gentianella moorcroftiana</i> (Wall ex G.Don.) Airy Shaw.	0.28	8	3.40	0.408	1.84
21.	<i>Geranium pratense</i> Linn	0.71	15	4.77	0.319	3.71
22.	<i>Geranium wallichinum</i> D. Don ex Sweet	1.65	28	5.82	0.206	8.15
23.	<i>Hyssopus officinalis</i> Linn.	0.38	7	5.75	0.863	3.22
24.	<i>Lactuca macrorhiza</i> C.B. Clarke	0.35	8	4.20	0.504	1.97
25.	<i>Lomatogonium carinthiacum</i> (Wulfen) Reichb	0.41	8	5.00	0.600	2.28

26.	<i>Nepeta glutinosa</i> Benth	0.61	13	4.62	0.347	3.63
27.	<i>Pleurospermum candollei</i> (DC.) C.B. Clarke	0.11	12	1.00	0.086	1.81
28.	<i>Potentilla cuneata</i> Wall. ex Lehm.	0.55	12	4.71	0.404	4.14
29.	<i>Potentilla parviflora</i> Desf.	5.58	75	7.44	0.099	31.58
30.	<i>Primula denticulata</i> Smith	1.00	13	7.50	0.563	4.82
31.	<i>Ranunculus laetus</i> Wall ex D. Don	0.21	8	2.60	0.312	2.04
32.	<i>Rheum moorcroftianum</i> Royle	0.75	25	3.00	0.120	9.26
33.	<i>Rheum webbianum</i> Royle	0.06	7	1.00	0.150	1.35
34.	<i>Rhodiola heterodonta</i> (Hook. f. & Thoms) Boriss	0.35	12	3.00	0.257	2.52
35.	<i>Saussurea roylea</i> (DC.) Sch. Bip.	0.88	18	4.81	0.263	4.93
36.	<i>Sedum ewersii</i> Ledeb	2.11	27	7.93	0.298	9.79
37.	<i>Sibbaldia parviflora</i> Edgew	2.75	35	7.85	0.224	12.00
38.	<i>Silene gonosperma</i> (Rupr.) Bocquet	0.40	12	3.42	0.294	2.66
39.	<i>Silene viscosa</i> (L.) Pers.	0.28	8	3.40	0.408	1.82
40.	<i>Stellaria media</i> Linn.	3.91	73	5.34	0.073	24.83
41.	<i>Tanacetum tibeticum</i> Hook. f. Thoms ex C.B. Clarke	0.13	8	1.60	0.192	1.80
42.	<i>Taraxacum officinale</i> Wigg.	0.41	13	3.12	0.234	2.78
43.	<i>Thylacospermum caespitosum</i> (Camb.) Sch.	0.11	7	1.75	0.263	1.36

Table 7: Distribution of herb species in Ropa-Giavung area of district Kinnaur at 4500-5000m elevation.

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Aconitum ferox</i> Wall ex Seringe	0.38	18	2.09	0.114	3.31
2.	<i>Anaphalis triplinervis</i> (Sims) C.B. Clarke	2.06	38	5.39	0.141	11.53
3.	<i>Anaphalis contorta</i> (D. Don) Hook. f.	2.18	43	5.03	0.116	11.64
4.	<i>Androsace mucronifolia</i> Watt.	3.13	38	8.17	0.213	13.21
5.	<i>Androsace sarmentosa</i> Wall	7.43	63	11.73	0.185	25.42
6.	<i>Anemone obtusiloba</i> D. Don	0.43	18	2.36	0.129	3.39
7.	<i>Arenaria festucoides</i> Benth	3.43	38	8.95	0.234	12.30
8.	<i>Aster flaccidus</i> Bunge	0.31	18	1.72	0.094	2.71
9.	<i>Bergenia stracheyi</i> (Hook. f. Thoms) Engl.	1.88	25	7.53	0.301	11.62
10.	<i>Bistorta affinis</i> (D. Don.) Greene	8.43	50	16.86	0.337	26.99
11.	<i>Delphinium brunonianum</i> Royle	0.50	18	2.72	0.149	3.90
12.	<i>Draba alpina</i> Linn.	0.38	18	2.09	0.114	2.92
13.	<i>Epilobium latifolium</i> Linn	0.43	18	2.36	0.129	3.21
14.	<i>Geranium wallichianum</i> D. Don ex Sweet	0.50	25	2.00	0.080	4.02
15.	<i>Gnaphalium thomsonii</i> Hook. f.	1.50	32	4.73	0.150	6.85
16.	<i>Oxyria digyna</i> (L.) Hill	0.56	13	4.25	0.319	2.88
17.	<i>Pleurospermum brunonis</i> (DC.) Benth ex Clarke	0.31	18	1.72	0.094	3.15
18.	<i>Potentilla argyrophylla</i> Wall ex Lehm.	9.00	100	9.00	0.090	53.39
19.	<i>Primula denticulata</i> Smith	0.50	13	3.75	0.281	3.09
20.	<i>Ranunculus laetus</i> Wall ex D. Don	0.75	18	4.09	0.223	5.56
21.	<i>Rheum moorcroftianum</i> Royle	0.31	18	1.72	0.094	3.62
22.	<i>Saussurea graminifolia</i> Wall ex DC.	0.25	18	1.36	0.074	2.64
23.	<i>Saussurea obvallata</i> (DC) Edgew	0.43	18	2.36	0.129	5.40
24.	<i>Saussurea roylea</i> (DC.) Sch. Bip.	1.00	25	4.00	0.160	5.26
25.	<i>Sedum ewersii</i> Ledeb	1.75	32	5.52	0.175	8.99
26.	<i>Selinum tenuifolium</i> Wall ex C.B. Clarke	0.25	18	1.36	0.074	2.74
27.	<i>Sibbaldia parviflora</i> Edgew	7.18	50	14.36	0.287	26.67
28.	<i>Stellaria media</i> Linn.	1.63	32	5.15	0.163	7.25
29.	<i>Thylacospermum caespitosum</i> (Camb) Sch.	0.56	32	1.78	0.057	5.20
30.	<i>Thymus linearis</i> Benth. ex. Benth	3.56	25	14.26	0.571	20.99

The value of concentration of dominance (*C*), index of diversity (*H*), richness index (*R*) and evenness index (*E*) for trees, shrubs and herbs at different altitudes was given in Table 8. The higher the value of concentration of dominance, the greater is the homogenous nature of the community and vice-versa. The diversity indices and

richness index was more in lower elevation indicating higher diversity of the species. The evenness index was comparatively more in lower altitudinal ranges than higher altitudinal ranges indicating that species are evenly distributed in lower elevations.

Table 8: Concentration of dominance (C), diversity index (H), richness index (R) and evenness index (E) for trees, shrubs and herbs at different elevations in Ropa-Giavung area of district Kinnaur.

Altitude	Plant Category	Concentration of Dominance (C)	Diversity Index (H)	Richness Index (R)	Evenness Index (E)
3000-3500 m	Tree	0.167	2.019	2.13	0.81
	Shrub	0.165	2.650	2.63	0.89
	Herb	0.030	3.970	9.85	0.90
3500-4000 m	Shrub	0.109	2.440	1.84	0.90
	Herb	0.036	3.540	5.35	0.93
4000-4500 m	Herb	0.065	3.160	5.18	0.84
4500-5000 m	Herb	0.073	2.980	3.54	0.88

Table 9: Index of similarity and dissimilarity for herb species at different altitudes in Ropa-Giavung area of district Kinnaur.

Altitudes	3500-4000 m	4000-4500 m	4500-5000 m
3000-3500 m	0.40 (0.60)	0.16(0.84)	0.07(0.93)
3500-4000 m	-	0.38(0.62)	0.23(0.77)
4000-4500 m	-	-	0.46(0.54)

Note: Values in parenthesis are index of dissimilarity.

Index of similarity and dissimilarity for shrubs between 3000-3500 m and 3500-4000 m, was 0.57 and 0.43 respectively. This indicating more similarity of species between these elevations. Index of similarity for herb species between different altitudes was low as given in Table-9. This indicating more dissimilarity of species between different altitudes.

PLANTS OF MEDICINAL VALUE

The important plants of medicinal value found in the Ropa-Giavung valley of cold desert area in Kinnaur district were compiled following Chopra *et al.* (1956), Kirtikar and Basu (1987) and Kala (2002). These include, *Aconitum ferox*, *Androsace mucronifolia*, *Artemisia brevifolia*, *Artemisia gmelinii*, *Aster flaccidus*, *Bergenia stracheyi*, *Betula utilis*, *Bupleurum falcatum*, *Cassiope fastigiata*, *Caltha palustris*, *Corydalis gowaniana*, *Cousinia thomsonii*, *Cynoglossum micranthum*, *Dactylorhiza hatagirea*, *Datisca cannabina*, *Delphinium brunonianum*, *Ephedra gerardiana*, *Echinops cornigerus*, *Erigeron alpinus*, *Fragaria vesca*, *Galium aparine*, *Gentianella moorcroftiana*, *Geranium wallichianum*, *Heracleum candicans*, *Hippophae rhamnoides*, *Hyoscyamus niger*, *Hyssopus officinalis*, *Jasminum humile*, *Juniperus communis*, *Juniperus polycarpus*, *Meconopsis aculeata*, *Mentha longifolia*, *Micromeria biflora*, *Origanum vulgare*, *Oxyria digyna*, *Pleurospermum candollei*, *Polygonatum verticillatum*, *Primula denticulata*, *Ranunculus hirtellus*, *Rheum*

webbianum, *Rhodiola heterodonta*, *Rosa webbiana*, *Rumex nepalensis*, *Salvia nubicola*, *Saussurea obvallata*, *Sedum ewersii*, *Selinum tenuifolium*, *Solanum nigrum*, *Tanacetum longifolium*, *Taraxacum officinale*, *Thalictrum foliolosum*, *Thymus linearis*, *Trifolium pretense*, *Urtica dioica* and *Verbascum Thapsus*.

THREATENED PLANTS

Out of 60 medicinal plant species recorded from the area, 14 species *i.e.* *Bergenia stracheyi*, *Betula utilis*, *Dactylorhiza hatagirea*, *Datisca cannabina*, *Ephedra gerardiana*, *Hippophae rhamnoides*, *Hyssopus officinalis*, *Hyoscyamus niger*, *Juniperus polycarpus*, *Meconopsis aculeata*, *Polygonatum verticillatum*, *Rheum webbiana*, *Rhodiola heterodonta*, *Saussurea obvallata* fall in the category of threatened plants. The habitat of most of the plant species have shrunk due to expansion of human population and environmental degradation primarily due to heavy live stock grazing, uncontrolled and unscientific harvest of species, unregulated tourism and construction of roads etc. The better conservation of natural resources can be done by inclusion of a section on the plant conservation especially of rare and endangered medicinal plants in the wild life protection act, promotion of community based conservation, in-situ conservation through the establishment of nature reserves, ex-situ conservation through tissue culture, developing cultivation technologies and nurseries of medicinal plants and conducting of regular

training on the procedure of medicinal plants collection, processing among the local people, traders and real stake holders.

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