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Status of Plant Diversity along Altitudinal Gradients in Murti Panag Valley of Rakchham-Chitkul Wildlife Sanctaury in District Kinnaur Himachal Pradesh

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Abstract

A study was conducted to assess the plant diversity in different elevations varying from 3,300 to 4,500 m above msl in Murti Panag Valley of Rakchham- Chitkul Wildlife Sanctaury in district Kinnaur. Himachal Pradesh during 2008. The total number of plant species in this valley was 131 belonging to 46 families and 91 genera. The dominant families were Asteraceae, Rosaceae, Ploygonaceae, Lamiaceae and Ranunculaceae. The number of tree species was six and three with the dominance of *Populus ciliata* and *Juniperus polycarpos* at 3,300-3,700 m and 3,700—4100 m elevation respectively. The number of shrub species was 13, 14 and nine at the elevation of 3,300—3,700 m, 3,700—4,100 m and 4,100—4,500 m respectively. *Berberis jaeschkeana* was dominant shrub at 3,300—3,700 m and 3,700—4,100 m, whereas Juniperus indica was dominant at 4,100—4,500 m clevation. The number of herb species was 73, 54 and 54 with the dominance of *Sibbaldea cuneata. Thymus linearis* and *Heracleum lanatum* at 3,300—3,700m, 3,700—4,100 m and 4,100—4,500 m elevation ranges respectively. The distribution pattern of species was mostly contiguous in all the altitudinal ranges. Index of diversity for herb was 4.02, 3.78 and 3.67 for 3,300—3,700 m, 3,700—4,100 m and 4,100—4,500 m elevation respectively. Out of 45 medicinal plant species as recorded from the area, eight species fall in the category of threatened plants.

Key words : Plant diversity, Dominance, Distribution pattern, Diversity index, Medicinal plant.

The variations in terms of its size, climate and altitudinal ranges Himalayas have created environments which are unique and characteristic to this region only. The diverse climate and the varied environmental conditions prevailing in the lap of Himalayas support diverse habitat and ecosystems with equally diverse life forms. Himalayas otherwise known for its rich and diverse plant wealth had shown a rapid decline in population of many plant species in recent past. Some of them have already been lost whereas many of them are in the verge of extinction. If suitable steps to conserve the Himalayan flora not taken well in time, the delay may lead to the total extinction of rare and valuable plants. The current decline in biodiversity largely through human activities is a serious threat to our ecosystem. Hence, attempts are on to preserve this biodiversity in-situ and ex-situ conservation. Rakchham-Chitkul wildlife sanctuary is one of the high altitude sanctuary established in Kinnaur district of Himachal Pradesh. This sanctuary having flora of temperate to arctic climate and inhabitants of Chitkul village have got their rights pertaining to grazing collection of timber, fuel wood, fodder, pine needles and other minor forest produce well within the sanctuary. In addition, graziers from other parts of Himachal Pradesh and Uttarakhand also get permits for grazing of their cattle inside the sanctuary. In this sanctuary, continuous removal of plant species for various uses and overgrazing by migratory and other livestock infact, have resulted in loss of biodiversity. If these naturally occurring plant resources are not conserved timely then they may soon become extinct. The assessment of plant wealth in this sanctuary may provide a key for its conservation. Keeping these aspects in view, a study was undertaken to assess the plant diversity in Murti Panag valley of Rakchham Chitkul wild life sanctuary in district Kinnaur of Himachal Pradesh.

Methods

The present study was conducted in Murti Panag valley of Rakchham Chitkul wild life sanctuary of district Kinnaur, Himachal Pradesh during 2008 at an

Table 1. Distribution of tree species in Murti Panag valley at 3,300—3,700 m elevation.

	Name of the species	Density (per/ha)	Frequency (%)	Abundance	A/F	IVI
1	*Juniperus polycarpos* C. Koch.	15.00	20.00	0.75	0.04	39.15
2	*Pinus wallichiana* A. B. Jackson	30.00	20.00	1.50	0.08	41.00
3	*Populus ciliata* Wall. ex Royle	80.00	40.00	2.00	0.05	117.92
4	*Prunus cormuta* (Wall. ex Royle) Steud.	25.00	20.00	1.25	0.06	37.01
5	*Prunus persica* (Linn.) Batsh.	25.00	20.00	1.25	0.06	32.85
6	*Salix alba* Linn.	30.00	20.00	1.50	0.08	32.08

elevation of 3,300—4,500 m. The study site was situated 31^0 20′ 58.1′′ to $31^0$21′ 32.7′′ N latitudes and 78^0 26′ 14.8′′ to 78^0 27′ 02.1′′ E longitudes. The whole area of the valley was divided into three altitudes i.e. 3,300—3,700 m, 3,700—4,100 m and 4,100-4,500 m for conducting the phyto-sociological study. Quadrats of size 10 m × 10 m, 3 m × 3 m and 1 m × 1 m laid out randomly for enumerating trees, shrubs and herbs + regeneration respectively. The seedlings were considered as herb while saplings as shrubs. The vegetation data were analyzed for density, frequency and abundance according to formulas given by Curtis and Mclntosh (1). 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 (2). The plant species diversity was calculated by using Shanon-Wiener diversity Index (H) (3).

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

Concentration of dominance (C) was measured by Simpson's Index (4)

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

Where Ni = importance value of species i and N = total importance value of all the species in both the indices.

Richness Index was estimated following Margalef (5) i.e. R = S-1/In N

Evenness Index was calculated following Hill (6) i.e. E = H/In S

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

Table 2. Distribution of shrub species in Murti Panag valley at 3,300—3,700 m elevation *Sapling.

	Name of the species	Density (per/ha)	Frequency (%)	Abundance	A/F	IVI
1	*Berberis jaeschkeana* C. K. Schneider	4916.67	42.50	10.41	0.24	99.23
2	*Cotoneaster bacillaris* Wall. ex Lindley.	277.78	7.50	3.33	0.44	5.54
3	*Cotoneaster microphyllus* Wall. ex Lindl.	1583.33	22.50	6.33	0.28	22.36
4	*Indigofera hebepetala* Benth ex Baker	361.11	7.50	4.33	0.58	5.33
5	*Juniperus communis* Linn.	1027.78	10.00	9.25	0.93	10.84
6	*Juniperus indica* Bertol	2583.33	17.50	13.29	0.76	23.38
7	*Lonicera angustifolia* Wall. ex DC.	1388.89	7.50	16.67	2.22	12.75
8	*Lonicera hypoleuca* Decne	3527.78	32.50	9.77	0.30	34.53
9	*Ribes alpestre* Wall. ex Decne	750.00	7.50	9.00	1.20	8.78
10	*Rosa webbiana* Wall. ex Royle	3055.56	40.00	6.88	0.17	38.56
11	*Salix fragilis* *Linn	1027.78	12.50	7.40	0.59	11.57
12	*Spiraea canescens* D. Don	916.67	15.00	5.50	0.37	12.74
13	*Syringa emodi* *Wall. ex Royle	1388.89	10.00	12.50	1.25	14.39

Table 3. Distribution of herb species in Murti Panag valley at 3,300-3,700 m elevation. **Regeneration.

	Name of the species	Density (m^2)	Frequency (%)	Abundance	A/F	IVI
1	*Achillea millefolium* Linn.	0.83	8.33	10.00	1.20	2.98
2	*Aconogonum alpinum* (All.) Schur.	0.83	8.33	10.00	1.20	2.51
3	*Anaphalis contorta* (D. Don) Hook. F.	0.08	8.33	1.00	0.12	1.00
4	*Anemone biflora* DC.	1.92	25.00	7.67	0.31	6.67
5	*Anemone rivularis* Buch. Ham. ex DC.	0.50	8.33	6.00	0.72	2.18
6	*Arenaria kashmirica* Edgew. ex Edgew. & Hook. f.	1.00	8.33	12.00	1.44	3.75
7	*Arisaema flavum* (Forsskal) Schott	0.25	8.33	3.00	0.36	2.05
8	*Artemisia dubia* Wall. ex Besser	1.00	8.33	12.00	1.44	3.97
9	*Astragalus candolleanus* Royl ex Benth.	0.50	8.33	6.00	0.72	3.97
10	*Astragalus chlorostachy* Lindley.	0.42	16.67	2.50	0.15	4.07
11	*Bupleurum falcatum* Linn.	0.33	8.33	4.00	0.48	1.84
12	*Bupleurum himalayensis* Klotz & Garcke	0.17	16.67	1.00	0.06	4.13
13	*Chenopodium album* Linn.	0.42	8.33	5.00	0.60	3.70
14	*Cynoglossum furcatum* Wall. ex Roxb	0.33	16.67	2.00	0.12	2.44
15	*Cirsium wallichii* DC.	0.08	8.33	1.00	0.12	1.57
16	*Conyza viscidula* Wall.	0.58	25.00	2.33	0.09	5.24
17	*Corydalis rutifolia* (Smith) DC.	0.92	8.33	11.00	1.32	3.79
18	*Cremanthodium arnicoides* (DC ex Royle) R. Good	0.67	8.33	8.00	0.96	3.41
19	*Cynoglossum wallichii* G. Don	0.17	8.33	2.00	0.24	1.57
20	*Dianthus angulatus* Royle	0.58	16.67	3.50	0.21	2.99
21	*Elsholtzia incisa* Benth.	0.67	16.67	4.00	0.24	6.25
22	*Epilobium angustifolium* Linn.	0.58	16.67	3.50	0.21	3.22
23	*Epilobium latifolium* Linn.	0.25	8.33	3.00	0.36	1.39
24	*Erigeron alpinus* Linn.	1.42	16.67	8.50	0.51	4.87
25	*Euphrasia himalayica* Wettst.	0.33	8.33	4.00	0.48	2.08
26	*Fragaria vesca* Linn.	0.33	8.33	4.00	0.48	1.53
27	*Fritillaria oxypetalum* (D. Don) Baker	0.33	8.33	4.00	0.48	1.49
28	*Galium acutum* Edgew.	2.33	33.33	7.00	0.21	8.02
29	*Gentiana argentea* (1). Don) C. B. Clarke	1.67	20.00	8.33	0.42	5.63
30	*Geranim pratense* Linn.	1.50	25.00	6.00	0.24	6.35
31	*Heracleum lanatum* Michx.	0.58	25.00	2.33	0.09	11.96
32	*Humulus lupulus* Linn.	0.17	8.33	2.00	0.24	1.52
33	*Impatiens amplexicaulis* Edgew.	0.75	16.67	4.50	0.27	3.67
34	*Iris kemaonensis* D. Don ex Royle	0.50	8.33	6.00	0.72	2.28
35	*Lactuca dissecta* D. Don	0.67	25.00	2.67	0.11	3.91
36	*Lepidium apetalum* Willd.	0.17	8.33	2.00	0.24	1.33
37	*Lonicera angustifolia* **Wall. ex DC.	0.25	8.33	3.00	0.36	1.76
38	*Malva rotundifolia* Linn.	0.33	8.33	4.00	0.48	1.77
39	*Medicago falcata* Linn.	1.67	25.00	6.67	0.27	8.77
40	*Mentha longifolia* (Linn.) Hudson	0.17	8.33	2.00	0.24	1.30
41	*Morina coulteriana* Royle	0.92	25.00	3.67	0.15	8.37
42	*Nepeta erecta* (Benth.) Benth.	0.83	25.00	3.33	0.13	4.72
43	*Nepeta floccosa* Benth.	0.83	8.33	10.00	1.20	3.52
44	*Orobanche alba* Stephen ex Willd.	0.17	8.33	2.00	0.24	1.92
45	*Oxyria digyna* (Linn.) Hill.	0.92	8.33	11.00	1.32	3.04
46	*Plantago lanceolata* Linn.	0.33	8.33	4.00	0.48	1.72
47	*Plantago tibetica* Hook. f. & Thoms.	0.33	8.33	4.00	0.48	1.72
48	*Polygonatum verticillatum* (Linn.) All.	2.50	43.33	5.77	0.13	14.77
49	*Polygonatum multiflorum* (Linn.) All.	0.83	8.33	10.00	1.20	4.33
50	*Polygonum filicaule* Wall. ex Meissner.	0.67	8.33	8.00	0.96	2.44
51	*Polygonum plebeium* R. Br.	1.58	16.67	9.50	0.57	5.32
52	*Polygonum polystachya* (Wall. ex Meissner) Gross	1.25	16.67	7.50	0.45	18.45
53	*Potentilla atrosanguinea* Lodd.	1.92	25.00	7.67	0.31	6.67
54	*Ranunculus arvensis* Linn.	0.67	16.67	4.00	0.24	3.97
55	*Rumex acetosa* Linn.	0.67	8.33	8.00	0.96	2.98

Table 3. Continued.

	Name of the species	Density (m^2)	Frequency (%)	Abundance	A/F	IVI
56	*Rumex hastatus* D. Don	0.50	8.33	6.00	0.72	1.98
57	*Salvio moorcroftiana* Wall. ex. Benth.	0.50	8.33	6.00	0.72	2.44
58	*Saussurea lappa* (Decne.) Sch. Bip.	0.17	8.33	2.00	0.24	1.87
59	*Scrophularia calycina* Benth.	0.08	8.33	1.00	0.12	1.09
60	*Sedum ewersii* Ledeb.	1.00	16.67	6.00	0.36	4.06
61	*Selinum vaginatum* C. B. Clarke (Edgew)	0.42	16.67	2.50	0.15	2.77
62	*Senecio laetus* Edgew.	0.25	16.67	1.50	0.09	2.30
63	*Sibbaldia cuneata* Hornem. ex Kuntze	2.00	16.67	12.00	0.72	20.15
64	*Silene conoidea* Linn.	1.25	33.33	3.75	0.11	6.30
65	*Sisymbrium strictum* Hook. f. & Thoms.	0.50	8.33	6.00	0.72	2.01
66	*Stellaria media* Linn.	0.42	8.33	5.00	0.60	1.77
67	*Swertia purpurascens* Wall. (D. Don.)	0.17	8.33	2.00	0.24	3.23
68	*Taraxacum officinale* Wigg.	0.17	8.33	2.00	0.24	1.29
69	*Thalictrum reniforme* Wall.	0.75	33.33	2.25	0.07	5.46
70	*Thymus linearis* Benth. ex Benth.	2.08	16.67	12.50	0.75	6.69
71	*Urtica dioica* Linn.	0.83	8.33	10.00	1.20	2.59
72	*Verbascum thapsus* Linn.	0.17	8.33	2.00	0.24	3.31
73	*Veronica biloba* Linn.	0.50	16.67	3.00	0.18	2.73

Results and Discussion

The total number of plant species in this valley was 131 belonging to 46 families and 91 genera. The dominant families were Asteraceae, Rosaceae, Ploygonaceae, Lamiaceae and Ranunculaceae. At elevation 3,300—3,700 m, the total number of herb species was six (Table 1). *Populus ciliata* was the dominant species having maximum density (80/ha) and frequency (40%). This was followed by *Pinus wallichiana, Prunus cornuta* and *Juniperus polycarpos* in term of density. The maximum value of abundance was recorded for Populus ciliata which was followed by *Pinus wallichiana, Prunus cornuta* and *Juniperus polycarpos.* On the basis of IVI, *Populus ciliata* observed maximum value (117.92) followed by *Pinus wallichiana* (41.0), *Juniperus polycarpos* (39.15) and *Prunus cornuta* (37.01). The distribution pattern of all the species except *Juniperus polycarpos* 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 (7—9).

At elevation of 3,300—3,700 m, the total number of shrub species was 13 (Table 2). *Berberis jaeschkeana* was the dominant species having maximum density (4,916.07/ha) and frequency (42.50%). This was followed by *Lonicera hypoleuca, Rosa webbiana* and *Juniperus indica* in term of density. *Lonicera augustifolia* recorded the maximum value (16.67) of abundance followed by *Juniperus indica. Syringa emodi* and *Berberis jaeschkeana.* On the basis of IVI, *Berberis jaeschkeana* recorded the highest value (99.23) followed by Rosa webbiana (38.56), *Lonicera hypoleuca* (34.53) and *Juniperus indica* (23.38). The distribution pattern of all the species was contiguous.

In herbs including regeneration, the total num-

Table 4. Distribution of tree species in Murti Panag valley at 3,700—4,100 m elevation.

	Name of the species	Density (per/ha)	Frequency (%)	Abundance	A/F	IVI
1	*Betula utilis* D. Don	60.00	35.00	1.71	0.05	97.37
2	*Juniperus polycarpos* C. Koch.	35.00	30.00	1.17	0.04	120.16
3	*Pinus wallichiana* A. B. Jackson.	40.00	25.00	1.60	0.06	82.47

Table 5. Distribution of shrub species in Murti Panag valley at 3700—4100 m elevation. *Sapling.

	Name of the species	Density (per/ha)	Frequency (%)	Abundance	A/F	IVI
1	*Berberis jaeschkeana* C. K. Schneider	7027.78	45.00	14.06	0.31	113.69
2	*Betula utilis* *D. Don	4250.00	32.50	11.77	0.36	35.58
3	*Cotoneaster microphyllus* Wall. ex Lindl.	805.56	7.50	9.67	1.29	8.53
4	*Juniprus communis* Linn.	1222.22	7.50	14.67	1.99	9.67
5	*Jumiperus indica* Bertol.	3444.44	20.00	15.50	0.78	26.14
6	*Lonicera hispida* Pallas ex Willd.	1416.67	17.50	7.29	0.42	14.34
7	*Lonicera myrtillus* Hook. f. & Thoms.	1194.44	10.00	10.75	1.08	9.96
8	*Lonicera angustifolia* Wall. ex DC.	1000.00	7.50	12.00	1.60	8.06
9	*Lonicera hypoleuca* Decne.	2027.78	10.00	18.25	1.83	14.12
10	*Lonicera quinqueocularis* Hardw.	277.78	10.00	2.50	0.25	5.59
11	*Rosa webbiana* Wall. ex Royle.	1416.67	17.50	7.29	0.42	15.67
12	*Spiraea canescens* D. Don.	1805.56	22.50	7.22	0.32	19.86
13	*Syringa emodi* *Wall. ex Royle (s).	305.56	20.00	1.38	0.07	10.35
14	*Viburnum cotinifolium* D. Don.	805.56	7.50	9.67	1.29	8.43

ber of species was 73 at elevation 3,300—3,700 m (Table 3). *Polygonatum verticillatum* was the dominant species having maximum density (2.50 m^2) and frequency (43.33%). This was followed by *Gallum acutum*, *Thymus linears* and *Sibbaldia cuneata* in term of density. The highest value of abundance was observed for *Thymus linearis* (12.50) followed by *Sibbaldia cuneata, Corydalis rutifolia* and *Nepeta floccosa.* On the basis of IVI, Sibbaldia cuneata recorded the highest value (20.15) followed by Polygonum polystachya (18.45), *Polygonatum verticillatum* (14.77) and *Heracleum lanatum* (11.96). The lowest value of IVI was observed for *Anaphalis contorta*. The distribution pattern of all the species

Table 6. Distribution of herb species in Murti Panag valley at 3,700—4,100 m elevation. **Regeneration.

	Name of the species	Density (per m^2)	Frequency (%)	Abundance	A/F	IVI
1	*Anaphalis contorta* (D. Don) Hook. f.	0.20	16.67	1.20	0.07	2.32
2	*Aquilegia pubiflora* Wall. ex Royle	0.20	6.67	3.00	0.45	1.49
3	*Arenaria kashmrica* Edgew. & Hook. f.	2.13	13.33	16.00	1.20	8.21
4	*Artemisia dubia* Wall. ex Besser	0.27	15.00	1.78	0.12	2.75
5	*Artemisia sieversiana* Willd.	0.80	6.67	12.00	1.80	4.36
6	*Astragalus candolleanus* Royle ex Benth.	0.27	6.67	4.00	0.60	2.54
7	*Astragalus rhizanthus* Royle ex Benth.	0.33	13.33	2.50	0.19	2.33
8	*Betula utilis* **D. Don	0.13	6.67	2.00	0.30	1.52
9	*Bupleurum falcatum* Linn.	0.93	40.00	2.33	0.06	7.53
10	*Chenopodium foliolsum* (Moench) Asch	0.27	13.33	2.00	0.15	2.88
11	*Cynoglossum furcatum* Wall. ex Roxb.	0.67	26.67	2.50	0.09	4.70
12	*Dianthus angulatus* Royle	0.87	26.67	3.25	0.12	5.13
13	*Epilobium angustifolium* Linn.	0.33	13.33	2.50	0.19	2.45
14	*Eragrostis viscosa* (Retz) Trin.	0.47	11.67	4.00	0.34	2.57
15	*Erigeron alpinus* Linn.	0.20	6.67	3.00	0.45	1.23
16	*Gentiana argentea* (D. Don) C. B. Clarke.	1.60	33.33	4.80	0.14	7.49
17	*Gentianella paludosa* (Hook.) Harry Smith	1.13	20.00	5.67	0.28	5.54
18	*Geranium wallichianum* D. Don ex Sweet	0.35	6.67	5.25	0.79	1.74
19	*Heracleum lanatum* Michx.	0.33	26.67	1.25	0.05	8.77
20	*Heracleum pinnatum* C. B. Clarke	0.33	13.33	2.50	0.19	7.30
21	*Impatiens urticifolia* Wall.	0.93	13.33	7.00	0.53	4.15
22	*Iris kemaonensis* D. Don ex Royle	0.67	13.33	5.00	0.38	3.58
23	*Lactuca dissecta* D. Don	0.73	20.00	3.67	0.18	3.96
24	*Medicago falcata* Linn.	2.13	26.67	8.00	0.30	11.65

Table 6. Continued.

	Name of the species	Density (per m^2)	Frequency (%)	Abundance	A/F	IVI
25	*Morina coulteriana* Royle	1.13	40.00	2.83	0.07	12.28
26	*Nepeta floccosa* Benth.	2.07	20.00	10.33	0.52	8.28
27	*Nepeta laevigata* (D. Don) Hand. Mazz.	0.93	13.33	7.00	0.53	3.82
28	*Origanum vulgare* Linn.	2.13	26.67	8.00	0.30	12.61
29	*Orobanche alba* Stephen ex Willd.	0.40	15.00	2.67	0.18	4.50
30	*Oxalis corniculata* Linn.	0.53	6.67	8.00	1.20	2.30
31	*Pedicularis pectinata* Wall. ex Benth.	0.47	20.00	2.33	0.12	3.84
32	*Picrorhiza kurrooa* Royle ex Benth.	3.25	25.00	13.00	0.52	15.03
33	*Pinus wallichiana* **A. B. jackson	0.27	6.67	4.00	0.60	2.63
34	*Plantago tibetica* Hook. f. & Thoms.	1.47	15.00	9.78	0.65	5.96
35	*Polygonatum verticillatum* (Linn.) All.	1.20	20.00	6.00	0.30	7.64
36	*Polygonum polystachya* (Wall. Ex Meissner.) Gross	0.80	11.67	6.86	0.59	12.82
37	*Potentilla atrosanguinea* Lodd.	1.47	20.00	7.33	0.37	5.70
38	*Ranunculus arvensis* Linn.	0.53	13.33	4.00	0.30	3.49
39	*Rheum australe* D. Don	0.40	26.67	1.50	0.06	9.94
40	*Rheum webbianum* Royle	0.27	13.33	2.00	0.15	5.75
41	*Rhodiola heterodonta* (Hook. f. & Thoms.) Boriss.	0.20	6.67	3.00	0.45	1.29
42	*Rumex hastatus* D. Don	0.13	6.67	2.00	0.30	1.07
43	*Scorzonera virgatus* DC.	0.20	13.33	1.50	0.11	2.16
44	*Sedum ewersii* Ledeb.	0.40	6.67	6.00	0.90	1.79
45	*Selinum tenuifolium* Wall. ex C. B. Clarke	0.60	13.33	4.50	0.34	7.30
46	*Senecio laetus* Edgew.	0.60	13.33	4.50	0.34	3.20
47	*Silene conoidea* Linn.	2.00	20.00	10.00	0.50	7.45
48	*Silene viscosa* (Linn.) Pers.	1.20	20.00	6.00	0.30	4.97
49	*Swertia paniculata* Wall.	0.80	6.67	12.00	1.80	3.53
50.	*Swertia purpurascens* Wall. (D. Don)	2.33	13.33	17.50	1.31	9.62
51	*Taraxacum officinale* Wigg.	0.40	13.33	3.00	0.23	2.71
52	*Thalictrum reniforme* Wall.	0.47	13.33	3.50	0.26	2.91
53	*Thymus linearis* Benth ex Benth.	5.07	33.33	15.20	0.46	16.96
54	*Verbascum thapsus* Linn.	0.53	33.33	1.60	0.05	12.24

was contiguous.

At elevation 3,700—4,100 m, the total number of tree species was 3 (Table 4). *Betula utilis* was the dominant species laving maximum density (60/ha) and frequency (35%). This was followed by *Pirus wallichiana* and *Juniperus polycarpos* in term of density. The maximum value of abundance was recorded for *Betula utilis* (1.71) followed by *Pinus wallichiana* and *Juniperus polycarpos.*The highest value of IVI was observed for *Juniperus polycarpos* (120.16) followed by *Betula utilis* (97.37) and *Pinus wallichiana* (82.47). The distribution pattern of *Pinus wallichiana* was contiguous while *Betula utilis* and *Juniperus polycarpos* showed random distribution.

At elevation 3,700—4,100 m, total number of shrub species was 14 (Table 5). *Berberis jaeschkeana* was the dominant species having maximum density (7, 027.78 /ha) and frequency (45%). This was followed by *Betula utilis, Juniperus indica* and *Lonicera hypoleuca* in term of density. The maximum value of abundance was recorded for *Lonicera hypoleuca* (18.25) followed by *Juniperus indica. Juniperus communis* and *Berberis jaeschkeana*. On the basis of IVI, *Berberis jaeschkeana* recorded the maximum value (113.69) followed by *Betula utili*s (35.58), *Juniperus indica* (26.14) and *Spiraea canescens* (19.86). The distribution pattern of all the species was contiguous.

At elevation 3,700—4,100 m, the total number of herb species was 54 (Table 6). Thymus linearis was the dominant species having maximum density (5.07/ m^2) followed by *Picrorhiza kurrooa, Origanum vulgare* and *Silene conoidea*. The highest frequency was recorded for *Bupleurum falcatum* (40%) followed by *Verbascum thapsus, Thymus linearis* and *Gentiana argentea. Swertia purpurascens* observed

Table 7. Distribution of shrub species in Murti Panag valley at 4,100—4,500 m elevation.

	Name of the species	Density (per/ha)	Frequency (%)	Abundance	A/F	IVI
1	*Berberis jaeschkeana* C. K. Schneider	3888.89	25.00	14.00	0.56	60.76
2	*Cotoneaster microphyllus* Wall. ex Lindl.	694.44	12.50	5.00	0.40	8.75
3	*Juniperus communis* Linn.	1416.67	12.50	10.20	0.82	10.85
4	*Juniperus indica* Bertol.	20361.11	75.00	24.43	0.33	111.97
5	*Lonicera hispida* Pallas ex Willd.	4861.11	37.50	11.67	0.31	34.20
6	*Lonicera angustifolia* Wall. ex DC.	1388.89	12.50	10.00	0.80	10.07
7	*Lonicera hypoleuca* Decne.	1388.89	25.00	5.00	0.20	14.83
8	*Rosa webbiana* Wall. ex Royle.	4027.78	50.00	7.25	0.15	38.56
9	*Spiraea canescens* D. Don	1111.11	12.50	8.00	0.64	10.02

the maximum value for abundance (17.50) followed by *Artemisia dubia. Thymus linearis* and *Artemisia sieversiana.* On the basis of IVI, *Thymus linearis* observed the highest value (16.96) followed by *Picrorrhiza kurrooa, Polygonum polystachya* and *Origanum vulgare*. The lower IVI value of 1.23 was observed for *Erigeron alpinus.* The distribution pattern of all the species was contiguous except *Heracleum lanatum* and *Verbascum thapsus*. The regeneration of *Betula utili*s and *Pinus wallichiana* was recorded.

At elevation 4,100—4,500 m, the total number of shrub species was 9 (Table 7). *Juniperus indica* was the dominant species having maximum density (20, 361.11/ha) and frequency (75%). This was followed by *Lonicera hispida, Rosa webbiana* and *Berberis jaeschkeana*. The highest value of abundance was recorded for Juniperus indica (24.43) which was followed by *Berberis jaeschkeana. Lonicera hispida* and *Juniperus communis. Juniperus indica* observed the maximum value of IVI (111.97) followed by *Berberis jaeschkeana* (60.76), *Rosa webbiana* (38.56) and *Lonicera hispida* (34.20). The lowest IVI of 8.75 was recorded for *Cotoneaster microphyllus.* The distribution pattern of all the species was contiguous.

At elevation 4,100—4,500 m, the total number of herb species was 54 (Table 8).*Thymus linearis* was the dominant species having maximum density (6.92 / m^2) and frequency (41.76%). This was followed by *Geranium wallichianum, Gentiana argentea* and *Swertia purpurascens* in term of density. The highest value of abundance was observed for *Thymus linearis* (6.92) followed by *Geranium wallichianum, Gentiana argentea* and *Swertia purpurascens.* On the basis of IVI. *Heracleum lanatum* observed the maximum value (19.30) followed by *Thymus linearis* (19.28), *Polygonum polystachya* (17.76) and *Rheum webbianum* (15.33). The lowest IVI was recorded for *Silene edgeworthii* (1.29). The distribution pattern of most of the species was random and regular.

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 9. The higher the value of concentration of dominance, the greater is the homogenous nature of the community and vice-versa (10). The lower value of dominance shows that dominance of plants is shared by many species. The diversity indices and richness index was more in lower elevation indicating higher diversity of the species. The species diversity is regulated by long term factors like community stability and evolutionary time as heterogeneity of both macro and micro environment affects the diversification among different communities. The higher values of index of diversity indicate the variability in the type of species and heterogeneity in the communities, whereas, the lesser values point to the homogeneity in the community. The evenness index was comparatively more in lower altitudinal ranges than higher altitudinal ranges indicating that species are evenly distributed in lower elevations. The nature of plant community at a place is determined by the species that grow and develop in such environment (11). The difference in the species composition from altitude to altitude is mostly due to micro environment changes (12).

Medicinal Plants

The important plants of medicinal value found in

Table 8. Distribution of herb species in Murti Panag valley at 4100—4500 m elevation.

	Name of the species	Density (per m^2)	Frequency (%)	Abundance	A/F	IVI
1	*Anaphalis contorta* (D. Don.) Hook. f.	1.27	8.33	1.27	0.15	3.32
2	*Anaphalis triplinervis* (Sims) C. B. clarke	0.82	6.67	0.82	0.12	2.44
3	*Androsace rotundifolia* Hardw.	0.33	8.33	0.33	0.04	1.97
4	*Anemone rivularis Buch.* Ham. ex DC.	0.73	6.67	0.73	0.11	2.45
5	*Arenaria kashmirica* Edgew. ex Edgew. & Hook. f.	2.73	11.67	2.73	0.23	7.74
6	*Artemisia sieversiana* Willd.	0.92	6.67	0.92	0.14	3.98
7	*Bistorta affinis* (D. Don) Greene	0.72	8.33	0.72	0.09	2.82
8	*Bupleurum falcatum* Linn.	0.63	16.67	0.63	0.04	3.57
9	*Caltha palustris* Linn.	0.70	10.00	0.70	0.07	3.06
10	*Chenopodium foliolsum* (Moench) Asch	1.37	8.33	1.37	0.16	6.53
11	*Cremanthodium arnicoides* (DC ex Royle) R. Good	1.27	23.33	1.27	0.05	6.82
12	*Cynoglossum furcatum* Wall. ex Roxb.	0.63	16.67	0.63	0.04	3.24
13	*Epilobium angustifolium* Linn.	0.18	10.00	0.18	0.02	1.59
14	*Erigeron alpinus* Linn.	0.92	33.33	0.92	0.03	5.65
15	*Euphrasia himalayica* Wettst.	0.35	8.33	0.35	0.04	2.08
16	*Fragaria vesca* Linn.	0.92	18.33	0.92	0.05	3.79
17	*Galium acutum* Edgew.	2.08	16.67	2.08	0.13	5.53
18	*Gentiana argentea* (D. Don) C. B. Clarke	2.73	18.33	2.73	0.15	6.85
19	*Gentianella paludosa* (Hook.) Harry Smith	0.37	6.67	0.37	0.06	1.50
20	*Geranium wallichianum* D. Don ex Sweet	3.08	41.67	3.08	0.07	11.73
21	*Heracleum lanatum* Michx.	1.08	41.67	1.08	0.03	19.30
22	*Heracleum pinnatum* C. B. Clarke	0.55	16.67	0.55	0.03	9.28
23	*Iris kemaonensis* D. Don ex Royle	0.45	8.33	0.45	0.05	2.07
24	*Lactuca dissecta* Don	0.55	8.33	0.55	0.07	1.99
25	*Lomatogonium carinthiacum* (Wulfen) Reichb	0.27	10.00	0.27	0.03	1.78
26	*Morina longiflolia* Wall. ex DC.	1.08	33.33	1.08	0.03	6.54
27	*Nepeta laevigata* (D. Don) Hand. Mazz.	2.18	25.00	2.18	0.09	7.20
28	*Origanum vulgare* Linn.	0.92	8.33	0.92	0.11	4.17
29	*Orobanche alba* Stephen ex Willd.	0.63	16.67	0.63	0.04	5.39
30	*Oxyria digyna* (Linn.) Hill	0.73	10.00	0.73	0.07	2.66
31	*Pedicularis longiflora* Rudolph	0.37	15.00	0.37	0.02	2.61
32	*Pedicularis pectinata* Wall ex Benth	0.55	16.67	0.55	0.03	3.43
33	*Polygonatum verticillatum* (L.) All.	2.45	16.67	2.45	0.15	10.50
34	*Polygonum polystachya* (Wall. ex Meissner) Gross	1.37	23.33	1.37	0.06	17.76
35	*Potentilla atrosanguinea* Lodd.	2.00	10.00	2.00	0.20	4.71
36	*Potentilla multifida* Linn.	1.08	8.33	1.08	0.13	2.98
37	*Primula denticulata* Smith	0.55	15.00	0.55	0.04	3.10
38	*Rheum australe* D. Don	0.18	8.33	0.18	0.02	3.42
39	*Rheum webbianum* Royle	0.80	40.00	0.80	0.02	15.33
40	*Rhodiola heterodonta* (Hook. f. & Thoms.) Boriss.	0.72	10.00	0.72	0.07	2.69
41	*Rumex hastatus* D. Don	0.45	10.00	0.45	0.05	2.05
42	*Salix fragilis* **Linn	0.27	8.33	0.27	0.03	1.90
43	*Saussurea roylei* (DC.) Sch. Bip.	0.92	6.67	0.92	0.14	4.50
44	*Sedum ewersii* Ledeb.	1.07	16.67	1.07	0.06	4.12
45	*Sclinum tenuifolium* Wall. ex C. B. Clarke	1.35	6.67	1.35	0.20	10.81
46	*Selinum vaginatum* C. B. Clarke	0.20	8.33	0.20	0.02	2.49
47	*Senecio laetus* Edgew	1.05	16.67	1.05	0.06	4.28
48	*Sibbaldia cuneata* Hornem. ex Kuntze	0.33	8.33	0.33	0.04	1.70
49	*Silene conoidea* Linn.	1.00	25.00	1.00	0.04	4.96
50	*Silene edgeworthii* Bocquet	0.25	6.67	0.25	0.04	1.29
51	*Swertia paniculata* Wall.	1.73	16.67	1.73	0.10	7.69
52	*Swertia purpurascens* Wall.	2.35	25.00	2.35	0.09	9.27
53	*Thermopsis barbata* Royle	2.73	33.33	2.73	0.08	12.07
54	*Thymus linearis* Benth. ex Benth.	6.92	41.67	6.92	0.17	19.28

Table 9. Concentration of dominance (C), diversity index (H), richness index (R) and evenness index (E) for trees, shrubs and herbs at different elevations in Murti Panag valley.

Altitude (m)	Plant category	Concentration of dominance (C)	Index of diversity (H)	Richness Index (R)	Evenness Index (E)
3300—3700	Tree	0.23	1.64	1.35	0.92
	Shrub	0.16	2.18	1.78	0.85
	Herb	0.02	4.02	8.94	0.94
3700—4100	Tree	0.34	1.08	0.61	0.99
	Shrub	0.18	2.17	1.89	0.83
	Herb	0.03	3.78	6.65	0.95
1100—4500	Shrub	0.23	1.64	1.10	0.75
	Herb	0.04	3.67	6.45	0.92

the Murti Panag valley of Rakchham Chitkul wild life sanctuary in Kinnaur district were compiled following Chopra et al. (13), Kirtikar and Basu (14) and Kala (15). These include : *Achillea millefolium, Anaphalis contorta, Anemone rivularis, Arisaema flavum, Artimisia brevifolia, Betula utilis, Bupleurum falcatum, Caltha palustris, Cassiope fastigiata, Chenopodium album, Chenopodium foliosum, Cynoglossum wallichi, Epilobium angustifolium, Geranium pratense, Geranium wallichianum, Heracleum lanatum, Heracleum pinnatum, Juniperus polycarpos, Malva rotundifolia, Medicago falcata, Origanum vulgare, Oxyria digyna, Pedicularis pectinata, Picrorhiza kurrooa, Plantago lanceolata, Plantago tebetica, Polygonatum multiflorum, Polygonatum verticillatum, Ranunculus arvensis, Rheum australe, Rheum webbianum, Rhodiola heterodonta, Rumex hastatus. Salvia moorcroftiana, Saussurea lappa, Selium tenuifolium, Selium vaginatum Swertia paniculata, Swertia purpurascens, Taraxacum officinale. Thalictrum reniforme,Thymus linearis, Urtica dioica, Verbascum Thapsus.*

Threatened Plants

Out of 45 medicinal plant species recorded from the area, eight species i.e. *Betula utilis, Picrorhiza kurrooa. Rheum australe, Heracleum lanatum, Polygonatum multiflorum, Polygonatum verticillatum, Rheum webbianum, Rhodiola heterodonta* fall in the category of threatened plants when compared with the available literature like Red Data Book and CAMP Reports. 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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