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Phyto-Diversity Studies in Kanasa Valley of Rakchham Chitkul Wild life Sanctuary of District Kinnaur, Himachal Pradesh

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ABSTRACT: A study was carried out in Kanasa valley of Rakchham Chitkul wild life sanctuary of district Kinnaur, Himachal Pradesh to understand the phytodiversity along the altitudinal gradients with elevations varying in between 3000m to 3800m above msl during 2009-2010. Analysis of the data revealed that the composition of vegetation in Kanasa valley of the sanctuary showed the presence of total number of 130 plant species belonging to 43 families and 94 genera. The dominant families recorded were Rosaceae, Asteraceae, Ranunculaceae, Ploygonaceae and Lamiaceae. The maximum number of tree species recorded along the altitudinal gradient was 8 with the dominance of *Pinus wallichiana* at 3000m-3400m and *Abies pindrow* at 3400m-3800m respectively. The number of shrub species recorded were 17 and 16 in the elevation of 3000m-3400m and 3400-3800m having dominance of *Rhododendron campanulatum* at both the elevations. The number of herbs species recorded were 77 and 73 with the dominance of *Nepeta laevigata* at 3000m-3400m and *Anaphalis contorta* at 3400m-3800m elevations. The distribution pattern of species was mostly contiguous in the both the altitudinal ranges. Index of diversity for herb was 3.91 and 3.72 for 3000m-3400m and 3400m-3800m elevations respectively. Out of 52 medicinal plant species recorded from the area, 10 species viz; *Aconitum heterophyllum, Saussurea obvallata, Betula utilis, Meconopsis aculeata, Picrorhiza kurrooa, Taxus wallichiana, Aconitum violaceum, Heracleum lanatum, Polygonatum verticillatum, Rheum webbianum, Rhodiola heterodonta* and *Rhododendron anthopogon* fall in the category of threatened plants. Keeping in view the diversity and the threat status of the species, conservation of natural resources through promotion of community based *in-situ* conservation has been stressed upon. *Ex-situ* conservation through tissue culture, development of suitable agro-techniques and conducting regular trainings on the procedure of medicinal plants collection, their processing amongst the end users have also been advocated.

Key Words: Altitude, dominance, diversity index, distribution, threatened plant.

INTRODUCTION

The diverse climate and the varied environmental conditions prevailing in the lap of Himalayas support diverse habitat and ecosystems with equally diverse life forms. Variations in terms of its size, climate and altitudinal ranges, have created environments those are unique and characteristic to this region only. Himalayas 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. 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-site and ex-situ conservation. Rakchham-Chitkul wildlife sanctuary is one of the high altitude sanctuary established in 1962 in Kinnaur district of Himachal Pradesh. 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 know the phytosociology in Kanasa valley of Rakchham Chitkul wild life sanctuary in district Kinnaur of Himachal Pradesh.

MATERIALS AND METHODS

The present study was conducted in Kanasa valley of Rakchham Chitkul wild life sanctuary in district Kinnaur of Himachal Pradesh during 2009-2010 at an elevation of 3000-3800m. The study site was situated 31° 22.0' 54.2" to 31° 22.0' 51.6" N latitude and 78° 21.0' 17.8" to 78° 20.0' 51.2" E longitudes. The whole area of the valley was divided into two altitudes i.e. 3000-3400m and 3400-3800m for conducting the phyto-sociological study.

Quadrats of size 10mx10m, 3mx3m and 1mx1m 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 analyzed 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) (1963).

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

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

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

Where Ni = importance value of species i and N= total importance value of all the species in both the indices. Richness Index was estimated 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 130 belonging to 43 families and 94 genera. The dominant families were Rosaceae, Asteraceae, Ranunculaceae, Ploygonaceae and Lamiaceae. At elevation of 3000-3400m, the total number of tree species was 8 (Table 1). *Pinus wallichiana* was the dominant species having maximum density (220ha^{-1}) followed by *Betula utilis, Abies pindrow* and *Picea smithiana*. The maximum frequency was observed for *Betula utilis* (75%) followed by *Pinus wallichiana, Abies pindrow* and *Picea smithiana*. In the term of abundance, *Pinus wallichiana* recorded the highest value of (3.14) followed by *Betula utilis, Picea smithiana* and *Populus ciliata*. *Pinus wallichiana* observed the highest value of the IVI (92.95) followed by *Betula utilis* (69.81), *Abies pindrow* (49.98) and *Picea smithiana* (35.51). The ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the species was contiguous except *Abies pindrow* and *Pinus wallichiana*. 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 had earlier been reported by several workers (Singh and Yadava, 1974; Kunhikannan *et al*; 1998).

Table 1: Phytosciological attributes of tree species in Kanasa Nala area at 3000-3400m elevation.

S. No.	Name of the Species	Density (ha^{-1})	Frequency(%)	Abundance	A/F	IVI
1	*Abies pindrow* Royle	135.00	60.00	2.25	0.04	49.98
2	*Acer caesium* Wall. Ex Brandis	30.00	15.00	2.00	0.13	11.03
3	*Betula utilis* D. Don	185.00	75.00	2.47	0.03	69.81
4	*Picea smithiana* (Wall.) Boiss.	95.00	40.00	2.38	0.06	35.51
5	*Pinus wallichiana* A. B. Jackson	220.00	70.00	3.14	0.04	92.95
6	*Populus ciliata* Wall. ex Royle	80.00	35.00	2.29	0.07	29.69
7	*Sorbus lanata* (D. Don) Schauer	10.00	5.00	2.00	0.40	3.68
8	*Taxus wallichiana* (Zucc.) Pilger	20.00	10.00	2.00	0.20	7.35

Among 17 species of shrubs at elevation 3000-3400m (Table 2). *Salix fragilis* was the dominant species having maximum density (7555.56ha^{-1}) and frequency (80%). This was followed by *Berberis jaeschkeana, Rhododendron campanulatum* and *Rosa microphylla* in term of density. The highest value of abundance was recorded for *Hippophae salicifolia. Rhododendron campanulatum* recorded the highest value of IVI (62.45) followed by *Salix fragilis* (52.09), *Berberis jaeschkeana* (40.51) and *Rosa macrophylla* (28.81). The lowest IVI of 1.34 was observed for *Sorbus microphylla*. The distribution pattern of all the species was contiguous except *Syringa emodi*. In case of herbs including regeneration, the total number of species was 77 at elevation 3000-3400m (Table 3). The most dominant species was *Nepeta laevigata* having maximum density (8.40 ha^{-1}) followed by *Geranium wallichianum, Galium acutum* and *Ainsliaea latifolia.* The highest value of frequency was recorded for *Geranium wallichianum* (83.33%) followed by *Galium acutum, Ainsliaea latifolia* and *Nepeta laevigata*. In term of abundance, maximum value was observed for *Trigonella emodi* (22.50) followed by *Pimpinella diversifolia, Nepeta laevigata* and *Polygonatum multiflorum*. On the basis of IVI, maximum value was recorded for *Nepeta laevigata* (17.44) followed by *Geranium wallichianum* (16.50), *Bergenia stracheyi* (15.33) and *Polygonatum multiflorum* (13.41).

Table 2: Phytosciological attributes of shrub species in Kanasa Nala area at 3000-3400m elevation.

S. No.	Name of the Species	Density (ha^{-1})	Frequency(%)	Abundance	A/F	IVI
1	*Abies pindrow* Royle	444.44	17.50	2.29	0.13	7.89
2	*Berberis jaeschkeana* C. K. Scheider	3472.22	40.00	7.81	0.20	40.51
3	*Berberis coriaria* Royle	972.22	20.00	4.38	0.22	9.20
4	*Hippophae salicifolia* D. Don	833.33	7.50	10.00	1.33	15.59
5	*Lonicera hypoleuca* Decne.	1305.56	32.50	3.62	0.11	12.46
6	*Lonicera parviflora* Edgew.	222.22	5.00	4.00	0.80	2.10
7	*Picea smithiana* *(Wall.) Boiss.	666.67	20.00	3.00	0.15	11.12
8	*Pinus wallichiana* A. B. Jackson	444.44	20.00	2.00	0.10	10.27
9	*Rhododendron campanulatum* D. Don	2805.56	65.00	3.88	0.06	62.45
10	*Rosa macrophylla* Lindl.	2555.56	57.50	4.00	0.07	28.81
11	*Rosa webbiana* Wall. ex Royle	1083.33	27.50	3.55	0.13	11.35
12	*Salix fragilis* Linn.	7555.56	80.00	8.50	0.11	52.09
13	*Sorbus microphylla* * Wenzig	55.56	5.00	1.00	0.20	1.34
14	*Spiraea bella* Sims	277.78	10.00	2.50	0.25	3.37
15	*Syringa emodi* Wall. ex Royle	1083.33	52.50	1.86	0.04	16.84
16	*Taxus wallichiana** (Zucc.) Pilger	166.67	5.00	3.00	0.60	9.58
17	*Viburnum cotinifolium* D. Don	416.67	12.50	3.00	0.24	5.03

*Sapling

Table 3: Phytosciological attributes of herb species in Kanasa Nala area at 3000-3400m elevation.

S. No.	Name of the Species	Density(m^{-2})	Frequency(%)	Abundance	A/F	IVI
1	*Abies pindrow* **Royle	0.80	46.67	1.71	0.04	7.12
2	*Achillea millefolium* Linn.	1.53	35.00	4.38	0.13	4.22
3	*Ainsliaea latifolia* (D. Don) Sch. Bip.	5.53	66.67	8.30	0.12	12.20
4	*Anaphalis nubigena* DC.	0.67	20.00	3.33	0.17	2.14
5	*Anaphalis triplinervis* (Sims)C.B. Clarke	2.17	25.00	8.67	0.35	4.40
6	*Androsace rotundifolia* Hardw.	1.50	10.00	15.00	1.50	2.57
7	*Anemone obtusiloba* D. Don	0.53	26.67	2.00	0.08	2.58
8	*Anemone rivularis* Buch.-Ham. ex DC.	0.73	13.33	5.50	0.41	2.04
9	*Angelica glauca* Edgew	1.00	20.00	5.00	0.25	2.90
10	*Arabidopsis thaliana* (Linn.) Heynh.	0.20	6.67	3.00	0.45	0.70
11	*Arenaria festucoides* Benth.	0.27	6.67	4.00	0.60	0.74
12	*Artemisia gmelinii* Weber ex Steckm	0.13	6.67	2.00	0.30	0.67
13	*Asparagus filicinus* Buch.-Ham. ex D. Don	0.10	3.33	3.00	0.90	0.40
14	*Aster himalaicus* C.B.Clarke.	0.30	10.00	3.00	0.30	1.07
15	*Astragalus candolleanus* Royle ex Benth	1.00	26.67	3.75	0.14	5.31
16	*Berbers jaeschkeana* C. K. Schneider	0.13	6.67	2.00	0.30	0.77
17	*Bergenia stracheyi* (Hook.f.&Thoms.) Engl.	1.30	21.67	6.00	0.28	15.33
18	*Betula utilis* **D. Don	0.60	20.00	3.00	0.15	4.73
19	*Bupleurum falcatum* Linn.	0.60	15.00	4.00	0.27	1.93
20	*Chaerophyllum reflexum* Lindl.	1.60	20.00	8.00	0.40	4.24
21	*Cirsium wallichii* DC.	1.67	21.67	7.69	0.36	10.76
22	*Clematis grata* Wall.	0.17	8.33	2.00	0.24	0.94
23	*Corydalis cornuta* Royle	0.27	6.67	4.00	0.60	1.96
24	*Cotoneaster bacillaris* **Wall. ex Lindl.	0.20	6.67	3.00	0.45	1.10
25	*Cotoneaster microphyllus***Wall. ex Lindl.	0.25	8.33	3.00	0.36	1.29
26	*Cuscuta reflexa* Roxb.	1.00	10.00	10.00	1.00	1.86
27	*Cynoglossum wallichii* G. Don.	0.42	8.33	5.00	0.60	1.13
28	*Epipactus helleborine* (Linn.) Crantz	1.37	55.00	2.48	0.05	6.42
29	*Eragrostis viscosa* (Retzius) Stapf.	1.20	28.33	4.24	0.15	4.36
30	*Erigeron alpinus* Linn.	0.67	33.33	2.00	0.06	3.04
31	*Fragaria vesca* Linn.	4.13	46.67	8.86	0.19	8.13
32	*Fragaria indica* Andr.	0.13	6.67	2.00	0.30	0.60
33	*Galium acutum* Edgew.	6.75	75.00	9.00	0.12	12.81
34	*Geranium wallichianum* D. Don ex Sweet	7.78	83.33	9.34	0.11	16.50
35	*Heracleum lanatum* Michx.	0.80	33.33	2.40	0.07	10.30
36	*Jaeschkea oligosperma* (Griseb.) Knobloch	0.78	23.33	3.36	0.14	2.94
37	*Lactuca dissecta* D.Don	0.72	21.67	3.31	0.15	2.32
38	*Nepeta laevigata* (D. Don) Hand.-Mazz.	8.40	60.00	14.00	0.23	17.44

S. No.	Name of the Species	Density(m^{-2})	Frequency(%)	Abundance	A/F	IVI
39	*Origanum vulgare* Linn.	0.67	16.67	4.00	0.24	2.78
40	*Orobanche alba* Stephen ex Willd.	0.37	15.00	2.44	0.16	2.46
41	*Pedicularis hoffmeisteris* Klotzsch	0.65	11.67	5.57	0.48	1.80
42	*Pedicularis longiflora* Rudolph	0.40	6.67	6.00	0.90	1.08
43	*Pedicularis punctata* Decne	0.33	6.67	5.00	0.75	0.97
44	*Picea smithiana* **(Wall.) Boiss.	0.07	6.67	1.00	0.15	0.76
45	*Pimpinella diversifolia* DC.	1.25	8.33	15.00	1.80	2.32
46	*Pinus wallichiana* **A. B. Jackson	0.60	20.00	3.00	0.15	3.73
47	*Plantago tibetica* Hook. f. & Thoms.	0.73	13.33	5.50	0.41	1.91
48	*Plectanthus rugosus* Wall. ex Benth.	0.50	28.33	1.76	0.06	2.74
49	*Podophyllum hexandrum* Royle	0.58	21.67	2.69	0.12	2.88
50	*Polygonatum multiflorum* (Linn.) All.	5.13	40.00	12.83	0.32	13.41
51	*Polygonatum verticillatum* (Linn.) All.	1.07	13.33	8.00	0.60	3.44
52	*Polygonum polystachya* (Wall. ex Meiss.) Gross	1.07	65.00	1.64	0.03	13.13
53	*Potentilla atrosanguinea* Lodd.	0.53	6.67	8.00	1.20	3.30
54	*Potentilla nepalensis* Hook.	0.75	15.00	5.00	0.33	2.04
55	*Rhododendron campanulatum* **D. Don	0.25	8.33	3.00	0.36	1.00
56	*Rumex nepalensis* Sprengel	0.13	6.67	2.00	0.30	1.68
57	*Rumex hastatus* D. Don	0.40	6.67	6.00	0.90	0.94
58	*Salix lindleyana* Wall. ex Andersson	0.10	5.00	2.00	0.40	0.62
59	*Salvia nubicola* Wall. ex Sweet	0.30	5.00	6.00	1.20	0.95
60	*Selinum vaginatum* C. B. Clarke (Edgew)	0.30	5.00	6.00	1.20	2.04
61	*Senecio laetus* Edgew.	0.38	15.00	2.56	0.17	1.57
62	*Sibbaldia parviflora* Hornem. ex Kuntze	0.58	11.67	5.00	0.43	1.60
63	*Silene edgeworthii* Bocquet	0.67	13.33	5.00	0.38	1.81
64	*Smilax aspera* Linn.	1.27	46.67	2.71	0.06	5.34
65	*Spiraea canescens*** D. Don	0.20	10.00	2.00	0.20	0.97
66	*Stachys sericea* Wall. ex Benth.	0.25	8.33	3.00	0.36	0.97
67	*Syringa emodi* **Wall. ex Royle	0.40	13.33	3.00	0.23	2.91
68	*Taraxacum officinale* Wigg.	0.53	15.00	3.56	0.24	1.83
69	*Thalictuum foliolosum* DC.	2.60	26.67	9.75	0.37	10.38
70	*Thymus linearis* Benth. ex Benth.	3.00	13.33	22.50	1.69	5.15
71	*Trigonella emodi* Benth.	4.52	41.67	10.84	0.26	9.14
72	*Trillidium govanianum* (D. Don) Kunth	0.50	16.67	3.00	0.18	1.79
73	*Valeriana hardwickii* Wall.	0.42	8.33	5.00	0.60	1.21
74	*Veronica biloba* Linn.	0.53	13.33	4.00	0.30	5.84
75	*Viburnum cotinifolium* ** D. Don	0.07	6.67	1.00	0.15	0.52
76	*Viloa biflora* Linn.	1.20	13.33	9.00	0.68	2.40
77	*Vincetoxicum hirundinaria* Medicus	0.13	6.67	2.00	0.30	0.66

**Regenration

The lowest IVI was observed for *Asparagus filicinus* (0.40). The distribution pattern of all the species was contiguous except *Epipactus helleborine* and *Polygonatum polystachya*. The regeneration of *Abies pindrow, Betula utilis, Picea smithiana, Pinus wallichiana* and *Rhododendron campanulatum* was recorded. At elevation of 3400-3800m, the total number of tree species was 4 (Table 4). *Betula utilis* was the dominant species having maximum density (320 ha^{-1}), frequency (90%) and abundance (3.56) followed by *Abies pindrow* and *Acer acuminatum. Abies pindrow* recorded the highest value of IVI (136.15) followed by *Betula utilis* (117.31) and *Acer acuminatum* (36.46). The distribution pattern of all the species was random and regular except *Taxus wallichiana*.

At elevation 3400-3800m, the total number of shrub species was 16 (Table 5). The most dominant species was *Salix fragilis* having maximum density (3250ha^{-1}) followed by *Rhododendron campanulatum, Lonicera quinquelocularis* and *Rosa webbiana*. The highest frequency was recorded for *Rosa webbiana* (75%) followed by *Salix fragilis, Rhododendron campanulatum* and *Lonicera quinquelocularis*. *Lonicera parviflora* recorded maximum value of abundance (7) followed by *Lonicera quinquelocularis, Rhododendron campanulatum* and *Rosa webbiana*. On the basis of IVI, *Rhododendron campanulatum* recorded the highest value (51.22) followed by *Salix fragilis* (44.82) *Rosa webbiana* (39.29) and *Lonicera quinquelocularis* (37.18). The distribution pattern of all the species was contiguous except *Rosa webbiana.* At elevation 3400-3800m, the total number of herb species was 73 (Table 6). *Anaphalis contorta* was the dominant species having maximum density (8 ha^{-1}) and frequency (80%).

Table 4: Phytosciological attributes of tree species in Kanasa Nala area at 3400-3800m elevation.

S. No.	Name of the Species	Density (ha^{-1})	Frequency(%)	Abundance	A/F	IVI
1	*Abies pindrow* Royle	170.00	65.00	2.62	0.04	136.15
2	*Acer acuminatum* Wall. ex D. Don	50.00	50.00	1.00	0.02	36.46
3	*Betula utilis* D. Don	320.00	90.00	3.56	0.04	117.31
4	*Taxus wallichiana* (Zucc.) Pilger	15.00	15.00	1.00	0.07	10.07

Table 5: Phytosciological attributes of shrub species in Kanasa Nala area at 3400-3800m elevation.

S. No.	Name of the Species	Density (ha^{-1})	Frequency(%)	Abundance	A/F	IVI
1	*Abies pindrow* *Royle	27.78	2.50	1.00	0.40	1.38
2	*Acer acuminatum* * Wall. ex D. Don	111.11	5.00	2.00	0.40	2.66
3	*Berberis coriaria* Royle	972.22	12.50	7.00	0.56	10.93
4	*Betula utilis* *D. Don	500.00	15.00	3.00	0.20	13.43
5	*Cotoneaster microphyllus* Wall. ex Lindl.	500.00	12.50	3.60	0.29	9.45
6	*Juniperus indica* Bertol	416.67	20.00	1.88	0.09	9.03
7	*Lonicera parvifolia* Edgew.	972.22	12.50	7.00	0.56	10.33
8	*Lonicera quinquelocularis* Hardw.	2638.89	45.00	5.28	0.12	37.18
9	*Rhododendron campanulatum* D. Don	2916.67	57.50	4.57	0.08	51.22
10	*Rhododendron lepidotum* Wall. ex G. Don	250.00	7.50	3.00	0.40	4.47
11	*Rosa macrophylla* Lindl.	638.89	25.00	2.30	0.09	14.45
12	*Rosa webbiana* Wall. ex Royle	2416.67	75.00	2.90	0.04	39.29
13	*Salix fragilis* Linn.	3250.00	65.00	4.50	0.07	44.82
14	*Sorbus microphylla* Wenzig	55.56	2.50	2.00	0.80	1.22
15	*Syringa emodi* Wall. ex Royle	722.22	32.50	2.00	0.06	16.16
16	*Taxus wallichiana* *(Zucc.) Pilger	250.00	7.50	3.00	0.40	33.98

*Sapling

Table 6: Phytosciological attributes of herb species in Kanasa Nala area at 3400-3800m elevation.

S. No.	Name of the Species	Density (m^{-2})	Frequency(%)	Abundance	A/F	IVI
1	*Abies pindrow* **Royle	0.27	13.33	2.00	0.15	1.78
2	*Achillea millefolium* Linn.	0.40	13.33	3.00	0.23	1.39
3	*Actaea spicata* Linn.	0.30	15.00	2.00	0.13	1.37
4	*Ainsliaea latifolia* (D. Don) Sch. Bip.	5.60	46.67	12.00	0.26	9.34
5	*Anaphalis contorta* (D. Don) Hook. f.	8.00	80.00	10.00	0.13	19.46
6	*Androsace rotundifolia* Hardw.	0.40	5.00	8.00	1.60	0.83
7	*Anemone polyanthes* D. Don	0.20	3.33	6.00	1.80	0.50
8	*Angelica glauca* Edgew	0.17	8.33	2.00	0.24	0.86
9	*Arisaema flavum* (Forsskal) Schott	0.45	15.00	3.00	0.20	1.63
10	*Artemisia gmelinii* Weber ex Steckm.	1.40	20.00	7.00	0.35	3.52
11	*Aruncus dioicus* (Walter) Fernald	0.20	6.67	3.00	0.45	0.69
12	*Bergenia stracheyi* (Hook. f. & Thoms.) Engl.	1.00	35.00	2.86	0.08	4.13
13	*Betula utilis* **D. Don	0.67	20.00	3.33	0.17	3.08
14	*Cassiope fastigiata* (Wall.) D. Don	7.47	53.33	14.00	0.26	18.54
15	*Chaerophyllum reflexum* Lindl.	0.40	5.00	8.00	1.60	1.04
16	*Cirsium wallichii* DC.	0.50	10.00	5.00	0.50	2.94
17	*Clematis barbellata* Edgew.	0.62	36.67	1.68	0.05	3.72
18	*Clintonia udensis* Trautv. & Meyer	0.53	6.67	8.00	1.20	1.18
19	*Cortusa brothen* Pax ex Lipsky	0.27	6.67	4.00	0.60	0.86
20	*Corydalis cornuta* Royle	3.00	15.00	20.00	1.33	14.88
21	*Cotoneaster microphyllus* **Wall. ex Lindl.	0.33	13.33	2.50	0.19	2.00
22	*Cynoglossum furcatum* Wall.ex Roxb.	0.27	6.67	4.00	0.60	0.78
23	*Epilobium cylindricum* D. Don	0.80	20.00	4.00	0.20	2.42
24	*Epipactus helleborine* (Linn.) Crantz	0.83	8.33	10.00	1.20	2.23

S. No.	Name of the Species	Density (m^{-2})	Frequency(%)	Abundance	A/F	IVI
25	*Eragrostis viscosa* (Retzius) Trin.	1.40	40.00	3.50	0.09	4.62
26	*Fragaria vesca* Linn.	0.40	13.33	3.00	0.23	1.33
27	*Fragaria indica* Andr.	0.17	3.33	5.00	1.50	0.41
28	*Galium elegans* Wall. ex Roxb.	5.90	66.67	8.85	0.13	10.55
29	*Geranium wallichianum* D. Don ex Sweet	2.88	53.33	5.41	0.10	7.13
30	*Impatiens scabrida* DC.	2.92	41.67	7.00	0.17	7.33
31	*Impatiens amplexicaulis* Edgew.	1.20	18.33	6.55	0.36	2.88
32	*Iris kemaonensis* D. Don ex Royle	2.00	13.33	15.00	1.13	4.41
33	*Jaeschkea oligosperma* (Griseb.) Knobloch	0.20	6.67	3.00	0.45	0.72
34	*Ligularia amplexicaulis* DC.	1.65	55.00	3.00	0.05	7.48
35	*Nepeta discolor* Royle ex Benth.	1.47	13.33	11.00	0.83	2.69
36	*Oxyria digyna* (Linn.) Hill	0.33	8.33	4.00	0.48	0.97
37	*Pedicularis longiflora* Rudolph	0.40	6.67	6.00	0.90	1.00
38	*Phleum alpinum* Linn.	0.25	8.33	3.00	0.36	0.84
39	*Phlomis bracteosa* Royle ex Benth.	2.80	40.00	7.00	0.18	13.10
40	*Picrorhiza kurrooa* Royle ex Benth.	2.25	15.00	15.00	1.00	4.49
41	*Plantago tibetica* Hook. f. & Thoms.	0.40	6.67	6.00	0.90	1.00
42	*Podophyllum hexandrum* Royle	0.47	13.33	3.50	0.26	1.72
43	*Polemonium caeruleum* Linn.	0.20	6.67	3.00	0.45	0.75
44	*Polygonatum cirrhifolium* (Wall.) Royle	1.00	43.33	2.31	0.05	4.69
45	*Polygonatum multiflorum* (Linn.) All.	8.40	60.00	14.00	0.23	17.03
46	*Polygonatum verticillatum* (Linn.) All.	5.25	46.67	11.25	0.24	15.11
47	*Polygonum alatum* Buch.-Ham. ex Spreng.	5.05	21.67	23.31	1.08	9.26
48	*Polygonum denticulatum* Meissn.	0.17	8.33	2.00	0.24	0.75
49	*Polygonum polystachya* (Wall. ex Meiss.) Gross	3.00	60.00	5.00	0.08	15.97
50	*Potentilla atrosanguinea* Lodd.	5.03	46.67	10.79	0.23	19.01
51	*Potentilla cuneata* Wall. ex Lehm.	0.53	6.67	8.00	1.20	1.52
52	*Primula denticulata* Smith.	0.03	1.67	2.00	1.20	0.16
53	*Rheum australe* D. Don	0.17	16.67	1.00	0.06	2.49
54	*Rhododendron lepidotum* Wall. ex G. Don	0.15	5.00	3.00	0.60	0.73
55	*Rumex nepalensis* Sprengel	0.20	5.00	4.00	0.80	1.83
56	*Salix fragilis*** Linn	0.30	15.00	2.00	0.13	1.75
57	*Salix lindleyana* Wall. ex Andersson	0.47	13.33	3.50	0.26	1.84
58	*Salvia lanata* Roxb.	0.20	6.67	3.00	0.45	0.80
59	*Sedum ewersii* Ledeb.	2.00	13.33	15.00	1.13	3.34
60	*Selinum tenuifolium* Wall. ex C. B. Clarke	0.10	5.00	2.00	0.40	0.58
61	*Senecio kunthianus* Wall.	0.40	13.33	3.00	0.23	1.45
62	*Sibbaldia parviflora Willd.*	3.75	16.67	22.50	1.35	5.80
63	*Sorbus microhylla* Wenzig	0.15	5.00	3.00	0.60	0.64
64	*Silene viscosa* (L.) Pers.	0.33	13.33	2.50	0.19	1.31
65	*Taraxacum officinale* Wigg.	0.17	3.33	5.00	1.50	0.46
66	*Thalictrum foliolosum* DC.	0.30	31.67	0.95	0.03	2.60
67	*Thymus linearis* Benth. ex Benth.	3.22	61.67	5.22	0.08	9.14
68	*Trigonella emodi* Benth.	0.40	5.00	8.00	1.60	1.66
69	*Trillidium govanianum* (D. Don) Kunth	0.42	8.33	5.00	0.60	1.13
70	*Valeriana hardwickii* Wall.	0.30	5.00	6.00	1.20	0.80
71	*Valeriana himalayana Grub.*	1.22	33.33	3.65	0.11	4.14
72	*Verbascum thapsus* Linn.	0.03	1.67	2.00	1.20	0.36
73	*Viola biflora* Linn.	0.42	8.33	5.00	0.60	1.02

** Regeneration

This was followed by *Cassiope fastigiata, Galium elegans* and *Ainsliaea latifolia* in term of density. *Polygonum alatum* recorded maximum abundance (23.31) followed by *Sibbaldia parviflora, Corydalis cornuta* and *Sedum ewersii*. *Anaphlis contorta* recorded maximum value of IVI (19.46) followed by *Potentilla atrosanguinea* (19.01), *Cassiope fastigiata* (18.54) and *Polygonatum multiflorum* (17.03). The lowest IVI of 0.16 was observed for *Primula denticulata*. The distribution pattern of all the species was contiguous except *Polygonatum cirrhifolium* and *Thalictrum foliolosum.* The regeneration of *Abies pindrow* and *Betula utilis* was recorded.

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 7. The higher the value of concentration of dominance, the greater is the homogenous nature of the community and vice- versa (Kohli *et al*; 2014). 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. Differences in the species composition from altitude to altitude is mostly due to micro environment changes (Mishra *et al*; 1997).

Table 7: Concentration of dominance (C), diversity index (H), richness index (R) and evenness index (E) for tree, shrub and herb at different elevations in Kanasa Nala Area.

Altitude	Plant Category	Concentration of dominance (C)	Index of Diversity (H)	Richness Index (R)	Evenness Index (E)
3000-3400m	Tree	0.20	1.75	1.387	0.841
	Shrub	0.12	2.43	2.361	0.857
	Herb	0.03	3.91	8.834	0.900
3400-3800m	Tree	0.37	1.10	0.637	0.793
	Shrub	0.19	2.40	2.345	0.865
	Herb	0.04	3.72	8.235	0.867

MEDICINAL PLANTS

The important plants of medicinal value found in Kanasa valley of Rakchham Chitkul wild life sanctuary in district Kinnaur of Himachal Pradesh were compiled following Kirtikar and Basu (1987) and Kala (2002). These include; *Acer caesium, Achilla millefolium, Anaphalis contorta, Anaphalis triplinervis, Anemone obtusiloba, Anemone rivularis, Arbidopsis thaliana, Artemisia gmelinii, Asparagus filicinus, Bergenia stracheyi, Betula utilis, Bupleurum falcatum, Cassiope fastigiata, Chaerophyllum reflexum, Corydalis cornuta, Cynoglossum wallichi, Cynoglossum furcatum, Fragaria vesca, Galium acutum, Geranium wallichianum, Heracleum lanatum Hippophae salicifolia, Iris kemaonensis, Lactuca dissecta, Oxyria digyna, Picrorhiza kurrooa, Pimpinella diversifolia, Phlomis bracteosa, Plantago tebetica, Polygonatum multiflorum, Polygonatum verticillatum, Potentilla nepalensis, Primula denticulata, Rheum australe, Rhododendron campanulatum, Rosa macrophylla, Rosa webbiana, Rumex hastatus, Rumex nepalensis, Salvia lanata, Salvia nubicola, Selinum tenuifolium, Selinum vaginatum, Sedum ewersii, Taraxacum officinale, Taxus wallichiana, Thalictrum foliolosum, Thymus linearis, Trillidium govanianum, Valeriana hardwickii, Verbascum thapsus, Viola biflora.*

THREATENED PLANTS

Out of 52 medicinal plant species recorded from the area, 10 species i.e. *Angelica glauca, Bergenia stracheyi, Betula utilis, Picrorhiza kurrooa, Podophyllum hexandrum, Taxus wallichiana, Polygonatum verticillatum, Polygonatum cirrhifolium, Rhododendron lepidotum* and *Rhododendron campanulatum* fall in the category of threatened plants when compared with the available literature like Red Data Book and CAMP Reports. The rarity in these medicinal plants is due to habitat alteration, narrow range of distribution along with other factors. A major threat is for the species those are uprooted and their underground parts such as rhizomes, tubers, bulbs and roots are used in medicine. 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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