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Assessment of Floristic Diversity in Khajjiar beat of Kalatop Khajjiar wild life sanctuary of district Chamba, Himachal Pradesh

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ABSTRACT: A study was carried out to know the floristic diversity along an altitudinal gradient varying from 2000-2400m above msl in Khajjiar beat of Kalatop Khajjiar wild life sanctuary of district Chamba, Himachal Pradesh during 2011. Total number of plant species was 101 belonging to 54 families and 95 genera. The dominant families were Asteraceae, Rosaceae, Polygonaceae and Lamiaceae. The number of trees species was 6 and 11 with the dominance of *Persea duthiei* and *Picea smithiana* at 2000-2200m and 2200-2400m elevation ranges respectively. The number of shrub species was 9 and 22 with the dominance of *Sarcococca saligna* and *Vibernum erubescens* at 2000-2200m and 2200-2400m elevations respectively. The number of herb species was 60 and 54 with the dominance of *Polygonum capitata* and *Bergenia ciliata* at 2000-2200m and 2200-2400m elevation ranges respectively. The distribution pattern of most of the plant species was contiguous in all altitudes. Index of diversity for herb species in these elevations ranges was 3.498 and 3.457. Out of 48 medicinal plant species recorded from the area, 2 species viz; *Dioscorea deltoidea* and *Podophyllum hexandrum* fall in the threatened category. The better conservation of natural resources can be done through promotion of community based conservation, *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 and processing among the end users.

Key Words: Dominance, distribution pattern, diversity index, conservation, dominance.

INTRODUCTION

The 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. Himalayas, otherwise known for its rich and diverse plant wealth is showing a rapid decline in population of many plant species in recent past. Some of them have already been lost whereas many of them are on the verge of extinction. If suitable steps to conserve the Himalayan flora not taken well in time, the delay may lead to total extinction of rare and valuable plants. The current decline in biodiversity largely through human activities is a serious threat to our ecosystem.

Kalatop Khajjiar wildlife sanctuary which covers an area of about 20.27 sq km was established in

1958 in Chamba district of Himachal Pradesh. The altitude of this sanctuary varies from 1185 to 2800m above msl whereas the climate ranges from sub -temperate to alpine. The sanctuary represents flora of sub-temperate to alpine climate and inhabitants of villages in and around the sanctuary are utilizing the sanctuary areas for grazing, collection of timber, fuel wood, fodder and other minor forest produce. The continuous removal of plant species for various uses and overgrazing by migratory and other livestock seems to have resulted in loss of biodiversity in this sanctuary. If these naturally occurring plant resources are not conserved timely then they may soon become extinct. Accordingly, the wealth needs to be protected from further degradation so as to conserve the endemic diversity in the medicinal plants before it is completely wiped out from nature. Keeping this in view attempts were made to assess the plant diversity including documentation of the medicinal plants found in Khajjiar Beat of Kalatop Khajjiar wild life sanctuary of district Chamba, Himachal Pradesh.

MATERIALS AND METHODS

The present study was conducted in Khajjiar beat of Kalatop Khajjiar wild life sanctuary in district Chamba of Himachal Pradesh during, 2011 at an elevation of 2000-2400m. The study site was situated at N 32° 32.202' to N 32° 31.798' latitude and E 76° 02.438' to E 76° 02.617' longitudes. The whole area of the valley was divided into two altitudes i.e. 2000-2200m and 2200-2400m 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 herbs whereas saplings as shrubs. The vegetation data was analysed for density, frequency and abundance as per 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 of the floral elements.

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 following Shannon-Wiener diversity Index (H) (Shannon-Wiener 1963).

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

Where Ni = Number of individuals of species i and N= Total number of individuals of all the species.

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

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 101 belonging to 54 families and 95 genera. The dominant families were Asteraceae, Rosaceae, Polygonaceae and Lamiaceae. At an elevation of 2000m-2200m, total number of tree species was 6 (Table 1), *Persea duthiei* was the dominant species having highest density (275 ha^{-1}) and frequency (60%).

Table 1: Phytosciological attributes of tree species in Khajjiar beat at an altitudinal zonation of 2000m-2200m.

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1.	*Abies pindrow* Royle.	50.00	10.00	5.00	0.500	38.18
2.	*Cedrus deodara* (Roxb. ex D. Don) G. Don f.	195.00	35.00	5.57	0.159	83.01
3.	*Neolitsea pallens* (D.Don.) Momiyama & Hara	35.00	35.00	1.00	0.029	26.44
4.	*Persea duthiei* (King. ex Hook.f.) Kostern	275.00	60.00	4.58	0.076	99.29
5.	*Picea smithiana* (Wall.) Boiss	55.00	35.00	1.57	0.045	45.75
6.	*Pyrus pashia* Buch.-Ham.ex D.Don.	10.00	10.00	1.00	0.100	7.30

This was followed by *Cedrus deodara* (195.00 ha^{-1}) and *Picea smithiana* (55.00ha^{-1}) in terms of density. *Cedrus deodara* recorded the highest value of abundance (5.57) followed by *Abies pindrow* (5.00) and *Persea duthiei* (4.58). *Persea duthiei* recorded the highest value of IVI (99.29) followed by *Cedrus deodara* (83.01) and *Picea smithiana* (45.75). The lowest value of IVI (7.30) was observed for *Pyrus pashia*. The community identified was *Persea duthiei - Cedrus deodara*.

The distribution pattern of all the species except *Picea smithiana and Neolitsea pallens* 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 9 species of shrubs including sapling at elevation 2000m-2200m (Table 2), *Sarcococca saligna* was the dominant species having highest value for density (11333.33 ha^{-1}), abundance (12.75) and frequency (80%). This was followed by *Viburnum erubescens* (3444.44ha^{-1}) and *Neolitsea pallens* (2444.44ha^{-1}) in terms of density. On the basis of IVI, *Sarcococca saligna* recorded the highest value (168.83) followed by *Viburnum erubescens* (43.69) and *Neolitsea pallens* (31.83).The lowest value of IVI (4.21) was observed for *Ilex dipyrena*. The distribution pattern of all the species was contiguous except *Sarcococca saligna.*

In case of herbs including regeneration, total number of herb species was 60 at an elevation of 2000m-2200m (Table 3). *Trifolium repens* was the dominant species having highest value for density (5.83) followed by *Polygonum capitata* (5.25m^{-2}), *Oxalis corniculata* (5.16m^{-2}) and *Fragaria vesca* (2.58m^{-2}). In term of frequency, *Oplismenus compositus* recorded the highest value (66.67%) followed by *Fagaria vesca* (58.33%) and *Oxalis corniculata* (58.33%). *Polygonum capitata* recorded the maximum value of abundance (21.00) followed by *Equisetum arvense* (15.00), *Acorus calamus* (14.00) and *Trifolium repens* (11.67). *Polygonum capitata* (18.40) recorded the highest value of IVI followed by *Trifolium repens* (17.28) and *Oxalis corniculata* (14.34). The lowest value of IVI (0.83) was observed for *Geranium wallichianum*. The distribution pattern of all the species was contiguous.

Table 2: Phytosciological attributes of shrub species in Khajjiar beat at an altitudinal zonation of 2000m-2200m.

S.No.	Species	Density (ha^{-1})	Frequ-ency(%)	Abund-ance	A/F	IVI
1.	*Berberis lycium* Royle	333.33	10.00	3.00	0.300	4.84
2.	*Daphne cannabina* Lour.ex Wall.	777.78	30.00	2.33	0.078	13.23
3.	*Ilex dipyrena** Wall.	222.22	10.00	2.00	0.200	4.21
4.	*Neolitsea pallens** (D.Don.) Momiyama & Hara	2444.44	60.00	3.67	0.061	31.83
5.	*Persea duthiei** (King. ex Hook.f.) Kostern	666.67	20.00	3.00	0.150	9.67
6.	*Prinsepia utilis* Royle.	555.56	10.00	5.00	0.500	6.41
7.	*Rubus niveus* Wall.	1555.56	20.00	7.00	0.350	17.29
8.	*Sarcococca saligna* (D.Don.) Muell.Arg	11333.33	80.00	12.75	0.159	168.83
9	*Viburnum erubescens* Wall.ex DC	3444.44	80.00	3.88	0.048	43.69

*****Saplings

Table 3: Phytosciological attributes of herb species in Khajjiar beat at an altitudinal zonation of 2000m-2200m.

S.No.	Species	Density (m^{-2})	Frequency(%)	Abundance	A/F	IVI
1.	*Achillea millefolium* Linn.	0.66	25.00	2.67	0.107	8.57
2.	*Achyranthes aspera* Linn.	0.41	16.67	2.50	0.150	2.29
3.	*Acorus calamus* Linn.	1.16	8.33	14.00	1.680	9.83
4.	*Ainsliaea latifolia* (D. Don) Sch. Bip	0.41	16.67	2.50	0.150	3.41
5.	*Ajuga bracteosa* Wall.ex Benth.	0.66	41.67	1.60	0.038	7.07
6.	*Anaphalis contorta* D.Don. (Hook.f.)	0.50	8.33	6.00	0.720	2.02
7.	*Anemone obtusiloba* D.Don.	0.25	16.67	1.50	0.090	1.92
8.	*Aquilegia fragrens* Benth.	0.50	25.00	2.00	0.080	3.88
9	*Arisaema flavum* (Forsskal) Schott (Forsk.) Scott.	0.33	16.67	2.00	0.120	4.90
10.	*Arisaema intermedium* Blume.	0.25	8.33	3.00	0.360	3.22
11.	*Artemisia parviflora* Roxb.	0.91	25.00	3.67	0.147	5.28
12.	*Aster molliusculus* Wall	0.41	16.67	2.50	0.150	2.20
13	*Bidens pillosa* Linn	0.50	16.67	3.00	0.180	3.24
14.	*Bistorta amplexicaulis* (D. Don) Green	0.43	16.67	2.60	0.156	3.70
15.	*Boenninghausenia abiflora* (Hook.) Reichb. ex Meissner.	0.58	16.67	3.50	0.210	3.32
16.	*Calanthe tricarinata* Lindey	0.66	33.33	2.00	0.060	10.57
17.	*Cedrus deodara** *(Roxb. ex D. Don) G. Don f.	0.16	8.33	2.00	0.240	3.28
18.	*Cirsium wallichii* DC.	0.16	8.33	2.00	0.240	1.85
19.	*Commelina paludosa* Blume.	0.83	25.00	3.33	0.133	4.65
20.	*Conyza stricta* Willd.	0.20	8.33	2.40	0.288	1.10
21.	*Cynoglossum micranthum* Desf.	0.16	16.67	1.00	0.060	1.85
22.	*Digitalis purpurea* Linn.	0.41	16.67	2.50	0.150	3.75
23.	*Dioscorea deltoidea* Wall.	0.08	8.33	1.00	0.120	0.88
24.	*Epilobium laxum* Royle.	0.58	25.00	2.33	0.093	3.23
25.	*Equisetum arvense* Linn.	2.50	16.67	15.00	0.900	7.37
26.	*Erigeron multiradiatus* Benth.	1.25	25.00	5.00	0.200	5.08
27.	*Fragaria vesca* Coville.	2.58	58.33	4.43	0.076	9.72
28.	*Galium asperifolium* Wall. ex Roxb.	0.50	25.00	2.00	0.080	3.01
29.	*Geranium wallichianum* D.Don ex Sweet.	0.08	8.33	1.00	0.120	0.83
30.	*Girardinia diversifolia* (Linn) Friis	0.83	33.33	2.50	0.075	12.25
31.	*Gnaphalium hypoleucum* DC.	0.58	16.67	3.50	0.210	4.14
32.	*Gypsophila cerastioides* D. Don.	0.75	16.67	4.50	0.270	3.74
33.	*Hedychium spicatum* Smith.	0.16	8.33	2.00	0.240	2.42
34.	*Ilex dipyrena* ** Wall.	0.08	8.33	1.00	0.120	2.68
35.	*Impatiens sulcata* - Wall.	0.50	16.67	3.00	0.180	4.01
36.	*Lactuca dissecta* D.Don.	0.41	16.67	2.50	0.150	2.40
37.	*Lecanthus peduncularis* (Royle) Wedd.	0.91	25.00	3.67	0.147	4.33

S.No.	Species	Density (m^{-2})	Frequency(%)	Abundance	A/F	IVI
38.	*Melilotus alba* Lam.	0.33	16.67	2.00	0.120	2.16
39.	*Micromeria biflora* - (Buch.-Ham. ex D.Don.)Benth	0.66	16.67	4.00	0.240	2.93
40.	*Oplismenus compositus* (Linn.) P.Beauv.	4.00	66.67	6.00	0.090	13.14
41.	*Oxalis corniculata* Linn.	5.16	58.33	8.86	0.152	14.34
42.	*Paris polyphylla* Smith.	0.50	33.33	1.50	0.045	6.41
43.	*Persea duthiei*** (King ex Hook.f.) Kosterm.	0.08	8.33	1.00	0.120	1.74
44.	*Pilea scripta* (Buch.-Ham. ex D.Don.) Wedd.	2.41	50.00	4.83	0.097	11.25
45.	*Plantago lanceolata* Linn.	1.25	41.67	3.00	0.072	6.36
46.	*Podophyllum hexandrum* Royle	0.41	25.00	1.67	0.067	5.52
47.	*Polygonum capitata* Buch.-Ham. ex D. Don	5.25	25.00	21.00	0.840	18.40
48.	*Pteracanthus urticifolious* (Kuntze.)Bremek.	0.33	8.33	4.00	0.480	2.17
49.	*Ranunculus diffusus* DC.	0.58	25.00	2.33	0.093	3.33
50	*Rubia cordifolia* (Hook.f.) Linn.	0.41	16.67	2.50	0.150	2.40
51.	*Rubus niveus*** Wall.	0.16	8.33	2.00	0.240	1.26
52.	*Rumex nepalensis* Sperng.	0.33	16.67	2.00	0.120	5.03
53.	*Smilacina purpurea* Wall.	0.16	16.67	1.00	0.060	1.72
54.	*Smilax aspera* Linn.	0.08	8.33	1.00	0.120	0.88
55.	*Taraxacum officinale* F.H. Wigg	0.41	16.67	2.50	0.150	2.84
56.	*Trichidium pedicellatum* J.M.Noble & Kraft.	0.58	33.33	1.75	0.053	4.79
57.	*Trifolium repens Linn.*	5.83	50.00	11.67	0.233	17.28
58.	*Urtica dioica* Linn.	0.45	16.67	2.70	0.162	6.18
59.	*Valeriana jatamansii* Jones.	0.66	25.00	2.67	0.107	7.26
60.	*Viola canescens* Wall. ex Roxb.	1.41	25.00	5.67	0.227	4.62

**Regeneration

Table 4: Phytosciological attributes of tree species in Khajjiar beat at an altitudinal zonation of 2200m-2400m.

S. No.	Species	Density (ha^{-1})	Frequ-ency(%)	Abund-ance	A/F	IVI
1.	*Abies pindrow* Royle.	25.00	20.00	1.25	0.060	20.10
2.	*Aesculus indica* (Colebr. ex Combess.) Hook.f.	5.00	5.00	1.00	0.200	4.53
3.	*Cedrus deodara* (Roxb. ex D. Don) G. Don f.	15.00	10.00	1.50	0.150	11.71
4.	*Celtis australis Linn.*	10.00	5.00	2.00	0.400	4.71
5.	*Neolitsea pallens* (D.Don.)Momiyama & Hara	25.00	20.00	1.25	0.060	15.95
6.	*Persea duthiei* (King. ex Hook.f.) Kostern	10.00	10.00	1.00	0.100	7.30
7.	*Picea smithiana* (Wall.)Boiss	385.00	100.00	3.85	0.040	206.45
8.	*Populus ciliata* Wall. ex Royle.	15.00	5.00	3.00	0.600	5.85
9.	*Quercus dilatata* Lindl.	5.00	5.00	1.00	0.200	3.75
10.	*Quercus leucotrichophora* A.Camus.	10.00	5.00	2.00	0.400	11.66
11.	*Rhus wallichii* Hook.f.	10.00	10.00	1.00	0.100	7.94

At an elevation of 2200m-2400m, total number of tree species was 11 (Table 4). *Picea smithiana* was the dominant species having highest value for density (385.00ha^{-1}), frequency (100%) and abundance (3.85). This was followed by *Neolitsea pallens* (25.00ha^{-1}), *Abies pindrow* (25.00ha^{-1}) and *Populus ciliata* (15.00ha^{-1}). On the basis of IVI, *Picea smithiana* recorded the highest value (206.45) followed by *Abies pindrow* (20.10), *Neolitsea pallens* (15.95) and *Cedrus deodara* (11.71). The lowest value of IVI (3.75) was observed for *Quercus dilatata*. The community identified was *Picea smithiana* - *Abies pindrow*. The distribution pattern of all the species except *Picea smithiana* was contiguous.

Among 22 species of shrubs including sapling (Table 5, *Viburnum erubescens* was the dominant species having highest value for density (300 ha^{-1}) and frequency (52.50%) at elevation of 2200m-2400m. This was followed by *Sarcococca saligna* (2555.56ha^{-1}) and *Indigofera heterantha* (2472.22ha^{-1}) in term of density. In case of abundance, *Sarcococca saligna* recorded the highest value (9.20) followed by *Indigofera heterantha* (8.09), *Rosa macrophylla* (7.11) and *Salix tetrasperma* (6.00). *Viburnum erubescens* recorded the highest value of IVI (44.97) followed by *Rosa macrophylla* (34.58), *Indegofera heterantha* (29.84) and *Sarcococca saligna* (27.44). The lowest value of IVI (0.92) was observed for *Hypericum oblongifolium*. The distribution pattern of all the species was contiguous.

Table 5: Phytosciological attributes of shrub species in Khajjiar beat at an altitudinal zonation of 2200-2400m.

S.No.	Species	Density (m^{-2})	Frequency(%)	Abundance	A/F	IVI
1.	*Berberis lycium* Royle	1250.00	30.00	3.75	0.125	19.69
2.	*Buddleja paniculata* Wall.	194.44	5.00	3.50	0.700	3.20
3.	*Cotoneaster microphyllus* Wall.ex Lindley.	1361.11	30.00	4.08	0.136	26.56
4.	*Daphne cannabina.* Lour.ex Wall.	611.11	22.50	2.44	0.109	11.50
5.	*Desmodium tiliaefolium* Don.	83.33	2.50	3.00	1.200	1.55
6.	*Hypericum oblongifolium* Choisy	27.78	2.50	1.00	0.400	0.92
7.	*Ilex dipyrena* *Wall.	83.33	5.00	1.50	0.300	2.24
8.	*Indigofera heterantha* Wall ex Brandis.	2472.22	27.50	8.09	0.294	29.84
9	*Neolitsea pallens** (D.Don.)Momiyama & Hara	305.56	10.00	2.75	0.275	5.57
10.	*Persea duthiei** (King. ex Hook.f.) Kostern	83.33	2.50	3.00	1.200	1.65
11.	*Quercus dilatata* *Lindl.	527.78	15.00	3.16	0.211	9.32
12.	*Quercus leucotrichophora* *A.Camus.	27.78	2.50	1.00	0.400	1.20
13	*Rabdosia rugosa* (Wall ex Benth.) Hara.	555.56	10.00	5.00	0.500	6.67
14.	*Rhamnus virgatus* (Roxb.) Lawson.	166.67	10.00	1.50	0.150	4.48
15.	*Rosa macrophylla* Lindley.	1777.78	22.50	7.11	0.316	34.58
16.	*Rubus niveus* Wall.	805.56	25.00	2.90	0.116	13.54
17.	*Salix tetrasperma* *Roxb.	333.33	5.00	6.00	1.200	5.64
18.	*Sarcococca saligna* (D.Don.) Muell.Arg	2555.56	25.00	9.20	0.368	27.44
19.	*Sorbaria tomentosa* (Lindley) Rehder.	1277.78	17.50	6.57	0.376	21.13
20.	*Spiraea canescens* D.Don.	1222.22	25.00	4.40	0.176	26.50
21.	*Ventilago denticulata* Willd.	111.11	2.50	4.00	1.600	1.82
22.	*Viburnum erubescens* Wall.ex DC	3000.00	52.50	5.14	0.098	44.97

*****Saplings

Table 6: Phytosciological attributes of herb species in Khajjiar beat at an altitudinal zonation of 2200m-2400m.

S.No.	Species	Density (m^{-2})	Frequency(%)	Abundance	A/F	IVI
1.	*Achillea millefolium* Linn.	0.23	10.00	2.3	0.233	3.12
2.	*Ainsliaea latifolia* (D.Don.) Sch.Bip.	0.10	3.33	3.0	0.900	1.26
3.	*Ajuga bracteosa* Wall.ex Benth.	0.30	13.33	2.3	0.169	7.95
4.	*Amaranthus paniculatus* Linn.	0.10	3.33	3.0	0.900	1.71
5.	*Anaphalis triplinervis* (Sims) C.B.Clarke	1.93	40.00	4.8	0.121	14.08
6.	*Androsace lanuginosa* Hardw.	0.20	6.67	3.0	0.450	1.85
7.	*Anemone obtusiloba* D.Don.	0.03	3.33	1.0	0.300	0.80
8.	*Aquilegia pubiflora* Wall.	0.23	10.00	2.3	0.233	3.12
9	*Arisaema intermedium* Blume	0.60	33.33	1.8	0.054	15.68
10.	*Artemisia parviflora* Roxb.	0.37	10.00	3.7	0.367	4.12
11.	*Aster molliusculus* Wall	0.17	6.67	2.5	0.375	1.53
12.	*Bergenia ciliata* (Haw.)Sternb.	1.17	20.00	5.8	0.292	19.19
13	*Bidens pilosa* Linn.	0.17	6.67	2.5	0.375	1.68
14.	*Bistorta amplexicaulis* (D.*Don.) Greene.*	0.73	30.00	2.4	0.081	10.34
15.	*Boenninghausenia albiflora* (Hook.) Reichb ex Meissner.	0.50	13.33	3.8	0.281	4.28
16.	*Cirsium wallichii* DC.	0.13	10.00	1.3	0.133	4.35
17.	*Commelina paludosa* Blume.	0.27	6.67	4.0	0.600	2.31
18.	*Conyza stricta* Willd.	0.10	6.67	1.5	0.225	1.36
19.	*Digitalis purpurea* Linn.	0.17	6.67	2.5	0.375	2.33
20.	*Epilobium laxum* Royle.	0.30	6.67	4.5	0.675	2.43
21.	*Erigeron alpinus* Linn.	3.45	70.00	4.9	0.070	22.36
22.	*Euphorbia cognata* (Klotzsch & Garcke) Boiss.	0.17	6.67	2.5	0.375	2.51
23.	*Fragaria vesca* Coville.	1.23	33.33	3.7	0.111	8.89
24.	*Galium rotundifolium* Linn.	2.50	50.00	5.0	0.100	16.49
25.	*Geranium wallichianum* D.Don ex Sweet.	0.93	36.67	2.5	0.069	10.17
26.	*Geum elatum* Wall. ex G. Don	0.17	6.67	2.5	0.375	2.12
27.	*Gnaphalium hypoleuceum* DC.	0.17	6.67	2.5	0.375	1.73
28.	*Gypsophila cerastioides*.D.Don.	0.60	13.33	4.5	0.338	5.31
29.	*Habenaria pectinata* D. Don.	0.13	6.67	2.0	0.300	1.73
30.	*Hedychium spicatum* Smith.	0.10	3.33	3.0	0.900	2.19
31.	*Impatiens sulcata* Wall.	0.17	6.67	2.5	0.375	2.14
32.	*Lactuca dissecta* D. Don	1.48	43.33	3.4	0.079	12.29
33.	*Lecanthus peduncularis* (Royle) Wedd.	0.23	6.67	3.5	0.525	2.23
34.	*Micromeria biflora* (Buch.-Ham. ex D.Don.)Benth.	0.42	6.67	6.3	0.938	2.79
35.	*Oplismenus compositus* (Linn.) Beauv.	0.83	16.67	5.0	0.300	5.23
36.	*Persea duthiei*** (King ex Hook.f.) Kosterm.	0.08	3.33	2.5	0.750	2.09

Continued….

S.No.	Species	Density (m^{-2})	Frequency(%)	Abundance	A/F	IVI
37.	*Lecanthus peduncularis* (Royle) Wedd.	0.91	25.00	3.67	0.147	4.33
38.	*Melilotus alba* Lam.	0.33	16.67	2.00	0.120	2.16
39.	*Micromeria biflora* - (Buch.-Ham. ex D.Don.)Benth	0.66	16.67	4.00	0.240	2.93
40.	*Oplismenus compositus* (Linn.) P.Beauv.	4.00	66.67	6.00	0.090	13.14
41.	*Oxalis corniculata* Linn.	5.16	58.33	8.86	0.152	14.34
42.	*Paris polyphylla* Smith.	0.50	33.33	1.50	0.045	6.41
43.	*Persea duthiei*** (King ex Hook.f.) Kosterm.	0.08	8.33	1.00	0.120	1.74
44.	*Pilea scripta* (Buch.-Ham. ex D.Don.) Wedd.	2.41	50.00	4.83	0.097	11.25
45.	*Plantago lanceolata* Linn.	1.25	41.67	3.00	0.072	6.36
46.	*Podophyllum hexandrum* Royle	0.41	25.00	1.67	0.067	5.52
47.	*Polygonum capitata* Buch.-Ham. ex D. Don	5.25	25.00	21.00	0.840	18.40
48.	*Pteracanthus urticifolious* (Kuntze.)Bremek.	0.33	8.33	4.00	0.480	2.17
49.	*Ranunculus diffusus* DC.	0.58	25.00	2.33	0.093	3.33
50	*Rubia cordifolia* (Hook.f.) Linn.	0.41	16.67	2.50	0.150	2.40
51.	*Rubus niveus*** Wall.	0.16	8.33	2.00	0.240	1.26
52.	*Rumex nepalensis* Sperng.	0.33	16.67	2.00	0.120	5.03
53.	*Smilacina purpurea* Wall.	0.16	16.67	1.00	0.060	1.72
54.	*Smilax aspera* Linn.	0.08	8.33	1.00	0.120	0.88

******Regeneration

In case of herbs including regeneration, total number of herb species was 54 (Table 6) at elevation of 2200m-2400m. *Erigeron alpinus* was the dominant species having highest value for density (3.45m^{-2}) and frequency (70.0%) followed by *Galium rotundifolium* (2.50m^{-2}) and *Anaphalis triplinervis* (1.93m^{-2}). In case of abundance, *Trifolium repens* recorded the maximum value (7.2) followed by *Bergenia ciliata* (5.80)*, Galium rotundifolium* (5.00) and *Oplismenus composites* (5.00). *Erigeron alpinus* recorded the highest value of IVI (22.36) followed by *Bergenia ciliata* (19.19) and *Rumex nepalensis* (18.92). The lowest value of IVI (0.80) was observed for *Anemone obtusiloba*. The distribution pattern of all the species was contiguous. 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 is 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*., 2004). The lower value of dominance shows that dominance of plants is shared by many 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 higher value of evenness indices indicates that species are evenly distributed in this region. The nature of plant community at a place is determined by the species that grow and develop in such environment (Bliss, 1962).

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 Khajjiar beat of the sanctuary.

Altitude	Plant Category	Concentration of Dominance (C)	Diversity Index (H)	Richness Index (R)	Evenness Index (E)
2000-2200m	Tree	0.239	1.371	1.037	0.765
	Shrub	0.356	1.506	1.204	0.685
	Herb	0.014	3.498	7.298	0.543
2200-2400m	Tree	0.486	1.113	2.157	0.464
	Shrub	0.085	2.581	3.221	0.818
	Herb	0.037	3.457	7.119	0.866

Index of similarity and dissimilarity for trees, shrubs and herbs at different altitudes of Khajjiar beat in Kalatop Wildlife sanctuary of District Chamba (H.P.).

Altitudes		2200-2400
Trees	2000-2200	0.58(0.42)
Shrubs	2000-2200	0.51(0.49)
Herbs	2000-2200	0.68(0.32)

MEDICINAL AND THREATENED PLANTS

The important plants of medicinal value found in Khajjiar beat of Kalatop-Khajjiar wild life sanctuary in district Chamba of Himachal Pradesh were compiled following Chopra *et al* (1956), Kirtikar and Basu (1987) and Kala (2002). These include; *Achillea millefolium, Achyranthes aspera, Acorus calamus,Aesculus indica*, *Ajuga bracteosa, Anaphalis contorta, Anaphalis triplinervis, Anemone obtusiloba, Aquilegia pubiflora, Artemisia parviflora, Aster molliusculus, Berberis lycium, Bergenia ciliata, Boenninghausenia albiflora, Cirsium wallichii, Cynoglossum micranthum, Digitalis purpurea, Dioscorea deltoidea, Erigeron alpinus, Erigeron multiradiatus, Euphorbia cognata, Fragaria vesca, Galium asperifolium, Geum elatum*, *Geranium wallichianum, Hedychium spicatum, Lactuca dissecta, Micromeria biflora, Oxalis corniculata, Paris polyphylla, Plantago lanceolata*, *Podophyllum hexandrum, Polygonum capitata, Primula denticulata, Ranunculus diffusus*, *Rhamnus virgatus, Rosa macrophylla*, *Rubia cordifolia, Rumex nepalensis*, *Salvia lanata, Sarcococca saligna, Senecio graciliflora, Smilax aspera, Taraxacum officinale, Trifolium repens, Urtica dioica, Valeriana jatamansii* and *Viola canescens* . Out of 48 medicinal plant species recorded from the area, 2 species i.e. *Dioscorea deltoidea* and *Podophyllum hexandrum* 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, *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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