

Assessment of Plant Diversity in Fatehpur Beat of Shikari Devi Wild Life Sanctuary of District Mandi, Himachal Pradesh

R.K. Verma* and K.S. Kapoor
Himalayan Forest Research Institute,
Conifer Campus, Panthaghati
Shimla-171013 (Himachal Pradesh), India

(Corresponding author: R.K. Verma)

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ABSTRACT: A study was conducted to understand the plant diversity along an altitudinal gradient with elevations varying from 2400-3300m above msl in Fatehpur beat of Shikari Devi wild life sanctuary of district Mandi, Himachal Pradesh during 2016. Total 159 plant species belonging to 47 families and 93 genera were recorded from the study area. The dominant families were Rosaceae, Compositae, Polygonaceae, Labiatae and Leguminosae. The number of tree species was 9, 4 and 5 with the dominance of *Abies pindrow*, *Picea smithiana* and *Quercus semecarpifolia* at 2400-2700, 2700-3000 and 3000-3300 m elevation respectively. The number of shrub species was 10, 8 and 8 at the elevation of with the dominance of *Berberis lycium*, *Berberis lycium* and *Salix denticulata* at 2400-2700, 2700-3000 and 3000-3300 m elevation respectively. The number of herbs species was 37, 36 and 42 at 2400-2700, 2700-3000 and 3000-3300 m elevation with the dominance of *Valeriana jatamansi*, *Iris kemaonensis* and *Anaphalis triplinervis* respectively. The distribution pattern of species was mostly contiguous in all the altitude ranges. Index of diversity for herb was 3.42, 3.45 and 3.50 for 2400-2700, 2700-3000 and 3000-3300 m elevation respectively. Out of 60 medicinal plant species recorded from the area, 4 species i.e. *Angelica glauca*, *Polygonatum verticillatum* *Rhododendron campanulatum* and *Taxus wallichiana* fall in the category of threatened plants. 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: Diversity, Dominance, Diversity index, Conservation, Distribution.

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INTRODUCTION

India is one of the world's top 12 mega-diversity Nations and out of its total plant wealth, about 15,000 species of flowering plants have been described. This biological diversity providing subsistence to the human race in terms of food, medicine, housing, etc. is being continuously depleted due to intense anthropogenic pressures. It has been observed that nearly 1,000 plant species are put in the categories of medicinal and wild relatives of economically important crops and fruit trees those are under the threat of extinction. 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 varied environmental conditions prevailing in the Himalayas support diverse habitat and ecosystems with diverse life forms. 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. 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-site and ex-situ conservation.

Shikari Devi wildlife sanctuary was established in 1974 in Mandi district of Himachal Pradesh. It covers an area of about 3,065 ha. Altitude of this sanctuary varies from 1800 to 3350 m above msl whereas the climate ranges from temperate to alpine. The sanctuary represent the flora of temperate to alpine climate and inhabitants of villages in and around the sanctuary have got their rights pertaining to grazing, collection of timber, fuel wood, fodder, pine needles and other minor forest produce. In addition, graziers 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. Keeping this in view attempts were made to assess the plant diversity including documentation of the medicinal plants found in Fatehpur Beat of Shikari Devi wild life sanctuary of district Mandi, Himachal Pradesh.

MATERIALS AND METHODS

The present study was conducted in Fatehpur beat of Shikari Devi wild life sanctuary in district Mandi of Himachal Pradesh during, 2016 at an elevation of 2400-3300m. The study site was situated at N 31° 30' 00.2" to N 31° 28' 45.6" latitude and E 76° 11' 34.9" to E 77° 10' 01.1" longitudes. The whole area of the valley was divided into three altitudes i.e. 2400-2700m, 2700-3000m and 3000-3300m for conducting the phytosociological study. Quadrats of size 10m×10m, 3m×3m and 1m×1m 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).

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

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

Total 159 plant species belonging to 47 families and 93 genera were recorded from the study area. The dominant families were Rosaceae, Compositae, Ploygonaceae, Labiatae and Leguminosae. At an elevation of 2400-2700m, the total number of tree species was 9 (Table 1). *Picea smithiana* was the dominant species having maximum density (300.00ha⁻¹), abundance (3.33) and frequency (90.00%). This was followed by *Abies pindrow* (255.00 ha⁻¹) in terms of density. *Abies pindrow* observed the highest value of IVI (80.25) followed by *Picea smithiana* (61.81). At this elevation the community identified was *Picea smithiana- Abies pindrow*. The A/F ratio indicates that the distribution pattern of all the species was random and contiguous. The random distribution is the commonest pattern in nature whereas, contiguous 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, Radha and Puri 2018; Kumar and Duggal 2019).

Table 1: Phytosociological attributes of the tree species in Fatehpur Beat at an altitudinal zonation of 2400-2700m.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1	<i>Abies pindrow</i> Royle	255.00	75.00	3.40	0.045	80.25
2	<i>Acer acuminatum</i> Wall. ex D. Don	145.00	60.00	2.42	0.040	25.36
3	<i>Aesculus indica</i> (Wall. ex Cambess.) Hook	100.00	35.00	2.86	0.082	24.68
4	<i>Juglans regia</i> Linn.	165.00	80.00	2.06	0.026	37.21
5	<i>Picea smithiana</i> (Wall.) Boiss	300.00	90.00	3.33	0.037	61.81
6	<i>Populus ciliata</i> Wall. ex Royle.	45.00	20.00	2.25	0.113	14.08
7	<i>Prunus cornuta</i> (Wall. ex. Royle) Steudel	110.00	45.00	2.44	0.054	19.77
8	<i>Pyrus pashia</i> Buch-Ham. ex D.Don.	135.00	45.00	3.00	0.067	21.63
9	<i>Quercus semecarpifolia</i> Sm.	100.00	35.00	2.86	0.082	15.22

At this elevation, the total number of shrub species was 10 (Table 2). *Sarcococca saligna* was the dominant species having maximum density (2777.78 ha⁻¹) and abundance (9.17) followed by *Berberis lycium* (1666.67 ha⁻¹) in terms of density. In term of frequency, *Berberis lycium* recorded the highest value (77.50%) followed by *Rosa macrophylla* (45.00). *Berberis lycium* observed the highest value of IVI (53.65) followed by *Cotoneaster microphyllus* (49.15). The A/F ratio indicates that the distribution pattern of all the species except *Berberis lycium* was contiguous. The general preponderance of contiguous distribution in vegetation has been reported by several workers (Verma & Kapoor, 2014; Verma, 2015; Verma, 2016).

At an elevation of 2500-2800m, total number of herb species was 37 (Table 3). *Valeriana jatamansii* was the dominant species having maximum density (4.33 m⁻²) and frequency (70.00%) followed by *Fragaria vesca* (3.62 m⁻²) in term of density. In term of abundance, *Iris kemaonensis* recorded the highest value (6.29) followed by *Valeriana jatamansii* (6.19). *Valeriana jatamansii* observed the highest value of IVI (43.99) followed by *Lecanthus peduncularis* (18.00) and *Salvia nubicola* (14.35). The A/F ratio indicates that the distribution pattern of all the species except *Arisaema intermedium* and *Polygonum capitata* was contiguous. The value of diversity index for tree, shrub and herb were 1.96, 2.20 and 3.42 respectively.

Table 2: Phytosociological attributes of the shrub species in Fatehpur Beat at an altitudinal zonation of 2400-2700m.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Arundinaria falcata</i> Nees.	750.00	17.50	3.75	0.214	17.82
2.	<i>Berberis lycium</i> Royle.	1666.67	77.50	1.94	0.025	53.65
3.	<i>Callicarpa macrophylla</i> Vahl.	1250.00	40.00	6.22	0.156	27.54
4.	<i>Cotoneaster microphyllus</i> Wall. ex Lindley	1527.78	27.50	5.00	0.182	49.15
5.	<i>Daphne cannabina</i> . Lour.ex Wall.	972.22	32.50	2.71	0.084	21.83
6.	<i>Indigofera heterantha</i> Wall. ex Brandis.	750.00	27.50	2.50	0.091	16.97
7.	<i>Rosa macrophylla</i> Lindl.	1166.67	45.00	2.30	0.051	31.65
8.	<i>Salix denticulata</i> Anderson	666.67	17.50	3.25	0.186	17.21
9.	<i>Sarcococca saligna</i> (D.Don.) Muell.Arg	2777.78	27.50	9.17	0.333	45.53
10.	<i>Viburnum erubescens</i> Wall.ex DC	611.11	27.50	2.00	0.073	18.66

At an elevation of 2700-3000m, the total number of tree species was 4 (Table 4). *Picea smithiana* was the dominant species having maximum density (350.00ha⁻¹) and frequency (85.00%). This was followed by *Abies pindrow* (300.00ha⁻¹) in terms of density. In case of abundance, *Abies pindrow* recorded the highest value (5.00) followed by *Picea smithiana* (4.12). *Picea smithiana* observed the highest value of IVI (141.02) followed by *Abies pindrow* (94.40) and *Quercus semecarpifolia* (40.42). At this elevation the community identified was *Picea smithiana*- *Abies pindrow*. The A/F ratio indicates that the distribution pattern of all the species except *Picea smithiana* was contiguous.

At this elevation, total number of shrub species was 8 (Table 5). *Berberis lycium* was the dominant species having maximum density (3111.11ha⁻¹) and frequency (100.00%). This was followed by *Cotoneaster microphyllus* (2444.44 ha⁻¹) in terms of density. In term of abundance, *Cotoneaster microphyllus* recorded the highest value (5.50) followed by *Daphne cannabina* (3.73). *Berberis lycium* observed the highest value of

IVI (54.18) followed by *Viburnum erubescens* (45.82). The A/F ratio indicates that the distribution pattern of all the species except *Berberis lycium* was contiguous.

At an elevation of 2500-2800m, total number of herb species was 36 (Table 6). *Trifolium repens* was the dominant species having maximum density (4.65 m⁻²) and abundance (10.73) followed by *Anaphalis triplinervis* (2.40 m⁻²) and *Fragaria vesca* (2.22 m⁻²) in term of density. In case of frequency, *Geranium wallichianum* and *Rumex nepalensis* observed the highest value (53.33%) followed by *Anaphalis triplinervis* (50.00%). *Iris kemaonensis* observed the highest value of IVI (24.48) followed by *Anaphalis triplinervis* (17.46) and *Trifolium repens* (16.85). The A/F ratio indicates that the distribution pattern of the species was contiguous and random. The value of diversity index for tree, shrub and herb were 1.19, 2.03 and 3.45 respectively.

At an elevation of 3000-3300m, the total number of tree species was 5 (Table 7).

Table 3: Phytosociological attributes of the herb species in Fatehpur Beat at an altitudinal zonation of 2400-2700m.

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Actaea spicata</i> Linn.	1.33	33.33	4.00	0.120	8.62
2.	<i>Ajuga bracteosa</i> Wall ex Benth.	0.70	26.67	2.63	0.098	5.65
3.	<i>Anaphalis triplinervi</i> (Sims) C. B. Clarke	0.70	11.67	6.00	0.514	4.42
4.	<i>Angelica glauca</i> Edgew	0.27	11.67	2.29	0.196	2.35
5.	<i>Ainsliaea latifolia</i> (D. Don) Sch. Bip.	1.50	46.67	3.21	0.069	13.79
6.	<i>Arisaema intermedium</i> Blume.	0.80	41.67	1.92	0.046	8.45
7.	<i>Bergenia stracheyi</i> (Hook. f. & Thoms.) Engl.	0.42	26.67	1.56	0.059	3.86
8.	<i>Bistorta amplexicaulis</i> (D.Don.) Greene	0.62	15.00	4.11	0.274	3.25
9.	<i>Cirsium wallichii</i> DC	0.47	15.00	3.11	0.207	3.95
10.	<i>Cynoglossum micranthum</i> Desf.	0.70	30.00	2.33	0.078	6.99
11.	<i>Desmodium tiliaefolium</i> Don.	0.30	20.00	1.50	0.075	3.21
12.	<i>Epilobium laxum</i> Royle.	1.12	35.00	3.19	0.091	7.67
13.	<i>Fragaria vesca</i> Coville.	3.73	58.33	6.40	0.110	16.72
14.	<i>Geranium wallichianum</i> D.Don ex Sweet.	0.58	26.67	2.19	0.082	4.50
15.	<i>Geum elatum</i> Wall. ex G. Don	0.80	23.33	3.43	0.147	4.58
16.	<i>Impatiens sulcata</i> Wall.	0.23	11.67	2.00	0.171	2.14
17.	<i>Impatiens urticifolia</i> Wall.	0.85	26.67	3.19	0.120	5.44
18.	<i>Iris kemaonensis</i> D.Don ex Royle	1.47	23.33	6.29	0.269	13.28
19.	<i>Lecanthus peduncularis</i> (Royle) Wedd.	2.70	61.67	4.38	0.071	18.00
20.	<i>Nepeta erecta</i> Benth.	0.73	26.67	2.75	0.103	10.61
21.	<i>Oxalis corniculata</i> Linn.	0.35	23.33	1.50	0.064	3.74
22.	<i>Parochetus communis</i> Buch.-Ham. ex D. Don	0.65	20.00	3.25	0.163	4.12
23.	<i>Pilea scripta</i> Wedd.	0.73	23.33	3.14	0.135	7.01
24.	<i>Plantago lanceolata</i> Linn	1.27	26.67	4.75	0.178	12.07
25.	<i>Polygonum capitata</i> Buch-Ham.ex D.Don.	1.62	61.67	2.62	0.043	11.35
26.	<i>Primula denticulata</i> Smith	0.50	20.00	2.50	0.125	5.31
27.	<i>Pteracanthus urticifolius</i> (Kuntze) Bremek.	0.30	11.67	2.57	0.220	2.72
28.	<i>Ranunculus diffusus</i> DC.	0.85	35.00	2.43	0.069	6.76
29.	<i>Salvia nubicola</i> Wall. ex Sweet	1.47	53.33	2.75	0.052	14.19
30.	<i>Senecio graciliflorus</i> DC.	0.47	20.00	2.33	0.117	3.55
31.	<i>Silene viscosa</i> (Linn.) Pers.	1.20	23.33	5.14	0.220	6.20
32.	<i>Swertia purpurascens</i> Wall.	1.50	65.00	2.31	0.036	12.83
33.	<i>Taraxacum officinale</i> F.H.Wigg	0.47	8.33	5.60	0.672	2.47
34.	<i>Thalictium alpinum</i> Linn.	0.38	15.00	2.56	0.170	3.49
35.	<i>Trifolium repens</i> Linn	0.70	23.33	3.00	0.129	8.21
36.	<i>Urtica dioica</i> Linn.	0.73	15.00	4.89	0.326	4.18
37.	<i>Valeriana jatamansii</i> Jones	4.33	70.00	6.19	0.088	43.99

Table 4: Phytosociological attributes of the tree species in Fatehpur Beat at an altitudinal zonation of 2700-3000m.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Abies pindrow</i> Royle	300.00	60.00	5.00	0.083	94.40
2.	<i>Cedrus deodara</i> (Roxb. ex D. Don) G. Don	50.00	25.00	2.00	0.080	24.16
3.	<i>Picea smithiana</i> (Wall.)Boiss	350.00	85.00	4.12	0.048	141.02
4.	<i>Quercus semecarpifolia</i> Sm.	135.00	40.00	3.38	0.084	40.42

Table 5: Phytosociological attributes of the shrub species in Fatehpur Beat at an altitudinal zonation of 2700-3000m.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Arundinaria falcata</i> Nees.	1666.67	50.00	3.00	0.060	46.04
2.	<i>Berberis lycium</i> Royle.	3111.11	100.00	2.80	0.028	54.18
3.	<i>Callicarpa macrophylla</i> Vahl.	1500.00	40.00	3.38	0.084	27.45
4.	<i>Cotoneaster microphyllus</i> Wall. ex Lindley	2444.44	40.00	5.50	0.138	43.30
5.	<i>Daphne cannabina</i> . Lour.ex Wall.	2277.78	55.00	3.73	0.068	36.64
6.	<i>Prinsepia utilis</i> Royle.	944.44	40.00	2.13	0.053	20.85
7.	<i>Rosa macrophylla</i> Lindl.	1222.22	35.00	3.14	0.090	25.26
8.	<i>Viburnum erubescens</i> Wall.ex DC	1944.44	55.00	3.18	0.058	46.29

Table 6: Phytosociological attributes of the herb species in Fatehpur Beat at an altitudinal zonation of 2700-3000m.

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Anaphalis triplinervis</i> (Sims) C. B. Clarke	2.40	50.00	4.80	0.096	17.46
2.	<i>Anemone obtusiloba</i> D.Don.	1.40	40.00	3.50	0.088	9.60
3.	<i>Ariseama intermedium</i> Blume.	0.32	31.67	1.00	0.032	4.31
4.	<i>Arundinaria falcata</i> ** Nees.	0.65	18.33	3.55	0.193	6.62
5.	<i>Calanthe tricarinata</i> Lindley	0.85	28.33	3.00	0.106	5.78
6.	<i>Campanula latifolia</i> Linn.	0.57	35.00	1.62	0.046	5.98
7.	<i>Chaerophyllum reflexum</i> Lindley.	0.35	31.67	1.11	0.035	5.45
8.	<i>Circium wallichii</i> DC.	1.03	35.00	2.95	0.084	12.22
9.	<i>Cynoglossum micranthum</i> Desf.	0.68	35.00	1.95	0.056	5.62
10.	<i>Desmodium triflorum</i> (Linn.) DC.	0.72	35.00	2.05	0.059	7.03
11.	<i>Deutzia corymbosa</i> **R. Br.	0.68	28.33	2.41	0.085	4.82
12.	<i>Fragaria vesca</i> Coville.	2.22	28.33	7.82	0.276	8.65
13.	<i>Geranium wallichianum</i> D.Don ex Sweet	1.35	53.33	2.53	0.047	11.46
14.	<i>Iris kemaonensis</i> D.Don ex Royle	2.07	25.00	8.27	0.331	24.48
15.	<i>Lactuca lessertiana</i> (DC) C. B. Clarke	1.00	28.33	3.53	0.125	6.40
16.	<i>Nepeta erecta</i> Benth.	0.75	43.33	1.73	0.040	6.02
17.	<i>Origanum vulgare</i> Linn.	0.53	21.67	2.46	0.114	5.21
18.	<i>Phytolacca decandra</i> Linn.	0.53	40.00	1.33	0.033	5.41

Continued...

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
19.	<i>Pilea scripta</i> Wedd.	0.60	21.67	2.77	0.128	5.10
20.	<i>Plantago lanceolata</i> Linn.	1.43	25.00	5.73	0.229	6.87
21.	<i>Polygonatum verticillatum</i>	0.40	31.67	1.26	0.040	3.90
22.	<i>Polygonatum verticillatum</i> (Linn.) All.	1.07	40.00	2.67	0.067	8.60
23.	<i>Potentilla fruticosa</i> Linn.	0.65	31.67	2.05	0.065	4.75
24.	<i>Primula denticulata</i> Smith.	0.65	28.33	2.29	0.081	4.08
25.	<i>Ranunculus diffusus</i> DC.	0.40	31.67	1.26	0.040	5.15
26.	<i>Rumex nepalensis</i> Spreng.	2.32	53.33	4.34	0.081	14.85
27.	<i>Salvia nubicola</i> Wall. ex Sweet	1.00	40.00	2.50	0.063	8.53
28.	<i>Selinum vaginatum</i> C. B. Clarke	0.47	25.00	1.87	0.075	3.67
29.	<i>Senecio graciliflora</i> (Wall.) DC.	0.43	35.00	1.24	0.035	6.24
30.	<i>Swertia purpurascens</i> Wall.	0.43	25.00	1.73	0.069	5.77
31.	<i>Taraxacum officinale</i> Wigg	0.47	20.00	2.33	0.117	3.35
32.	<i>Thalictrum foliosum</i> .DC.	0.93	50.00	1.87	0.037	8.27
33.	<i>Trifolium repens</i> Linn.	4.65	43.33	10.73	0.248	16.85
34.	<i>Urtica dioica</i> Linn.	1.78	40.00	4.46	0.111	12.70
35.	<i>Valeriana jatamansii</i> Jones	3.00	50.00	6.00	0.120	16.38
36.	<i>Viola canescens</i> Wall. ex Roxb.	1.85	46.67	3.96	0.085	12.63

Note=**Regeneration

Table 7: Phytosociological attributes of the tree species in Fatehpur Beat at an altitudinal zonation of 3000-3100m.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Abies pindrow</i> Royle	20.00	10.00	2.00	0.200	9.27
2.	<i>Picea smithiana</i> (Wall.) Boiss	180.00	55.00	3.27	0.060	97.84
3.	<i>Prunus cornuta</i> (Wall. ex. Royle) Steudel	20.00	10.00	2.00	0.200	8.51
4.	<i>Quercus semecarpifolia</i> Sm.	535.00	80.00	6.69	0.084	163.84
5.	<i>Taxus wallichiana</i> Zucc.	45.00	25.00	1.80	0.072	20.54

Table 8: Phytosociological attributes of the shrub species in Fatehpur Beat at an altitudinal zonation of 3000-3100m.

S. No.	Species	Density (ha ⁻¹)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Berberis lycium</i> Royle.	888.89	20.00	4.00	0.200	19.61
2.	<i>Cotoneaster microphyllus</i> Wall. ex Lindley	2055.56	15.00	12.33	0.822	26.86
3.	<i>Picea smithiana</i> (Wall.) Boiss	500.00	20.00	2.25	0.113	14.32
4.	<i>Quercus semecarpifolia</i> *Sm.	666.67	20.00	3.00	0.150	16.47
5.	<i>Rhododendron campanulatum</i> D. Don	4222.22	35.00	10.86	0.310	76.81
6.	<i>Rosa macrophylla</i> Lindl.	611.11	25.00	2.20	0.088	20.69
7.	<i>Salix denticulata</i> *Anderson	8833.33	35.00	22.71	0.649	103.67
8.	<i>Viburnum erubescens</i> Wall ex DC	722.22	25.00	2.60	0.104	21.58

Note= *Sapling

Quercus semecarpifolia was the dominant species having maximum density (535.00 ha⁻¹), abundance (6.69) and frequency (80.00%). This was followed by *Picea smithiana* (180.00 ha⁻¹) in terms of density. *Quercus semecarpifolia* observed the highest value of IVI (163.84) followed by *Picea smithiana* (97.84) and *Taxus wallichiana* (20.54). At this elevation the community identified was *Quercus semecarpifolia* - *Picea smithiana*. The A/F ratio indicates that the distribution pattern of all the species was contiguous. The general preponderance of contiguous distribution in vegetation has been reported by several workers (Verma & Kapoor, 2016; Verma, 2016; Verma, 2017). At this elevation, the total number of shrub species was 8 (Table 8). *Salix denticulata* was the dominant species having maximum density (8833.33 ha⁻¹), frequency (35.00%) and abundance (22.71). This was followed by *Rosa macrophylla* (4222.22 ha⁻¹) in terms of density. *Salix denticulata* observed the highest value of IVI (103.67) followed by *Rhododendron arboreum* (76.81) and *Cotoneaster microphyllus* (26.86). The A/F ratio indicates that the distribution pattern of all the species was contiguous.

At an elevation of 3000-3300m, total number of herb species was 42 (Table 9). *Anaphalis triplinervis* was the dominant species having maximum density (4.90 m⁻²) and frequency (76.67%). This was followed by *Tanacetum dolichophyllum* (4.00 m⁻²) in term of density. In case of abundance, *Trifolium repens*

observed the highest value (13.33) followed by *Bergenia stracheyi* (9.89). *Anaphalis triplinervis* observed the highest value of IVI (27.56) followed by *Plantago lanceolata* (21.34) and *Primula denticulata* (20.60). The A/F ratio indicates that the distribution pattern of all the species was contiguous. The value of diversity index for tree, shrub and herb were 1.09, 1.78 and 3.48 respectively. The value of dominance index (C), index of diversity (H), richness index (R), Evenness Index (E) for trees, shrubs and herbs at different altitudes is given in Table 10. The higher the value of dominance index, the greater is the homogenous nature of the community and vice-versa. In other words, such communities are dominated by single species (Kohli *et al.*, 2004). The lower value of dominance shows that dominance of plant 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 the value of index of diversity indicates the variability in the type of species and heterogeneity in communities, whereas, the lesser value points to the homogeneity in the community. The higher value of richness index indicates higher diversity of the species. The altitudinal ranges having high evenness indicates that species are evenly distributed in those elevations.

Table 9: Phytosociological attributes of the herb species in Fatehpur Beat at an altitudinal zonation of 3000-3100m.

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
1.	<i>Aconogonum alpinum</i> (All.) Schur	0.62	15.00	4.11	0.274	5.70
2.	<i>Anaphalis triplinervis</i> (Sims) C.B. Clarke	4.90	76.67	6.39	0.083	27.56
3.	<i>Anemone obtusiloba</i> D.Don	0.72	10.00	7.17	0.717	4.58
4.	<i>Arisaema flavum</i> (Forsk.) Scott.	0.15	10.00	1.50	0.150	1.66
5.	<i>Bergenia stracheyi</i> (Hook. f. & Thoms.) Engl	1.48	15.00	9.89	0.659	8.85
6.	<i>Chaerophyllum reflexum</i> Lindl	0.23	10.00	2.33	0.233	2.14
7.	<i>Cirsium wallichii</i> DC.	0.33	15.00	2.22	0.148	3.50
8.	<i>Corydalis cornuta</i> Royle	0.18	10.00	1.83	0.183	2.41
9.	<i>Cynoglossum furcatum</i> Wall.ex Roxb.	0.28	15.00	1.89	0.126	3.51
10.	<i>Delphinium brunonianum</i> Royle	0.28	18.33	1.55	0.084	3.73
11.	<i>Desmodium triflorum</i> (Linn.) DC.	0.85	10.00	8.50	0.850	4.88
12.	<i>Epilobium laxum</i> Royle.	1.48	33.33	4.45	0.134	8.04
13.	<i>Eragrostis viscosa</i> (Retzius) Trin	0.95	10.00	9.50	0.950	6.13
14.	<i>Fragaria vesca</i> Coville.	0.85	18.33	4.64	0.253	5.80
15.	<i>Geranium wallichianum</i> D.Don ex Sweet.	0.72	18.33	3.91	0.213	5.21
16.	<i>Geum elatum</i> Wall.	3.33	50.00	6.67	0.133	17.96
17.	<i>Impatiens urticifolia</i> Wall.	0.90	18.33	4.91	0.268	6.58
18.	<i>Pedicularis hoffmeisteris</i> Klotzsch	0.23	10.00	2.33	0.233	2.63
19.	<i>Persicaria capitata</i> (Buch-Ham. Ex D. Don) H Gross	0.15	5.00	3.00	0.600	1.91
20.	<i>Phlomis bracteosa</i> Royle ex Benth.	0.23	15.00	1.56	0.104	3.00
21.	<i>Plantago lanceolata</i> Linn.	3.23	38.33	8.43	0.220	21.34

Continued...

S. No.	Species	Density (m ⁻²)	Frequency (%)	Abundance	A/F	IVI
22.	<i>Pleurospermum candollei</i> (DC.) C. B. Clarke	0.38	15.00	2.56	0.170	3.96
23.	<i>Poa alpina</i> Linn.	2.00	26.67	7.50	0.281	8.82
24.	<i>Polygonatum verticillatum</i> (Linn.) All.	0.38	18.33	2.09	0.114	4.05
25.	<i>Polygonum capitata</i> Buch.-Ham. ex D. Don	0.62	15.00	4.11	0.274	6.61
26.	<i>Polygonum polystachya</i> (Wall. ex Meissn.) Gross	0.57	10.00	5.67	0.567	3.62
27.	<i>Potentilla atosanguinea</i> Lodd.	1.72	38.33	4.48	0.117	12.20
28.	<i>Primula denticulata</i> Smith.	2.28	56.67	4.03	0.071	20.60
29.	<i>Quercus semecarpifolia</i> ** Sm.	0.43	28.33	1.53	0.054	4.74
30.	<i>Rhododendron campanulatum</i> ** D. Don	0.18	10.00	1.83	0.183	2.21
31.	<i>Rumex nepalensis</i> Sprengel	0.48	18.33	2.64	0.144	4.93
32.	<i>Senecio graciliflora</i> (Wall.) DC.	1.00	33.33	3.00	0.090	8.32
33.	<i>Sedum trifidum</i> Wall	0.57	10.00	5.67	0.567	4.97
34.	<i>Sibbaldia parviflora</i> Willd.	1.18	28.33	4.18	0.147	9.39
35.	<i>Silene edgeworthii</i> Bocquet	0.38	18.33	2.09	0.114	4.33
36.	<i>Swertia purpurascens</i> Wall.	2.15	38.33	5.61	0.146	14.21
37.	<i>Tanacetum dolichophyllum</i> Kitam.	4.00	51.67	7.74	0.150	17.45
38.	<i>Taraxacum officinale</i> Wigg	0.38	15.00	2.56	0.170	4.27
39.	<i>Thalictrum foliosum</i> .DC.	0.38	18.33	2.09	0.114	3.52
40.	<i>Trifolium repens</i> Linn.	1.33	10.00	13.33	1.333	4.55
41.	<i>Valeriana jatamansii</i> Jones	0.33	10.00	3.33	0.333	4.60
42.	<i>Viola canescens</i> Wall. ex Roxb.	0.57	15.00	3.78	0.252	5.86

Note= **Regeneration

Table 10: Dominance Index (C), Diversity index (H), Richness Index (R) and Evenness Index (E) for tree, shrub and herb at different elevations in Fatehpur Beat of the Sanctuary.

Name of the Site	Altitude	Plant Category	Dominance Index (C)	Diversity Index (H)	Richness Index (R)	Evenness Index (E)
Fatehpur Beat	2400-2700m	Tree	0.17	1.96	1.42	0.89
		Shrub	0.12	2.20	1.48	0.95
		Herb	0.04	3.42	4.66	0.94
	2700-3000m	Tree	0.34	1.19	0.58	0.85
		Shrub	0.14	2.03	1.11	0.97
		Herb	0.04	3.45	4.48	0.96
	3000-3300m	Tree	0.41	1.09	0.78	0.67
		Shrub	0.21	1.78	1.07	0.85
		Herb	0.04	3.50	5.21	0.93

MEDICINAL AND THREATENED PLANTS

The important plants of medicinal value found in Fatehpur beat of Shikari Devi wild life sanctuary in district Mandi of Himachal Pradesh were compiled following Chopra *et al* (1956), Kirtikar and Basu (1987) and Kala (2002). These include; *Acer acuminatum*, *Aesculus indica*, *Anaphalis triplinervis*, *Ajuga bracteosa*, *Angelica glauca*, *Anemone obtusiloba*, *Berberis lycium*, *Bergenia stracheyi*, *Bistorta amplexicaulis*, *Campanula latifolia*, *Chorthophyllum reflexum*, *Calanthe tricarinata*, *Corydalis cornuta*, *Cirsium wallichii*, *Cynoglossum micranthum*, *Cynoglossum furcatum*, *Daphne cannabina*, *Delphinium brunonianum*, *Desmodium tiliaefolium*, *Desmodium triflorum*, *Epilobium laxum*,

Fragaria vesca, *Geranium wallichianum*, *Geum elatum*, *Iris kemaonensis*, *Indigofera heterantha*, *Juglans regia*, *Nepeta erecta*, *Oxalis corniculata*, *Origanum vulgare*, *Plantago lanceolata*, *Phlomis bracteosa*, *Pleurospermum candollei*, *Polygonum capitata*, *Polygonum verticillatum*, *Polygonum polystachya*, *Potentilla fruticosa*, *Potentilla atosanguinea*, *Pteracanthus urticifolius*, *Primula denticulata*, *Prunus cornuta*, *Pyrus pashia*, *Ranunculus diffusus*, *Rhododendron campanulatum*, *Rosa macrophylla*, *Rumex nepalensis*, *Salvia nubicola*, *Sarcococca saligna*, *Sedum trifidum*, *Senecio graciliflorus*, *Swertia purpurascens*, *Tanacetum dolichophyllum*, *Taraxacum officinale*, *Taxus wallichiana*, *Thalictrum foliosum*, *Trifolium repens*, *Urtica dioica*, *Valeriana jatamansi*, *Viburnum erubescens* and *Viola canescens*.

Out of 60 medicinal plant species recorded from the area, 4 species i.e. *Angelica glauca*, *Polygonum verticillatum*, *Rhododendron campanulatum* and *Taxus wallichiana* 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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