



## Floristic Diversity Along an Altitudinal Gradient in Tandhi Dhar of Tundah Wildlife Sanctuary of District Chamba, Himachal Pradesh

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**ABSTRACT:** A study was conducted to understand the floristic diversity along an altitudinal gradient with elevations varying from 2250-3750 m above msl in Tandhi Dhar of Tundah wildlife sanctuary in district Chamba, Himachal Pradesh during 2020. The total number of plant species was 125 belonging to 113 genera and 47 families. The dominant families were Asteraceae, Fabaceae, Geraniaceae, Lamiaceae, Orchidaceae, Pinaceae and Polygonaceae. The number of tree species at 2250-2750m, 2750-3250m and 3250-3750m was 4, 3 and 4 respectively with the dominance of *Pinus wallichiana* at all elevation. The number of shrub species was 9, 9, 5 with the dominance of *Sorbaria tomentosa*, *Viburnum erubescens* and *Rhododendron campanulatum* in the elevation of 2250-2750m, 2750-3250m and 3250-3750m respectively. The number of herb species was 61, 58, and 55 at 2250-2750m, 2750-3250m and 3250-3750m elevation ranges respectively. On the basis of importance value index (IVI), *Geranium wallichianum*, *Trifolium repens* and *Anaphalis triplinervis* was the dominant herb at these elevation ranges respectively. The distribution pattern of plant species was mostly contiguous in all the altitudes ranges. Index of diversity for herb species was 3.750, 3.730 and 3.520 at 2250-2750m, 2750-3250m and 3250-3750m elevation ranges respectively. Out of 61 medicinal plant species recorded from the sanctuary, 9 species viz., *Arnebia benthamii*, *Bergenia stracheyi*, *Betula utilis*, *Dactylorhiza hatagirea*, *Juniperus communis*, *Jurinea dolomiaea*, *Polygonatum verticillatum*, *Rhododendron campanulatum* and *Selinum tenuifolium* 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.

**Keywords:** Floristic diversity, Dominance, Diversity index, Conservation, Distribution.

### INTRODUCTION

India is one of the world's top 12 mega-diversity Nations and out of its total plant wealth, about 18,000 species of flowering plants have been described. Estimates of other plant taxa include 5,000 species of algae, 1,600 lichens, 20,000 fungi, 2,700 bryophytes and 600 pteridophytes. 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 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-site and *ex-situ* conservation.

Tundah wildlife sanctuary was established in 1962 in Chamba district of Himachal Pradesh. It covers an area of about 64.22 sq km. Altitude of this sanctuary varies from 2074 m to 5500 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 Tandidhar of Tundah wild life sanctuary of district Chamba, Himachal Pradesh.

## MATERIALS AND METHODS

The present study was conducted in Tandidhar of Tundah wild life sanctuary in district Camba of Himachal Pradesh during, 2020 at an elevation of 2100-5500m. The study site was situated at N 32°31'52.4" to N 32°30'48.8" latitude and E 76° 26'58.9" to E 76° 26'11.8" longitude. The whole area of the valley was divided into three altitudes *i.e.* 2250-2750m, 2750-3250m and 3250-3750m 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).

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

Dominance Index (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

Total number of plant species was 125 belonging to 113 genera and 47 families. The dominant families were Asteraceae, Fabaceae, Geraniaceae, Lamiaceae and Orchidaceae. At an elevation of 2250-2750m, total number of tree species was 4 (Table 1). *Pinus wallichiana* was the dominant species having maximum

density (400.00 ha<sup>-1</sup>), abundance (6.15) and frequency (65.00%). This was followed by *Picea smithiana* (175.00 ha<sup>-1</sup>) in term of density. On the basis of IVI, *Pinus wallichiana* recorded the highest value (184.24) followed by *Picea smithiana* (84.25) and *Aesculus indica* (17.30). The community identified was *Pinus wallichiana-Picea smithiana* in this elevation. The ratio of abundance to frequency (A/F) 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 (Kershaw, 1973; Singh and Yadava 1974; Kunhikannan *et al.* 1998).

The plant communities are never static but are always in a changing state and their studies are of great significance for management of grassland providing valuable information on the diversity and dominance of constituent species of the communities (Santvan, 1993). Billings (1978) while studying the alpine vegetation found it most susceptible to human and animal damage through trampling, camp sites, proliferation of trails which result in exposing soil and in irreversible ecosystem changes and extinction of certain species. The A/F ratio indicates that the distribution pattern of most of the species was contiguous. However, some species showed random distribution. 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.) while working in different ecosystem. The species present in alpine pasture were analyzed for different growth form classes and the contribution of all forbs, short forbs, cushion and spreading forbs was 41.46%, 52.44% and 6.01% to the total flora. The results are in conformity with the earlier studies made by Singh (1967); Santvan (1993); Verma *et al.* (2008). In the present study, 41.46 % tall forbs, 52.44 % short forbs and 6.10% cushion and spreading forbs were observed. Similar findings were reported by different workers while conducted the study in alpine pasture. Santvan (1993) for the alpine pasture near Rahla, reported 22.5% tall forbs, 45.0% short forbs and 32.5% cushion and spreading forbs. Verma *et al.* (2008) recorded 29.33% tall forbs, 54.66% short forbs and 16.0% cushion and spreading forbs for alpine pasture of Talra, Himachal Pradesh. The short forbs usually have hairy leaves which protect them against frost. The cushion and spreading forbs are characterized by various adaptive features such as leaf rosettes, dense cushion, hairy growth etc. which provide relative protection against the harsh conditions of alpine environment. The annuals form a major component in the alpine and high sub alpine environment. It is difficult for most species to complete the entire life cycle in a single cold growing season (Bliss, 1971; Saville, 1972; Santvan, 1993; Verma *et al.*, 2008).

**Table 1: Phytosociological attributes of the tree species in Tandri Dhar at an altitudinal zonation of 2250-2750m**

Sr. No.	Species	Density (ha <sup>-1</sup> )	Frequency (%)	Abundance	A/F	IVI
1	<i>Aesculus indica</i> Hook.f.	15.00	15.00	1.00	0.067	17.30
2	<i>Picea smithiana</i> Wall (Boiss)	175.00	40.00	4.38	0.109	84.25
3	<i>Pinus wallichiana</i> A.B. Jakssoon.	400.00	65.00	6.15	0.095	184.24
4	<i>Pyrus pashia</i> Buch.-Ham ex D.don	15.00	15.00	1.00	0.067	14.22

Among 9 shrub species at elevation 2250m-2750m (Table 2), *Sorbaria tomentosa* was the dominant species having maximum density (2888.89 ha<sup>-1</sup>) and frequency (33.33%). This was followed by *Rabdosia rugosa* (2222.22ha<sup>-1</sup>) and *Indigofera heterantha* (2037.04 ha<sup>-1</sup>) in terms of density. In terms of

abundance, *Indigofera heterantha* (11.00) has the maximum value. *Sorbaria tomentosa* recorded the highest value of IVI (48.89) followed by *Rabdosia rugosa* (44.15) and *Indigofera heterantha* (41.10). The distribution pattern of all the species was contiguous (Verma and Kapoor 2014; Verma, 2015; Verma, 2016).

**Table 2: Phytosociological attributes of the shrub species in Tandri Dhar at an altitudinal zonation of 2250-2750m.**

Sr. No	Species	Density (ha <sup>-1</sup> )	Frequency (%)	Abundance	A/F	IVI
1	<i>Berberis lycium</i> Royle.	1222.22	16.67	6.50	0.390	33.30
2	<i>Callicarpa macrophylla</i> Vahl.	925.93	10.00	10.00	1.000	14.92
3	<i>Cotoneaster microphyllus</i> Wall.ex Lindl.	1111.11	26.67	4.00	0.150	40.35
4	<i>Desmodium tiliaefolium</i> (D. Don) Wall.	1296.30	26.67	4.67	0.175	32.53
5	<i>Indigofera heterantha</i> Wall ex Brandis.	2037.04	16.67	11.00	0.660	41.10
6	<i>Prinsepia utilis</i> Royle.	740.74	16.67	4.00	0.240	25.84
7	<i>Rabdosia rugosa</i> (Wall ex Benth.) Hara	2222.22	33.33	6.00	0.180	44.15
8	<i>Sarcococca saligna</i> Muell. Arg.	740.74	16.67	4.00	0.240	19.31
9	<i>Sorbaria tomentosa</i> (Lindl) Rehder.	2888.89	33.33	7.75	0.233	48.49

In case of herbs including regeneration there was 61 species at 2250m-2750m elevation (Table 3). *Trifolium repens* was the dominant species having maximum density (1.57 m<sup>-2</sup>) and abundance (10.44). This was followed by *Thalictrum foliolosum* (1.10 m<sup>-2</sup>) in term of density. The highest frequency was observed for *Plantago lanceolata* (35.00%) followed by *Oxalis corniculata* (31.67%). On the basis of IVI, *Geranium*

*wallichianum* recorded the highest value (21.09) followed by *Trifolium repens* (19.23) and *Eragrostis viscosa* (18.14). The lowest IVI value was observed for *Achyranthes aspera*. The ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the species except *Plantago lanceolata* was contiguous.

**Table 3: Phytosociological attributes of the herb species in Tandri Dhar at an altitudinal zonation of 2250-2750 m.**

Sr. No.	Species	Density (m <sup>-2</sup> )	Frequency (%)	Abundance	A/F	IVI
1.	<i>Achyranthus aspera</i> Linn.	0.03	3.33	1.00	0.300	1.00
2.	<i>Aconogonum molle</i> (D. Don) Hara	0.07	3.33	2.00	0.600	1.60
3.	<i>Ajuga bracteosa</i> Wall. ex Benth.	0.10	3.33	3.00	0.900	2.05
4.	<i>Alysicarpus monilifer</i> (L.) DC.	0.15	6.67	2.25	0.338	4.12
5.	<i>Anaphalis triplinervis</i> (Sims) C.B.Clarke	0.25	10.00	5.00	0.250	7.34
6.	<i>Arctium lappa</i> L.	0.50	10.00	2.50	0.500	12.59
7.	<i>Arisaema intermedium</i> Blume.	0.25	6.67	3.75	0.563	8.30
8.	<i>Aster falonori</i> (C.B.Clarke) Hutch.	0.07	3.33	2.00	0.600	3.06
9.	<i>Bergenia ciliata</i> (Haw.) Sternb.	0.03	3.33	1.00	0.300	1.06
10.	<i>Bidens pilosa</i> L.	0.03	3.33	1.00	0.300	1.61
11.	<i>Calanthe tricarinata</i> Lindley.	0.22	6.67	3.25	0.488	5.33
12.	<i>Capsella bursa-pastoris</i> (Linn.) Medik.	0.07	3.33	2.00	0.600	1.60
13.	<i>Cirsium wallichii</i> DC.	0.18	10.00	1.83	0.183	6.21
14.	<i>Corydalis juncea</i> Wall.	0.15	6.67	2.25	0.338	3.58
15.	<i>Parochetus communis</i> D.Don	0.13	6.67	2.00	0.300	5.85
16.	<i>Datura stramonium</i> L.	0.10	3.33	3.00	0.900	1.72
17.	<i>Desmodium multiflorum</i> DC.	0.03	3.33	1.00	0.300	1.04
18.	<i>Desmodium triflorum</i> (L.) DC.	0.03	3.33	1.00	0.300	1.26
19.	<i>Elsholtzia fruticosa</i> (D.Don) Rehder	1.00	18.33	5.45	0.298	17.40

20.	<i>Epilobium laxum</i> Royle.	0.03	3.33	1.00	0.300	1.30
21.	<i>Eragrostisviscosa</i> (Retz.) Trin.	0.65	15.00	4.33	0.289	2.51
22.	<i>Euphorbia cognate</i> (Klotzsch&Gracke) Boiss.	0.13	3.33	4.00	1.200	2.50
23.	<i>Fragaria vesca</i> L.	0.57	18.33	3.09	0.169	8.98
24.	<i>Galium asperifolium</i> Wall.	0.13	3.33	4.00	1.200	1.91
25.	<i>Gnaphalium hypoleucum</i> DC.	0.07	3.33	2.00	0.600	2.09
26.	<i>Geranium pretense</i> Linn.	0.18	10.00	1.83	0.183	4.57
27.	<i>Geranium wallichianum</i> D.Don.ex.Sweet.	0.10	3.33	3.00	0.900	21.09
28.	<i>Gerbera gossypina</i> (Royle) Beauv.	0.25	10.00	2.50	0.250	6.63
29.	<i>Girardinia diversifolia</i> (Link.)Friis.	0.10	3.33	3.00	0.900	2.15
30.	<i>Goodyera repens</i> (L.) R.Br.	0.10	6.67	1.50	0.225	3.64
31.	<i>Impatiens sulcata</i> Wall.	0.13	10.00	1.33	0.133	3.89
32.	<i>Cicerbita macrorrhiza</i> Royle.	0.18	10.00	1.83	0.183	3.96
33.	<i>Leontopodiummonocephalum</i> Edgew.	0.07	3.33	2.00	0.600	1.67
34.	<i>Malva rotundifolia</i> Desf.	0.18	6.67	2.75	0.413	7.52
35.	<i>Mentha longifolia</i> (L.) Huds.	0.03	3.33	1.00	0.300	1.15
36.	<i>Oxalis corniculata</i> L.	0.57	31.67	1.79	0.057	14.28
37.	<i>Oxalis latifolia</i> Kunth.	0.18	6.67	2.75	0.413	4.73
38.	<i>Parnassia cabulica</i> Planchon ex C.B. Clarke.	0.10	6.67	1.50	0.225	2.30
39.	<i>Pedicularis royle</i> Maxim.	0.07	3.33	2.00	0.600	1.38
40.	<i>Phlomis bracteosa</i> Royle ex Benth.	0.07	6.67	1.00	0.150	2.07
41.	<i>Phytolacca acinusa</i> Roxb.	0.10	3.33	3.00	0.900	1.61
42.	<i>Pilea scripta</i> Buch.-Ham. ex D.Don) Wedd.	0.07	3.33	2.00	0.600	1.38
43.	<i>Plantago lanceolata</i> L.	0.50	35.00	1.43	0.041	12.41
44.	<i>Polygonum capitatum</i> Buch.-Ham. ex D. Don	0.03	3.33	1.00	0.300	1.39
45.	<i>Potentilla atosanguinea</i> G.Lodd. ex D.Don	0.07	3.33	2.00	0.600	1.38
46.	<i>Potentilla peduncularis</i> D. Don	0.07	3.33	2.00	0.600	1.60
47.	<i>Primula denticulata</i> Smith.	0.07	3.33	2.00	0.600	1.60
48.	<i>Pteracanth usurticifolius</i> (Wall ex Kuntze) Bremek.	0.13	3.33	4.00	1.200	2.50
49.	<i>Rabdosia rugosa</i> (Wall ex Benth.) Hara	0.03	3.33	1.00	0.300	1.04
50.	<i>Ranunculus diffuses</i> DC.	0.15	3.33	4.50	1.350	3.43
51.	<i>Rumex nepalensis</i> Spreng.	0.50	21.67	2.31	0.107	11.81
52.	<i>Salvia moorcroftiana</i> Wall. ex Benth.	0.13	6.67	2.00	0.300	3.81
53.	<i>Salvia nubicola</i> Wall. ex Sweet	0.25	13.33	1.88	0.141	7.32
54.	<i>Senecio graciliflorus</i> (Wall.) DC.	0.13	6.67	2.00	0.300	3.33
55.	<i>Sibbaldia purpurea</i> Royle.	0.07	3.33	2.00	0.600	1.74
56.	<i>Selinum tenuifolium</i> Wall ex C.B. Clarke.	0.38	18.33	2.09	0.114	9.02
57.	<i>Thalictrum foliolosum</i> DC.	1.10	25.00	4.40	0.176	18.14
58.	<i>Thymus linearis</i> Benth.	0.07	3.33	2.00	0.600	1.38
59.	<i>Trifolium repens</i> L.	1.57	15.00	10.44	0.696	19.23
60.	<i>Trifolium pretence</i> L.	0.15	6.67	2.25	0.338	2.75
61.	<i>Urtica dioica</i> L.	0.22	13.33	1.63	0.122	5.94

At an elevation of 2750-3250m, total number of tree species was 3 (Table 4). *Picea smithiana* was the dominant species having maximum density (240.00 ha<sup>-1</sup>) and frequency (50.00%). This was followed by *Quercus semecarpifolia* (210.00 ha<sup>-1</sup>) and *Pinus wallichiana* (170.00 ha<sup>-1</sup>) in term of density. In case of abundance, *Quercus semecarpifolia* (10.50) recorded the highest value followed by *Picea smithiana* (4.80). On the basis of IVI, *Picea smithiana* recorded the highest value (125.93) followed by *Quercus semecarpifolia* (99.34) and *Pinus wallichiana* (74.73). The community identified was *Picea smithiana-Quercus semecarpifolia* in this elevation. The ratio of

abundance to frequency (A/F) indicates that the distribution pattern of all the species was contiguous.

Among 9 shrub species at elevation 2750-3250m (Table 5), *Viburnum erubescens* was the dominant species having maximum density (3944.44 ha<sup>-1</sup>) and frequency (30.00%) followed by *Rabdosia rugosa* (2555.56 ha<sup>-1</sup>) interms of density. In terms of abundance, *Cotoneaster microphyllus* (18.33) had maximum value. *Viburnum erubescens* recorded the highest value of IVI (88.09) followed by *Desmodium multiflorum* (42.59) and *Rabdosia rugosa* (40.91). The distribution pattern of all the species was contiguous.

**Table 4: Phytosociological attributes of the tree species in Tandri Dhar at an altitudinal zonation of 2750-3250m.**

Sr. No.	Species	Density (ha <sup>-1</sup> )	Frequency (%)	Abundance	A/F	IVI
1.	<i>Picea smithiana</i> (Wall.)Boiss	170.00	40.00	4.25	0.106	74.73
2.	<i>Pinus wallichiana</i> A.B. Jaksson.	240.00	50.00	4.80	0.096	125.93
3.	<i>Quercus semecarpifolia</i> Smith.	210.00	20.00	10.50	0.525	99.34

**Table 5: Phytosociological attributes of the shrub species in Tandri Dhar at an altitudinal zonation of 2750-3250m.**

Sr. No.	Species	Density (ha <sup>-1</sup> )	Frequency (%)	Abundance	A/F	IVI
1.	<i>Berberis lyceum</i> Royle	1277.78	7.50	15.33	2.044	33.54
2.	<i>Callicarpa macrophylla</i> Vahl.	250.00	22.50	1.00	0.044	18.93
3.	<i>Cotoneaster bacillaris</i> Wall.ex Lindl.	250.00	7.50	3.00	0.400	9.39
4.	<i>Cotoneaster microphyllus</i> Wall.ex Lindl.	1527.78	7.50	18.33	2.444	31.49
5.	<i>Desmodium multiflorum</i> DC.	1527.78	22.50	4.58	0.153	42.59
6.	<i>Quercus semecarpifolia</i> * Smith.	333.33	22.50	1.33	0.059	23.75
7.	<i>Rabdosia rugosa</i> (Wall ex Benth.) Hara	2555.56	15.00	15.33	1.022	40.91
8.	<i>Spiraea canescens</i> D.Don	333.33	7.50	4.00	0.533	10.34
9.	<i>Viburnum erubescens</i> Wall.	3944.44	30.00	15.78	0.701	89.06

Note: \*Saplings

In case of herbs including regeneration there was 58 species at 2750-3250m elevation (Table 6). *Trifolium repens* was the dominant species having maximum density (2.43 m<sup>-2</sup>), abundance (14.60) and frequency (26.67%). This was followed by *Plantago lanceolata* (0.93 m<sup>-2</sup>) in term of density. On the basis of IVI,

*Trifolium repens* recorded the highest value (25.10) followed by *Anaphalis triplinervis* (20.23) and *Plantago lanceolata* (16.97). The lowest IVI (1.10) was observed for *Spiranthes sinensis*. The ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the species was contiguous.

**Table 6: Phytosociological attributes of the herb species in Tandri Dhar at an altitudinal zonation of 2750-3250m.**

Sr. No.	Species	Density (m <sup>-2</sup> )	Frequency (%)	Abundance	A/F	IVI
1.	<i>Achillea millefolium</i> Linn.	0.43	16.67	2.60	0.156	8.51
2.	<i>Aconogonum molle</i> (D. Don) Hara.	0.13	3.33	4.00	1.200	3.35
3.	<i>Anaphalis triplinervis</i> (Sims.) C.B.Clarke.	0.87	20.00	4.33	0.217	20.23
4.	<i>Anemone obtusiloba</i> D.Don	0.53	20.00	2.67	0.133	12.93
5.	<i>Arisaema intermedium</i> Blume.	0.17	6.67	2.50	0.375	4.54
6.	<i>Artemisia parviflora</i> Roxb. ex D.Don	0.07	3.33	2.00	0.600	1.97
7.	<i>Aster falconeri</i> (C.B.Clarke) Hutch.	0.40	13.33	3.00	0.225	6.57
8.	<i>Capsella bursa-pastoris</i> (Linn.) Medik.	0.03	3.33	1.00	0.300	1.29
9.	<i>Chaerophyllum reflexum</i> Aitch.	0.07	3.33	2.00	0.600	1.54
10.	<i>Cirsium wallichii</i> DC.	0.30	20.00	1.50	0.075	10.02
11.	<i>Clematis grata</i> Wall.	0.20	6.67	3.00	0.450	3.86
12.	<i>Conyza stricta</i> Willd.	0.07	3.33	2.00	0.600	1.44
13.	<i>Corydalis ramosa</i> Wall.	0.10	6.67	1.50	0.225	3.10
14.	<i>Cynoglossum micranthum</i> Desf.	0.13	6.67	2.00	0.300	3.62
15.	<i>Elsholtzia fruticosa</i> (D.Don) Rehder	0.47	16.67	2.80	0.168	9.26
16.	<i>Epilobium laxum</i> Royle.	0.17	6.67	2.50	0.375	3.47
17.	<i>Eragrostis viscosa</i> (Retz.) Trin.	0.20	6.67	3.00	0.450	3.86
18.	<i>Erigeron linifolius</i> Willd.	0.10	3.33	3.00	0.900	1.93
19.	<i>Euphorbia cognate</i> (Klotzsch&Garcke) Boiss.	0.07	3.33	2.00	0.600	1.60
20.	<i>Euphorbia wallichii</i> Hook.f.	0.27	6.67	4.00	0.600	5.70
21.	<i>Fragaria vesca</i> L.	0.17	3.33	5.00	1.500	2.23
22.	<i>Galium asperfolium</i> Wall. ex Roxb.	0.20	6.67	3.00	0.450	3.54
23.	<i>Geranium wallichianum</i> D.Don.ex.Sweet.	0.13	6.67	2.00	0.300	3.33
24.	<i>Geum elatum</i> Wall. ex G. Don	0.10	3.33	3.00	0.900	1.64
25.	<i>Inula cappa</i> (Buch.-Ham. ex D.Don) DC.	0.33	13.33	2.50	0.188	7.24
26.	<i>Lactuca dissecta</i> D.Don.	0.07	3.33	2.00	0.600	1.54
27.	<i>Malva rotundifolia</i> Desf.	0.03	3.33	1.00	0.300	1.19



28.	<i>Mentha longifolia</i> (L.) Huds	0.40	3.33	12.00	0.630	15.36
29.	<i>Micromeriabiflora</i> (Buch-Ham ex D.Don) Benth.	0.47	6.67	7.00	1.050	6.95
30.	<i>Nepeta erecta</i> Royle ex Benth.	0.37	16.67	2.20	0.132	7.05
31.	<i>Oplismenus compositus</i> (L.) Beauv.	0.27	3.33	8.00	0.420	4.93
32.	<i>Origanum vulgare</i> L.	0.53	6.67	8.00	1.200	7.72
33.	<i>Oxalis corniculata</i> L.	0.27	3.33	8.00	2.400	3.10
34.	<i>Parnassia cabulica</i> Planchon ex C.B. Clarke.	0.07	6.67	1.00	0.150	2.31
35.	<i>Phlomisbracteosa</i> Royle ex Benth. in Hook.	0.07	3.33	2.00	0.600	1.44
36.	<i>Phytolacca acinosa</i> Roxb.	0.03	3.33	1.00	0.300	1.16
37.	<i>Pilea scripta</i> (Buch.-Ham ex D.Don.) Benth.	0.20	6.67	3.00	0.450	3.86
38.	<i>Plantago lanceolata</i> L.	0.93	16.67	3.50	0.131	16.97
39.	<i>Poa alpine</i> L.	0.67	6.67	10.00	1.500	6.70
40.	<i>Polygonum capitatum</i> Buch.-Ham. ex D. Don	0.20	6.67	3.00	0.450	3.54
41.	<i>Potentilla atrosanguinea</i> G.Lodd. ex D. Don	0.07	3.33	2.00	0.600	1.97
42.	<i>Primula denticulata</i> Smith.	0.07	3.33	2.00	0.600	2.81
43.	<i>Rubia cordifolia</i> (Hook.f.) Linn.	0.07	3.33	2.00	0.600	1.60
44.	<i>Rumex nepalensis</i> Spreng.	0.27	10.00	2.67	0.267	6.47
45.	<i>Salvia nubicola</i> Wall. ex Sweet	0.07	6.67	1.00	0.150	2.58
46.	<i>Selinum tenuifolium</i> Wall ex C.B. Clarke.	0.13	6.67	2.00	0.300	4.70
47.	<i>Senecio graciliflorus</i> (Wall.) DC.	0.10	3.33	3.00	0.900	1.93
48.	<i>Sibbaldia cuneata</i> Hornem. ex Kuntze	0.20	10.00	2.00	0.200	9.20
49.	<i>Silene viscosa</i> (L.) Pers.	0.03	3.33	1.00	0.300	1.19
50.	<i>Spiranthes sinensis</i> (Persoon) Ames	0.03	3.33	1.00	0.300	1.10
51.	<i>Sweritia nervosa</i> (G.Don) C.B. Clarke	0.10	6.67	1.50	0.225	3.10
52.	<i>Taraxacum officinale</i> (L.) Weber ex F.H. Wigg	0.07	6.67	1.00	0.150	2.92
53.	<i>Thalictrum foliolosum</i> DC.	0.27	10.00	2.67	0.267	5.40
54.	<i>Thymus linearis</i> Benth.	0.90	6.67	13.50	0.225	9.95
55.	<i>Trifolium repens</i> L.	2.43	26.67	14.60	0.876	25.10
56.	<i>Trifolium pratense</i> L.	0.20	10.00	2.00	0.200	3.86
57.	<i>Urtica dioica</i> Linn.	0.07	3.33	2.00	0.600	2.93
58.	<i>Viola canescens</i> Wall.	0.17	3.33	5.00	1.500	3.37

At an elevation of 3250-3750 m, total number of tree species was 4 (Table 7). *Betula utilis* was the dominant species having maximum density (210.00 ha<sup>-1</sup>), abundance (6.33) and frequency (45.00%). This was followed by *Pinus wallichiana* and *Abies pindrow* having density 90.00 ha<sup>-1</sup> each. On the basis of IVI, *Abies pindrow* recorded the highest value (92.81) followed by *Betula utilis* (90.55) and *Picea smithiana* (58.71). The community identified was *Abies pindrow-Betula utilis* in this elevation. The ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the species except *Abies pindrow* was contiguous.

The contiguous distribution is the commonest pattern in nature, random distribution is found in very uniform environment.

Among 5 shrub species at elevation 3250-3750m (Table 8), *Rhododendron campanulatum* was the dominant species having maximum density (4027.78 ha<sup>-1</sup>), abundance (23.60) and frequency (20.00%). This was followed by *Juniperus cummunis* (3277.78 ha<sup>-1</sup>) in terms of density. *Rhododendron campanulatum* recorded the highest value of IVI (89.74) followed by *Juniperus cummunis* (75.15) and *Salix fragilis* (70.87). The distribution pattern of all the species was contiguous.

**Table 7: Phytosociological attributes of the tree species in Tandri Dhar at an altitudinal zonation of 3250-3750m.**

Sr. No.	Species	Density (ha <sup>-1</sup> )	Frequency (%)	Abundance	A/F	IVI
1.	<i>Abies pindrow</i> Royle.	90.00	35.00	2.00	0.044	92.81
2.	<i>Betula utilis</i> D. Don	210.00	45.00	6.33	0.181	90.55
3.	<i>Picea smithiana</i> Wall (Boiss)	55.00	10.00	5.00	0.500	57.94
4.	<i>Pinus wallichiana</i> A.B. Jaksson	90.00	35.00	2.67	0.076	58.71

**Table 8: Phytosociological attributes of the shrub species in Tandri Dhar at an altitudinal zonation of 3250-3750m.**

Sr. No.	Species	Density (ha <sup>-1</sup> )	Frequency (%)	Abundance	A/F	IVI
1.	<i>Cotoneaster microphyllus</i> Wall.ex Lindl.	833.33	20.00	3.75	0.188	33.78
2.	<i>Juniperus cummunis</i> Linn.	3277.78	12.50	18.13	1.888	75.15
3.	<i>Rhododendron campanulatum</i> D. Don	4027.78	20.00	23.60	0.906	89.74
4.	<i>Salix fragilis</i> L.	2916.67	20.00	13.13	0.656	70.87
5.	<i>Viburnum erubescens</i> Wall.	1250.00	12.50	9.00	0.720	30.46

In case of herbs including regeneration there was 55 species at 3250-3750m elevation (Table 9). *Anaphalis triplinervis* was the dominant species having maximum density (2.30 m<sup>-2</sup>) and frequency (26.67%). This was followed by *Trifolium repens* (1.42 m<sup>-2</sup>) in term of density. In term of abundance, *Trifolium repens* (17.00) recorded the highest value. On the basis of IVI,

*Anaphalis triplinervis* recorded the highest value (38.84) followed by *Geranium wallichianum* (20.02) and *Jurinea dolomiaea* (16.17). The lowest IVI (1.18) was observed for *Bistorta amplexicaulis*. The ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the species was contiguous.

**Table 9: Phytosociological attributes of the herb species in Tandri Dhar at an altitudinal zonation of 3250-3750m.**

Sr. No.	Species	Density (m <sup>-2</sup> )	Frequency (%)	Abundance	A/F	IVI
1.	<i>Achillea millefolium</i> Linn.	0.08	3.33	2.50	0.750	1.42
2.	<i>Anaphalis triplinervis</i> (Sims.) C.B. Clarke.	2.30	26.67	8.63	0.323	38.84
3.	<i>Anemone obtusiloba</i> D.Don	0.20	6.67	3.00	0.450	4.04
4.	<i>Arisaema flavum</i> (Forssk.) Schott	0.03	3.33	1.00	0.300	1.37
5.	<i>Arnebia benthamii</i> (Wall, ex G. Don) Johnston.	0.27	11.67	2.29	0.196	12.37
6.	<i>Artemisia parviflora</i> Roxb. ex D.Don	0.18	8.33	2.20	0.264	4.52
7.	<i>Parochetus communis</i> D. Don	0.18	8.33	2.20	0.264	3.43
8.	<i>Aster molliusculus</i> (Lindl. ex DC.) C.B. Clarke	0.35	11.67	3.00	0.257	7.98
9.	<i>Bistorta amplexicaulis</i> (D. Don) Greene	0.03	3.33	1.00	0.300	1.18
10.	<i>Campanula latifolia</i> Linn.	0.07	6.67	1.00	0.150	2.89
11.	<i>Cirsium wallichii</i> DC.	0.07	3.33	2.00	0.600	1.60
12.	<i>Cynoglossum micranthum</i> Desf.	0.12	6.67	1.75	0.263	2.68
13.	<i>Dactylorhiza hatagirea</i> (D.Don) Soo	0.12	6.67	1.75	0.263	4.51
14.	<i>Delphinium brunonianum</i> Royle.	0.30	6.67	4.50	0.675	4.30
15.	<i>Eragrostis viscosa</i> (Retz.) Trin.	0.07	3.33	2.00	0.600	1.60
16.	<i>Euphorbia cognate</i> (Klotzsch&Garcke) Boiss.	0.08	6.67	1.25	0.188	2.35
17.	<i>Euphorbia wallichi</i> Hook.f.	0.20	6.67	3.00	0.450	3.28
18.	<i>Galium asperifolium</i> Wall.	0.07	3.33	2.00	0.600	1.35
19.	<i>Geranium pratens</i> Linn.	0.18	6.67	2.75	0.413	3.83
20.	<i>Geranium wallichianum</i> D. Don. ex.Sweet.	1.42	26.67	5.31	0.199	20.02
21.	<i>Geum elatum</i> Wall. ex G. Don	0.12	6.67	1.75	0.263	2.45
22.	<i>Habenaria pectinata</i> D.Don	0.08	3.33	2.50	0.750	2.89
23.	<i>Hypericum elodeoides</i> Choisy in DC., Prodr.	0.15	3.33	4.50	1.350	2.24
24.	<i>Inula cappa</i> (Buch.-Ham ex D. Don.) DC.	0.35	15.00	2.33	0.156	16.17
25.	<i>Jurinea dolomiaea</i> Boiss.	0.07	3.33	2.00	0.600	1.55
26.	<i>Lactuca dissecta</i> D. Don.	0.03	3.33	1.00	0.300	1.66
27.	<i>Morina longifolia</i> Wall. ex DC.	0.23	3.33	7.00	2.100	3.70
28.	<i>Oplismenus composites</i> (L.) Beauv.	0.08	6.67	1.25	0.188	2.26
29.	<i>Oxalis latifolia</i> Kunth.	0.07	3.33	2.00	0.600	1.42
30.	<i>Oxyria digyna</i> (L.) Hill	0.70	20.00	3.50	0.175	11.46
31.	<i>Parnassia cabulica</i> Planchon ex C.B. Clarke.	0.08	3.33	2.50	0.750	1.63
32.	<i>Pedicularis hoffmeisteri</i> Klotzsch	0.07	3.33	2.00	0.600	1.60
33.	<i>Persicaria polystachya</i> (Wall. ex Meisn.)	0.07	3.33	2.00	0.600	1.35
34.	<i>Phlomisbracteosa</i> Royle ex Benth. in Hook.	0.15	8.33	1.80	0.216	3.39
35.	<i>Plantago lanceolata</i> L.	0.57	18.33	3.09	0.169	12.27
36.	<i>Poa alpine</i> L.	0.97	8.33	11.60	1.392	11.39
37.	<i>Polygonatum verticillatum</i> (L.) All.	0.08	3.33	2.50	0.750	2.28

38.	<i>Potentilla atrosanguinea</i> G.Lodd. ex D.Don	0.23	11.67	2.00	0.171	5.27
39.	<i>Potentilla peduncularis</i> D.Don	0.07	3.33	2.00	0.600	1.60
40.	<i>Primula denticulata</i> Smith.	0.73	23.33	3.14	0.135	14.57
41.	<i>Rumex nepalensis</i> Spreng.	0.15	6.67	2.25	0.338	4.96
42.	<i>Salvia moorcroftiana</i> Wall. ex Benth.	0.07	3.33	2.00	0.600	1.42
43.	<i>Saussurea fastuosa</i> (Decne.) Sch.Bip.	0.07	3.33	2.00	0.600	2.47
44.	<i>Senecio graciliflorus</i> DC.	0.23	15.00	1.56	0.104	5.74
45.	<i>Sibbaldia purpurea</i> Royle.	0.50	8.33	6.00	0.720	6.82
46.	<i>Selinum tenuifolium</i> Wall ex C.B. Clarke.	0.07	3.33	2.00	0.600	1.98
47.	<i>Swertia nervosa</i> (Wall. ex G. Don) C.B. Clarke	0.53	20.00	2.67	0.133	10.15
48.	<i>Tanacetum longifolium</i> Wall. ex DC.	0.15	8.33	1.80	0.216	4.19
49.	<i>Taraxacum officinale</i> (L.) Weber ex F.H. Wigg	0.15	8.33	1.80	0.216	5.95
50.	<i>Thermopsis inflata</i> Camb.	0.07	6.67	1.00	0.150	2.37
51.	<i>Thymus linearis</i> Benth.	0.92	6.67	13.75	2.063	8.72
52.	<i>Trifolium repens</i> L.	1.42	8.33	17.00	2.040	13.02
53.	<i>Trifolium pratense</i> L.	0.23	8.33	2.80	0.336	3.58
54.	<i>Verbascum thapsus</i> L.	0.03	3.33	1.00	0.300	1.27
55.	<i>Viola biflora</i> L.	0.15	3.33	4.50	1.350	2.07

The value of dominance index (C), index of diversity (H), richness Index (R) and evenness index (E) for trees, shrubs and herbs at different altitudes is given in Table 10. The values of dominance index for tree species varied from 0.260 to 0.460, for shrub species varied from 0.120 to 0.230 whereas, for herb species varied from 0.030 to 0.040. The value of diversity index in case of tree was ranged from 0.970 to 1.360, for shrub from 1.530 to 2.140 and for herb from 3.560 to 3.740. Richness index for tree was from 0.668, for shrub from 0.656 to 1.362 and for herb from 7.867 to 9.001. The values of evenness index for tree category was ranged from 0.700 to 0.921, for shrub from 0.906 to 0.974 and for herb from 0.888 to 0.983. 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 10: Dominance index (C), diversity index (H), richness index (R) and evenness index (E) for tree, shrub and herb at different elevations in Tandi Dhar of the sanctuary.**

Altitude	Plant Category	Dominance Index (C)	Diversity Index (H)	Richness Index (R)	Evenness Index (E)
<b>2250-2750m</b>	Tree	0.460	0.970	0.626	0.700
	Shrub	0.120	2.140	1.362	0.974
	Herb	0.032	3.720	9.001	0.905
<b>2750-3250m</b>	Tree	0.350	1.080	0.415	0.983
	Shrub	0.160	1.990	1.318	0.906
	Herb	0.030	3.740	8.339	0.921
<b>3250-3750m</b>	Tree	0.260	1.360	0.668	0.981
	Shrub	0.230	1.530	0.656	0.951
	Herb	0.040	3.560	7.867	0.888

## MEDICINAL AND THREATENED PLANTS

Total 61 important plants of medicinal value found in Tandi Dhar of Tundah wild life sanctuary in district Chamba of Himachal Pradesh were compiled following Chopra *et al.* (1956); Kirtikar and Basu (1987); Kala (2002). These include; *Achillea millefolium*, *Aesculus indica*, *Ajuga bracteosa*, *Anaphalis triplinervis*, *Anemone obtusiloba*, *Arnebia benthamii*, *Artemisia parviflora*, *Aesculus indica*, *Anaphalis triplinervis*, *Anemone obtusiloba*, *Arnebia benthamii*, *Artemisia parviflora*, *Aster molliusculus*, *Berberis lycium*,

*Bergenia ciliata*, *Callicarpa macrophylla*, *Capsella bursa-pastoris*, *Cirsium wallichii*, *Clematis grata*, *Corydalis ramosa*, *Dactylorhiza hatagirea*, *Delphinium brunonianum*, *Desmodium triflorum*, *Euphorbia cognata*, *Fragaria vesca*, *Galium asperifolium*, *Geranium pratense*, *Geranium wallichianum*, *Geum elatum*, *Habenaria pectinata*, *Inula cappa*, *Juniperus communis*, *Jurinea dolomiaca*, *Lactuca dissecta*, *Malva rotundifolia*, *Mentha longifolia*, *Micromeria biflora*, *Nepeta erecta*, *Origanum vulgare*, *Oxalis corniculata*, *Phlomis bracteosa*, *Plantago lanceolata*, *Polygonatum*



*verticillatum*, *Polygonum capitatum*, *Potentilla atosanguinea*, *Primula denticulata*, *Ranunculus diffusus*, *Rhododendron campanulatum*, *Rubia cordifolia*, *Rumex nepalensis*, *Salvia moorcroftiana*, *Sarcococca saligna*, *Selinum tenuifolium*, *Senecio graciliflorus*, *Taraxacum officinale*, *Thalictrum foliolosum*, *Thymus linearis*, *Trifolium repens*, *Urtica dioica*, *Verbascum thapsus* and *Viola canescens*

Out of 61 medicinal plant species recorded from the Tandidhar of Tundah Wildlife Sanctuary, 9 species viz; *Arnebia benthamii*, *Bergenia stracheyi*, *Betula utilis*, *Dactylorhiza hatagirea*, *Juniperus communis*, *Jurinea dolomiaea*, *Polygonatum verticillatum*, *Rhododendron campanulatum* and *Selinum tenuifolium*, fall in the category of threatened plants when compared with the available literature like Red Data Book and CAMP Reports. The less population of 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.

## CONCLUSIONS

Tandi Dhar area of Tundah wildlife sanctuary in district Chamba, Himachal Pradesh contains total 125 number of plant species belonging to 113 genera and 47 families. The distribution pattern of plant species was mostly contiguous. Out of 61 medicinal plant species recorded from the sanctuary, 9 species viz., *Arnebia benthamii*, *Bergenia stracheyi*, *Betula utilis*, *Dactylorhiza hatagirea*, *Juniperus communis*, *Jurinea dolomiaea*, *Polygonatum verticillatum*, *Rhododendron campanulatum* and *Selinum tenuifolium* fall in the category of threatened plants. The better conservation of natural resources can be done through promotion of community based conservation, developing cultivation/nursery technologies of medicinal plants and conducting of regular training on the medicinal plants collection and processing among the end users.

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