Plant Diversity and Floristic Composition of Three Forest Types in Mata Vaishno Devi Forest of Jammu and Kashmir, Western Himalaya, India

A. R. Koul, D. S. Chauhan* and N. P. Todaria

Department of Forestry and NR, HNB Garhwal University (Central University), Srinagar Garhwal 246 174, Uttarakhand, India

Abstract: An investigation was carried out to study the plant diversity and floristic composition on three forest types namely, mixed - broadleaved forest (800-1000m), *Pinus roxburghii* forest (1400-1600m) and *Quercus leucotrichophora* forest (2000-2200m) in Mata Vaishno Devi forest of J and K, Western Himalaya. Total 58 families, 102 genera and 116 species were recorded in three forests along the altitudes. Mixed- broadleaved forest represented a total of 29 families with 42 genera and 48 species. *Pinus roxburghii* forest was comprised of 30 families with 44 genera and 45 species while *Quercus leucotrichophora* forest also represented 30 families with 41 genera and 42 species. It revealed almost similar number of families and genera with little variation in number of species at different forests along altitudes. *Cassia fistula, Acacia catechu, Acacia modesta, Bauhinia variegata,* and *Dalbergia sissoo* were the dominant tree species in mixed- broadleaved forest at lower altitude, *Pinus roxburghii* and *Bauhinia variegata* were dominant in *Pinus roxburghii* forest at middle altitude and *Quercus leucotrichophora,* and *Rhododendron arboreum* were the dominant tree species in *Quercus leucotrichophora* forest at upper altitude. *Asteraceae, Euphorbiaceae, Poaceae, Acanthaceae, Lamiacaea, Mimosaceae, Rosaceae, Urticaceae* were the dominant families which were present in all the forest types along altitudes. Maximum numbers of species were characterized by clumped distribution. Stand density was higher in *Pinus roxburghii* forest whereas richness and diversity were higher in the mixed-broadleaf forests.

Keywords: Altitudes, density, plant diversity, mixed- broadleaved forest, *Pinus roxburghii* forest, *Quercus leucotrichophora* forest.

1. INTRODUCTION

The diversified landforms, land relief and environmental conditions of Himalayan region support an array of forest types. Vegetation within a forest type is greatly affected by differences in the micro-climate, aspect and altitude [1]. The Himalayan forest vegetation ranges from tropical dry deciduous forests in the foothills to timber line and alpine meadows and above timberline [2]. Biodiversity is used variously for fuel wood, fodder, timber, leaf litter for manuring agricultural fields, construction, industrial raw material and several non-timber forest produce [3]. Forest of this region are mainly dominated by *Pinus roxburghii*, *Quercus leucotrichophora* and mixed dry deciduous broadleaved species like *Acacia catechu, Acacia modesta, Bauhinia variegata, Cassia fistula, Dalbergia sissoo* and *Mallotus philippensis*. Similar type studies have been undertaken on community structure and organization in the natural forests of different climatic zone of Central Himalaya [3-7] and North – Eastern Himalaya [8], yet, little information is available on the Himalayan forests for gradient analysis considering altitude, aspect and vegetation as important parameters [1].

The Vaishno Devi hill forest forms a part of the Trikuta hills of Jammu Shiwalik in Western Himalaya, India. The area represents very rich plant diversity and a variety of microclimates. These hills with its varied physiography, soil and climatic conditions, support different types of forests such as temperate coniferous forest, subtropical pine forest and alpine scrub forest. The area is open to much biotic pressure as the famous abode of Mata Vaishno Devi lies in these hills and thousands of people visit the holy shrine every year. This paper focuses on the plant diversity and other structural attributes in three different forest types along 800–2200m asl. altitudes of Vaishno Devi hills.

2. METHODOLOGY

2.1. Study Site

Trikuta Hills, the abode of Mata Vaishno Devi, respectfully known as Mata Vaishno Devi Hills, are located between 32^0 59' and 33^0 10' N latitude and 74^0 55' and 75^0 50'E longitude in the Reasi tehsil of district Udhampur in Jammu region of Jammu and Kashmir State in Western Himalaya, India (Figure **1**). These hills constitute a part of outermost hills of Jammu Shiwaliks. Trikuta Hills have gained tremendous importance during last couple of decades as one of the most reverend pilgrim places of the country. Every day thousands of devotees from different parts of the

*Address correspondence to this author at the Department of Forestry and NR, HNB Garhwal University (Central University), Srinagar Garhwal 246 174, Uttarakhand, India; Tel: 09412949549; Fax: 0137025257529;
E-mail: dsc_oci@ rediffmail.com/dschauhan2008@gmail.com

E-ISSN: 2311-858X/15

Figure 1: Map of Jammu and Kashmir, Western Himalaya, India.

country pay obeisance at the sacred place which is situated at a distance of 45 km from Jammu well connected by road.

The area is subjected to variety of climatic conditions from sub-tropical to temperate due to variation in altitude, topography, slope and aspect. The climate of the area is monsoonic with distinct warm and cool dry seasons. The average annual rainfall is about 1600mm, more than 60% of which is received during May- September. The mean annual temperature ranges from 5-36^{0}C. The soil is highly leached, poor in nutrients and alkaline to acidic in nature. The vegetation of these hills falls under subtropical deciduous hill and sub-temperate moist hill forest [9].

2.2. Methods

Vegetation analysis was carried out by using stratified sampling technique during December 2003 to December 2007. Whole study area was divided into three forest types along altitudes: mixed-broadleaved forests represent the foot hills ranging from 800–1000m asl; *Pinus roxburghii* forest ranges from 1400–1600m. asl. and *Quercus leucotrichophora* forest lies between 2000–2200m. asl.

A sample plot or quadrat of 10m x 10m was used for tree observation. Thirty 100m^2 sample plots per stand were laid and the occurrence of different species and the number and diameter of the individuals were recorded. One quadrat of 5m x 5m and four quadrats of 1m x 1m nested within 100m^2 were laid for shrubs and herbs respectively. Thus a total of thirty quadrats each for trees and shrubs and one hundred twenty quadrats for herbs were laid in each forest stand.

The phytosociological data was analyzed using conventional methods [10]. In each sample plot tree with >30cm cbh (circumference at breast height above the ground) were measured. A shrub is considered a phenerophyte with many branches from the base of stem.

The frequency, density, total basal cover and relative values for each species of the community were

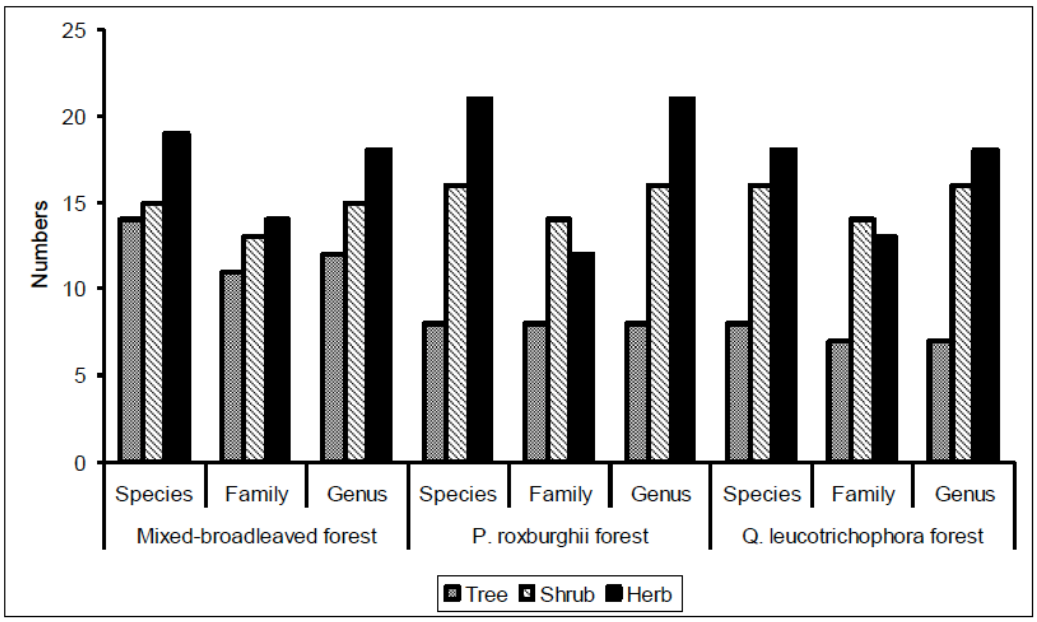

Figure 2: Families, genera and species encountered in three forest types in Mata Vaishno Devi hill forest.

calculated by using the formula [11]. The importance value index (IVI) for different species was calculated as a sum of relative frequency, relative density, and relative basal cover of each species [12, 13]. The distribution pattern of different species was studied using the ratio of abundance to frequency [14]. The distribution is considered regular for the A/F ratio of <0.025, between 0.025-0.05 random and clumped for the ratio >0.05 [15]. The dominance (C) for each community was calculated by Simpson's index ($C=\Sigma pi^2$), and diversity by Shannon index ($H=-\Sigma pi \ln pi$) [16, 17]. Here, pi represents the proportional abundance of the species in any given stand. Species richness (Margalef index) was calculated by [18] ($SR=S-1/\log n$), where S is the no. species, n is the no. of individuals.

3. RESULTS AND DISCUSSION

3.1. Floristic Composition

An inventory of the species composition showed that the area is occupied by total 58 families representing 102 genera and 118 species across all the three forest types along the altitudes of 800-2200m. asl. Mixed-broadleaved forest represented a total of 29 families with 42 genera and 48 species. *Pinus roxburghii* forest was comprised of 30 families with 44 genera and 45 species while *Quercus leucotrichophora* forest also represented 30 families with 41 genera and 42 species (Figure **2**). The dominant families are *Asteraceae* (15 species), *Euphorbiaceae* (8 species), *Poaceae* (7 species), *Acanthaceae* (6 species), *Lamiacaea* (5 species), *Mimosaceae, Rosaceae, Urticaceae* (4 species each), *Moraceae, Ranunculaceae* (3 species each) and *Buxaceae, Amaranthaceae, Apocynaceae, Caprifoliaceae, Malvaceae, Meliaceae, Hydrangeaceae, Oxalidaceae, Polygonaceae, Rhamanaceae, Solanaceae, Tiliaceae, Verbanaceae* (2 species each) and the rest of families are represented by single species. This revealed almost similar number of families with little variation in number of genera and species in different forest types. *Acacia catechu, Acacia modesta, Bauhinia variegata, Cassia fistula, Grewia oppositifolia,* and *Dalbergia sissoo* are the dominant tree species, *Justica adhatoda, Lantana camara* and *Colebrookia oppositifolia* are the dominant shrub species and *Cyndon dactylon, Senna tora, Dicliptera bupleuroides* and *Oxalis corniculata* are the dominant herb species present in mixed-broadleaved forest. While *Pinus roxburghii* forest was found mixed with *Bauhinia variegata* as tree species, *Senna occidentalis, Justica adhatoda* and *Codariocalyx motorius* as shrub species and *Cymbopogon martinii, Bromus inermis, Bothriochloa baldhii, Bidens bipinnata* and *Pennisetum flaccidum* as herbs species. The *Quercus leucotrichophora* forest was found mixed with *Pinus roxburghii, Rhododendron arboreum* and *Aesculus indica* as tree species, *Inula cappa, Buddleja asiatica, Cotinus coggygria, Indigofera dosua*, *Himalrandia tetrasperma* and *Debregesia salicifolia* as the dominant shrub species and *Arundinella nepalensis, Galium cryptanthum, Androsace rotundifolia* and *Ligusticum elatum* as the dominant herb species (Table **1**).

Table 1: Floristic Composition, Density and Important Value Index (IVI) in three Forest Types Along Altitudes in Mata Vaishno Devi Hill Forest

S No.	Plant Species	Family	Mixed-Broadleaved Forest (800–1000m)		*Pinus Roxburghii* Forest (1400–1600m)		*Quercus Leucotrichophora* Forest (2000–2200m)	
	Tree Species		Density/ $100m^2$	IVI	Density/ $100m^2$	IVI	Density/ $100m^2$	IVI
1	*ACACIA CATECHU*	Mimosaceae	0.46	21.39				
2	*ACACIA MODESTA*	Mimosaceae	0.70	24.21				
3	*AESCULUS INDICA*	Hippocastanaceae					0.87	20.16
4	*ALBIZIA CHINENSIS*	Mimosaceae			0.50	15.83		
5	*BAUHINIA VARIEGATA*	Caesalpiniaceae	0.73	24.61	0.97	26.20		
6	*BOMBAX CEIBA*	Bombacaceae	0.43	17.30				
7	*CASSIA FISTULA*	Caesalpiniaceae	1.00	32.68				
8	*CORNUS MACROPHYLLA*	Cornaceae					0.60	18.92
9	*DALBERGIA SISSOO*	Papilionaceae	0.50	26.70				
10	*ERYTHRINA SUBEROSA*	Papilionaceae			0.70	19.26		
11	*FICUS PALMATA*	Moraceae	0.30	19.79	0.23	10.72		
12	*FICUS RELIGIOSA*	Moraceae	0.20	26.52				
13	*GREWIA OPPOSITIFOLIA*	Tiliaceae	0.86	28.39	0.50	16.60		
14	*ILEX DIPYRENA*	Aquifoliaceae					0.40	11.01
15	*JATROPHA CURCAS*	Euphorbiaceae	0.33	10.24				
16	*MALLOTUS PHILIPPENSIS*	Euphorbiaceae	0.60	23.56				
17	*MELIA AZEDARACH*	Meliaceae	0.33	14.95				
18	*NEOLITSEA PALLENS*	Lauraceae					0.70	19.81
19	*OLEA FERRUGINEA*	Oleaceae			0.50	17.55		
20	*PINUS ROXBURGHII*	Pinaceae			5.67	170.97	3.33	100.46
21	*PINUS WALLICHIANA*	Pinaceae					0.60	16.78
22	*PYRUS PASHIA*	Rosaceae	0.63	17.89				
23	*QUERCUS LEUCOTRICHOPHORA*	Fagaceae					3.10	75.17
24	*RHODODENDRON ARBOREUM*	Ericaceae					1.23	28.69
25	*TOONA SINENSIS*	Meliaceae			0.67	22.87		
26	*ZIZIPHUS MAURITIANA*	Rhamnaceae	0.46	11.75				
SHRUB SPECIES								
1	*ABUTILON INDICUM*	Malvaceae	0.70	18.53				
2	*BERBERIS LYCIUM*	Berberidaceae	0.76	17.88				
3	*BOEHMERIA PLATYPHYLLA*	Urticaceae			0.70	13.26		
4	*BUDDLEJA ASIATICA*	Buddlejaceae					1.03	22.97
5	*CODARIOCALYX MOTORIUS*	Papilionaceae	0.53	15.59	1.90	25.54		
6	*CALOTROPIS PROCERA*	Asclepiadaceae	0.77	19.62				
7	*COLEBROOKIA OPPOSITIFOLIA*	Lamiaceae	1.50	31.25				
8	*CARISSA OPACA*	Apocynaceae	0.77	19.76				
9	*COTINUS COGGYGRIA*	Anacardiaceae					0.90	21.04
10	*DAPHNE PAPYRACEA*	Thymelacaeae					0.93	21.42
11	*DEBREGEASIA HYPOLEUCA*	Urticaceae	0.53	15.87				
12	*DEBREGEASIA SALICIFOLIA*	Urticaceae					0.90	20.88
13	*DEUTZIA COMPACTA*	Hydrangeaceae			0.95	16.61		
14	*DEUTZIA STAMINEA*	Hydrangeaceae					0.50	14.18
15	*DODONAEA ANGUSTIFOLIA*	Sapindaceae	0.27	10.09				
16	*EUPHORBIA ROYLEANA*	Euphorbiaceae			0.85	15.84		
17	*FLEMINGIA MACROPHYLLA*	Papilionaceae					0.83	19.96

Table 1 continued...

S No.	Plant Species	Family	Mixed-Broadleaved Forest (800–1000m)		*Pinus Roxburghii* Forest (1400–1600m)		*Quercus Leucotrichophora* Forest (2000–2200m)	
	Tree Species		Density/ $100m^2$	IVI	Density/ $100m^2$	IVI	Density/ $100m^2$	IVI
18	*HIMALRANDIA TETRASPERMA*	Rubiaceae			1.00	16.64	0.67	17.13
19	*HYPERICUM OBLONGIFOLIUM*	Hypericaceae					0.90	21.11
20	*INDIGOFERA DOSUA*	Papilionaceae					0.90	21.04
21	*INULA CAPPA*	Asteraceae					1.13	24.42
22	*INULA CUSPIDATE*	Asteraceae			1.25	19.27		
23	*JUSTICA ADHATODA*	Acanthaceae	2.17	40.05	1.75	24.20		
24	*LANTANA CAMARA*	Verbanaceae	2.07	38.99	1.00	16.59		
25	*LEPIDAGATHIS CUSPIDATA*	Acanthaceae			1.35	20.26		
26	*LEPTODERMIS LANCEOLATA*	Rubiaceae					0.83	19.81
27	*LONICERA QUINQUELOCULARIS*	Caprifoliaceae					0.23	8.83
28	*MIMOSA HIMALAYANA*	Mimosaceae					0.77	18.74
29	*NERIUM INDICUM*	Apocynaceae	0.60	16.70				
30	*OREOCNIDE FRUTESCENS*	Urticaceae			0.80	14.39		
31	*PLUMBAGO ZEYLANICA*	Plumbaginaceae	0.40	13.35				
32	*RUBUS ELLIPTICUS*	Rosaceae			0.80	14.56		
33	*SARCOCOCCA SALIGNA*	Buxaceaea			1.25	19.22	0.87	20.34
34	*SENNA OCCIDENTALIS*	Caesalpiniaceae			3.65	41.24		
35	*SIDA RHOMBIFOLIA*	Malvaecaea	0.57	16.20				
36	*SMILAX ASPERA*	Smilacaceae					0.67	17.09
37	*SOLANUM ERIANTHUM*	Solanaceae	0.43	13.57				
38	*SPIRAEA VACCINIFOLIA*	Rosaceae					0.33	11.06
39	*URENA LOBATA*	Malvaceae			0.70	13.66		
40	*VIBURNUM NERVOSUM*	Caprifoliaceae			0.95	16.14		
41	*ZIZYPHUS OXYPHYLLA*	Rhamnaceae	0.37	12.53				
HERB/CLIMBER SPECIES								
1	*ACHYRANTHES ASPERA*	Amaranthaceae	0.78	19.74	0.36	8.594		
2	*ADIANTUM INCISUM*	Adiantaceae	0.38	12.12				
3	*AGERATUM CONYZOIDES*	Asteraceae	0.47	13.93	0.50	10.803		
4	*AJUGA PARVIFLORA*	Lamiaceae			0.39	9.292		
5	*ANDROSACE ROTUNDIFOLIA*	Primulaceae					0.80	19.2
6	*ARUNDINELLA NEPALENSIS*	Poaceae					0.93	21.39
7	*ASPARAGUS ADSCENDENS*	Liliaceae			0.65	12.59		
8	*BIDENS BIPINNATA*	Asteraceae	0.35	11.6	1.56	22.724		
9	*BOENNINGHAUSENIA ALBIFLORA*	Rutaceae			0.34	8.406		
10	*BOERHAVIA DIFFUSA*	Nyctaginaceae	0.72	18.6				
11	*BOTHRIOCHLOA BLADHII*	Poaceae			1.72	25.143		
12	*BROMUS INERMIS*	Poaceae			1.71	24.28		
13	*BREEA ARVENSIS*	Asteraceae	0.43	13.33				
14	*BUPLEURUM FALCATUM*	Apiceae					0.72	17.86
15	*CISSAMPELOS PAREIRA (CLIMBER)*	Menispermaceae			0.56	10.548		
16	*CORCHORUS AESTUANS*	Teliaceae	0.35	11.6				
17	*CONYZA CANADENSIS*	Asteraceae					0.75	18.4
18	*CYMBOPOGON MARTINII*	Poaceae			1.92	26.594		
19	*CYNODON DACTYLON*	Poaceae	1.16	25.81				
20	*DELPHINIUM DENUDATUM*	Ranunculaceae					0.77	18.66

Table 1 continued...

S No.	Plant Species	Family	Mixed-Broadleaved Forest (800–1000m)		*Pinus Roxburghii* Forest (1400–1600m)		*Quercus Leucotrichophora* Forest (2000–2200m)	
	Tree Species		Density/ 100m^2	IVI	Density/ 100m^2	IVI	Tree Species	IVI
21	*DICLIPTERA BUPLEUROIDES*	Acanthaceae	1.29	27.9				
22	*DUCHESNEA INDICA*	Rosaceae					0.71	17.76
23	*EUPHORBIA HETEROPHYLLA*	Euphorbiaceae					0.50	14.05
24	*EUPHORBIA HELIOSCOPIA*	Euphorbiaceae	0.41	12.78				
25	*EUPHORBIA HIRTA*	Euphorbiaceae	0.68	17.93	0.46	10.035		
26	*GALIUM CRYPTANTHUM*	Rubiaceae					0.95	21.58
27	*GERANIUM WALLICHIANUM*	Geraniaceae					0.67	17
28	*LAUNAEA FALLAX*	Asteraceae			0.33	8.091		
29	*LIGUSTICUM ELATUM*	Apiaceae					0.79	19.14
30	*MARTYNIA ANNUA*	Martyniaceae	0.19	8.12				
31	*MICROMERIA BIFLORA*	Lamiaceae	0.38	12.12	0.68	12.994		
32	*ORIGANUM VULGARE*	Lamiaceae					0.62	16.12
33	*OXALIS CORNICULATA*	Oxalidaceae	0.98	22.99	0.58	11.869		
34	*PENNISETUM FLACCIDUM*	Poaceae			1.66	23.874		
35	*PTERACANTHUS ALATUS*	Acanthaceae					0.38	11.71
36	*PYROSTEGIA VENUSTA (CLIMBER)*	Bignoniaceae					0.60	09.83
37	*RUMEX NEPALENSIS*	Polygonaceae			0.46	10.122	0.59	15.76
38	*SAUSSUREA ALBESCENS*	Asteraceae					0.38	11.83
39	*SENNA TORA*	Caesalpiniaceae	0.81	20.09				
39	*SETARIA GLAUCA*	Poaceae			0.89	17.321		
40	*SIDA CORDATA*	Malvaeceae			0.39	9.085		
41	*SOLANUM AMERICANUM*	Solanaceae	0.23	8.86				
42	*SONCHUS BRACHYOTUS*	Asteraceae	0.40	12.64			0.59	15.71
43	*STELLARIA MEDIA*	Caryophyllaceae	0.30	10.71				
44	*TAGETES MINUTA*	Asteraceae			0.68	13.143		
45	*TARAXACUM OFFICINALE*	Asteraceae					0.48	13.72
46	*THALICTRUM JAVANICUM*	Ranunculaceae			0.65	12.713		
47	*THALICTRUM PEDUNCULATUM*	Ranunculaceae					0.51	14.26
48	*TRIDAX PROCUMBENS*	Asteraceae	0.75	19.12				
49	*VERVASCUM THAPSUS*	Scrophulariaceae			0.25	6.959		

3.2. Density, Diversity and Distribution

The overall tree density was recorded highest (10.83/100m^2) in *Quercus leucotrichophora* forest while shrub and herb density was observed highest (19.55 and 17.02/100m^2) respectively in *Pinus roxburghii* forest (Table **1**). Tree density in mixed-broadleaved forest was recorded highest (1.00/100m^2) for *Cassia fistula*, followed by (0.86/100m^2) *Grewia oppositifolia*. The important value index (IVI) of the tree species in mixed-broadleaved forest showed a variation from 32.68 to 10.24 with *Cassia fistula* and *Jatropha curcas* having the highest and lowest values respectively (Table **1**). Tree density was highest (5.67/100m^2) for *Pinus roxburghii* and the important value index (IVI) was also recorded highest for *Pinus roxburghii* (170.96) and lowest for *Ficus palmata* (10.72) in *Pinus roxburghii* forest. In *Quercus leucotrichophora* forest, tree density was recorded highest (3.33/100m^2) for *P. roxburghii,* followed by (3.10/100m^2) *Quercus leucotrichophora* and IVI varied from 11.01–100.46 with *Pinus roxburghii* having highest value and lowest value was obtained for *Ilex dipyrena* (Table **1**).

Shrub density and IVI was recorded maximum (2.17/100m^2 and 40.05) for *Justica adhatoda* followed by *Lantana camara* (2.07/100m^2 and 38.99) in mixed-broadleaved forest. *Senna occidentalis* recorded highest (3.65/100m^2 and 41.24) density and IVI values in *Pinus roxburghii* forest. In *Quercus leucotrichophora*

Table 2: Overall Density and Diversity Indices in Three Forest Types Along Altitudes in Mata Vaishno Devi Hill Forest

		Density/100m^2	Simpson Index	Shannon Index	Margalef Index
Mixed-broadleaved forest (800 - 1000 m)	Tree	7.57	0.083	2.556	70.524
	Shrub	12.33	0.099	2.504	76.876
	Herb	11.04	0.067	2.812	129.405
Pinus roxburghii forest (1400 – 1600 m)	Tree	9.37	0.003	1.464	39.737
	Shrub	19.55	0.084	2.640	89.531
	Herb	17.02	0.068	2.847	152.434
Quercus leucotrichophora forest (2000 – 2200 m)	Tree	10.83	0.208	1.789	40.486
	Shrub	12.40	0.081	2.871	87.478
	Herb	11.72	0.059	2.858	123.225

forest, highest density and IVI (1.13/100m^2 and 24.42) were recorded for *Inula cappa.* The herb composition in mixed-broadleaved forest revealed highest density and IVI values (1.29/100m^2 and 27.90) for *Dicliptera bupleuroides*. Maximum density and IVI (1.92/100m^2 and 26.59) for *Cymbopogon martinii* was observed in *Pinus roxburghii* forest. Highest density and IVI for *Galium cryptanthum* (0.95/100m^2 and 21.58) was recorded in *Quercus leucotrichophora* forest (Table **1**).

Table **2** depicts the pattern of diversity in three forest types along altitudes indicating that species richness (Margalef index) for tree species ranged from 39.737 to 70.524, Simpson index ranged from 0.003 to 0.208 and Shannon index ranged from 1.464 to 2.556. Margalef index ranged from 76.876 to 87.478, Simpson index from 0.081 to 0.099 and Shannon index ranged from 2.504 to 2.871 for shrub species. For herb species, Margalef index ranged from 123.225 to 152.434, Simpson index from 0.059 to 0.068 and Shannon index ranged from 2.812 to 2.858. As far as species richness is concerned, highest tree species richness was recorded in mixed-broadleaved forest, shrubs species richness in *Quercus leucotrichophora* forest and herb species richness in *Pinus roxburghii* forest. Simpson index for tree species was recorded maximum in *Quercus leucotrichophora* forest, for shrubs species in mixed-broadleaved forest and for herb species in *Pinus roxburghii* forest. Shannon index for tree species was recorded highest in mixed-broadleaved forest, for shrub and herb species in *Quercus leucotrichophora* forest.

An analysis of distribution pattern indicated that 101 species were clumped, 17 had a random and one species had a regular distribution in this hill forests (Figure **3**). Interestingly only two species, *Ficus palmata* and *Justica adhatoda* showed a change in the

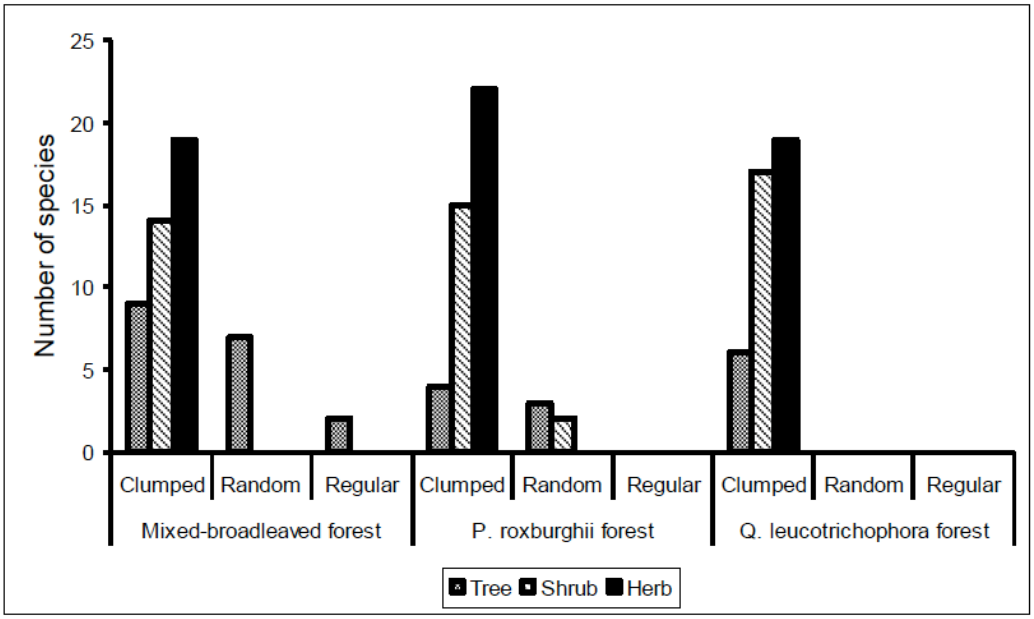

Figure 3: Distribution pattern of species in three forest types in Mata Vaishno Devi hill forest.

distribution pattern from forest to forest. *Ficus palmata* changed from random to clumped distribution pattern from mixed-broadleaved forest to *Pinus roxburghii* forest while *Justica adhatoda* changed from clumped to random distribution pattern from mixed-broadleaved forest to *Pinus roxburghii* forest. Of the total species analyzed approximately 85% species in three forest types had clumped distribution, 14% species showed random distribution and 1% species had a regular distribution pattern. Among trees species *Mallotus philippensis* showed regular distribution while *Quercus leucotrichophora, Rhododendron arboreum, Bauhinia variegata, Olea ferruginea* and *Toona sinensis* showed random distribution. *Albizia chinensis, Aesculus indica, Erythrina indica, Grewia oppositifolia, Pinus roxburghii, Pinus wallichiana, Bombax ceiba, Ficus religiosa, Ficus palmata, Jatropha curcas, Pyrus pashia, Ziziphus mauritiana, Cornus macrophylla, Ilex dipyrena,* and *Neolitsea pallens* all showed clumped distribution pattern along the altitudes. In case of shrub species *Justica adhatoda, Senna occidentalis, Deutzia compacta, Inula cuspidata, Oreocnide frutescens* and *Himalrandia tetrasperma* showed random distribution pattern and rest of the other species showed clumped distribution pattern in three forest types along the altitudes.

Phytosociological studies of Vaishno Devi Hills forest revealed many informative aspects. Important value index representing the extent of dominance of a species in the community showed that for mixed-broadleaved forest all the species had a uniform dominance showing not much variation in their IVI values. In *Pinus roxburghii* forest, *Pinus roxburghii* showed the higher value of IVI and was dominating the stand. Similarly in *Quercus leucotrichophora* forest, *Quercus leucotrichophora* recorded higher values and was thus dominating with no shrub or herb was found dominating nature in the stand.

On comparing the three forest types in relation to the floral composition, it was found that at 800-1000m broad leaved species viz: by *Acacia modesta, Bauhinia variegata, Cassia fistula, Grewia oppositifolia* and *Dalbergia sissoo* were the dominated tree species. *Justica adhatoda, Lantana camara* and *Colebrookia oppositifolia* were the dominant shrub species and *Cynodon dactylon, Dicliptera bupleuroides, Senna tora* and *Oxalis corniculata* were the dominant herb species present in the mixed-broadleaved forest. While at 1400-1600m being the intermediate stand between sub-tropical and temperate, was dominated by an almost pure pine forest with *Bauhinia variegata* and *Albizia chinensis* showing lesser and scattered presence. *Senna occidentalis, Justica adhatoda* and *Codariocalyx motorius* were shrub species and *Cymbopogon martinii, Bromus inermis, Bothriochloa bladhii, Bidens bipinnata* and *Pennisetum flaccidum* were herb species in the *Pinus roxburghii* forest. Altitudes of 2000-2200m contained *Quercus leucotrichophora* and *Pinus roxburghii* as the dominant tree species along with *Pinus wallichiana* in the shady portions. *Inula cappa, Buddleja asiatica, Cotinus coggygria, Indigofera dosua*, *Himalrandia tetrasperma* and *Debregesia salicifolia* were the dominant shrub species and *Arundinella nepalensis, Galium cryptanthum, Androsace rotundifolia* and *Ligusticum elatum* were the dominant herb species in *Quercus leucotrichophora* forest. *Asteraceae, Euphorbiaceae, Poaceae, Acanthaceae, Lamiacaea, Mimosaceae, Rosaceae* and *Urticaceae* were the dominant families which were present in all the forest types.

As far as species distribution pattern is concerned in this area, maximum numbers of species were characterized by clumped distribution across all the three forest types. Clumping in these species may be due to coppice forming habit, and patchy distribution of microhabitats suitable for plant growth [19]. According to Odum (1971) [20], the clumped distribution is common in nature while random distribution is found only in very uniform environments. Kumar *et al*. (2004) [21] has reported the clumped distribution for different sub-tropical forests in Garhwal Himalaya.

Stand density for tree species showed a gradual increase from mixed-broadleaved forest (800-1000m) to *Quercus leucotrichophora* forest (2000-2200m) (Table **2**). It may be due to a consistent extraction of fuel wood and fodder from mixed- broadleaved forests present at lower altitude. Shrub and herb density also increased from mixed-broadleaved forest to *Pinus roxburghii* forest (1400-1600m) and then again decreased towards *Quercus leucotrichophora* forest (Table **2**). Hence, three types of life forms behaved differently in forest types along altitudes [3, 22].

High richness and diversity was recorded in mixed-broadleaved forest, while lower values were recorded in *Pinus roxburghii* forest. Whereas *Quercus leucotrichophora* forest situated away from human habitation were characterized by high diversity. Our findings are similar to earlier observations [3, 22]. The diversity values found for the trees, shrubs and herbs in three forest types along altitudes were well within the range of the other studies reported for the Central Himalayan forests [4, 6, 23, 24]. Higher the value of

diversity greater will be the stability of community [6]. While observing different diversity indices together, it can be concluded that the mixed-broadleaved forest (at 800-1000m altitude) and *P. roxburghii* forest (at 1400-1600m altitude) had heterogeneity among different diversity indices and were under tremendous stress leading to imbalance of diversity except for the *Q. leucotrichophora* forest (at 2000-2200m altitude) which showed a gradual trend of change in different diversity indices. The recurrent human intervention for collection of fuelwood, fodder and practices of grazing and trampling may have changed the habitat fitness for many species [25]. Occurrence of *Acacia catechu, Bombax ceiba, Erythrina suberosa, Jatropha curcas,* and *Pyrus pashia* in mixed-broadleaved forest (800-1000m) suggest their tolerance to biotic pressure and wide ecological amplitude.

4. CONCLUSION

The main finding of our study on plant diversity and floristic composition in three forest types along the altitudinal gradient in Mata Vaishno Devi Hill Forest of J and K, Western Himalaya, India are as follows:

- Tree density increased from mixed-broad leaved forest (at 800-1000m altitude) to *Qurecus leucotrichophora* forest (at 2000-2200m altitude), while shrub and herb density was significantly higher in *Pinus roxburghii* forest (at 1400-1600m altitude) compared with three types of forests.

- Three types of life-forms (tree, shrub and herb) behaved differently in three forest types along altitudinal gradient. The recurrent human interventions for collection of fuel wood, fodder and practices of grazing and trampling may change the habitat fitness for many species.

- Maximum numbers of species were found clumped distribution pattern across all the three forest types may be due to coppice forming habit, and patchy distribution of microhabitats suitable for plant growth.

- Highest species richness was found in mixed-broad leaved forest (at 800-1000m altitude) and lowest in the *Pinus roxburghii* forest (at 1400-1600m altitude).

- Species diversity was found maximum in mixed-broad leaved forest (at 800-1000m altitude) and minimum in the *Pinus roxburghii* forest (at 1400-1600m altitude). Mixed-broad leaved forest and *Pinus roxburghii* forests had heterogeneity among different diversity indices and were under tremendous stress leading to imbalance of diversity.

This information on altitudinal variation among the plant of three forest types can be used as reference for future biodiversity monitoring programme on Western Himalaya.

ACKNOWLEDGEMENTS

We express our sincere thanks to the Mata Vaishno Devi Shrine Board, Katra, Jammu and Jammu and Kashmir Forest Department for giving permission for this work.

REFERENCES

[1] Pande PK, Nagi JDS and Sharma SC. Plant species diversity and vegetation analysis in moist temperate Himalayan Forests. Abstract First Indian Ecological Congress. New Delhi 1996; 27-31: 51.

[2] Saxena AK, Singh SP and Singh JS. Population structure of forest of Kumaon Himalaya: Implication for management. J Environ Manag 1984; 19: 307-324.

[3] Jeet Ram, Kumar A and Bhatt J. Plant diversity in six forest types of Uttaranchal, Central Himalaya, India. Current Science 2004; 86(7): 975-978.

[4] Saxena AK and Singh JS. A phyto-sociological analysis of woody species in forest communities of a part of Kumaon Himalaya. Vegetatio 1982; 50: 2-3. http://dx.doi.org/10.1007/BF00120674

[5] Singh JS and Singh SP. Structure and functioning of the forest ecosystem of Central Himalaya. Implications for management, regeneration of forest trees: In An Integrated Ecological study of Eastern Kumaun Himalaya with emphasis on National Resources (eds Singh, J.S. and Singh, S.P.), Final report (*HCS/DST/187-176),* Vol.II, Kumaon University, Nainital, India 1984; 85-113.

[6] Ralhan PK, Saxena AK and Singh JS. Analysis of forest vegetation at and around Nainital in Kumaon Himalaya. Proceedings of Indian National Science Academy 1982; B48: 122-138.

[7] Singhal RM, Rawat VRS, Kumar P, Sharma SD and Singh HB. Vegetational analysis of woody species of some forest of Chakarata Himalaya, India. Indian Forester 1986; 112 (2): 819-823.

[8] Khan ML, Rai JPN and Tripathi RS. Population structure of some tree species in disturbed and protected sub-tropical forests of north-east India. Acta Oecologia: Oecologia Applicata (France) 1987; 8: 247-255.

[9] Champion HG and Seth SK. A Revised survey of forest types in India. Govt. of India Publication, New Delhi 1968.

[10] Mullar-Dombois D and Ellenberg H. Aims and methods of vegetation ecology. John Wiley and Sons, Inc 1974.

[11] Curtis JT and McIntosh RP. The interrelations of certain analytical and synthetic phytosociological characters. Ecology 1950; 31: 434-455. http://dx.doi.org/10.2307/1931497

[12] Phillips EA. Methods of vegetation study. Henry Hill and Co., New York 1959.

[13] Curtis JT. The vegetation of Wisconsin: An ordination of plants communities. University Wisconsin Press, Medison 1959.

[14] Whitford PB. Distribution of woodland plants in relation to succession and clonal growth. Ecology 1949; 30: 199-208. http://dx.doi.org/10.2307/1931186

[15] Curtis JT and Cottam G. Plant Ecology Workbook, Laboratory and Field Manual. Burgers Publication Co, Minnesota 1956; pp. 193.

[16] Simpson EH. Measurement of diversity. Nature 1949; 163: 688. http://dx.doi.org/10.1038/163688a0

[17] Shannon CE and Weaver W. The Mathematical Theory of Communication. University of Illinois Press, Urbana, USA 1963; pp. 1-177.

[18] Margalef FR. Information Theory in Ecology Gen Syst 1978; 3: 36-71.

[19] Roy S and Singh JS. Consequences of habitat heterogeneity for availability of nutrients in a dry tropical forest. J Ecol 1994; 82: 503-509. http://dx.doi.org/10.2307/2261259

[20] Odum EP. Fundamentals of ecology. W.B. Saunders Co., Philadelphia 1971; pp. 574.

[21] Kumar M, Sharma CM and Rajwar GS. A study on community structure and diversity of a sub-tropical forest of Garhwal Himalayas. Indian Forester 2004; 130(2): 207-214.

[22] Uniyal P, Pokhriyal P, Dasgupta S, Bhatt D and Todaria NP. Plant diversity in two forest types along the disturbance gradient in Dewalgarh Watershed, Garhwal Himalaya. Current Science 2010; 98(7): 938-943.

[23] Upreti NJ, Tewari JC and Singh SP. The oak forests of Kumaon Himalaya; composition, diversity and regeneration. Mountain Research and Development 1985; 5: 163-174. http://dx.doi.org/10.2307/3673255

[24] Baduni NP and Sharma CM. Effect of aspect on the structure of some natural stands of *Cupressus torulosa* in Himalayan moist temperate Forest. Proceedings of Indian National Science Academy 1996; B62: 345-352.

[25] Pandey SK and Shukla RP. Plant diversity and community patterns along the disturbance gradient in plantation forests of Sal (*Shorea robusta* Gaertn.). Current Science 1999; 77: 814-818.

Received on 09-10-2015 Accepted on 12-10-2015 Published on 31-12-2015

DOI: http://dx.doi.org/10.12974/2311-858X.2015.03.01.2