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Species Diversity and Pedological Characteristics in Selected Sites of Senchal Wildlife Sanctuary, West Bengal, India

Debnath Palit (Corresponding author)

Assistant Professor in Botany and Head, PG Department of Conservation Biology, The University of Burdwan

Durgapur Government College, J.N.Avenue,Durgapur-713214 , West Bengal, India

Tel: 91-983-217-5737 E-mail: debnath_palit@yahoo.com

Arnab Banerjee

Assistant Professor, PG Department of Conservation Biology, The University of Burdwan

Durgapur Government College, J.N.Avenue,Durgapur-713214 , West Bengal, India

Tel: 91-943-350-1162 E-mail: arnabenvsc @yahoo.com

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Abstract

The aim of the investigation was to analyze phytosociological characteristics and diversity pattern of subalpine evergreen forest of Senchal wildlife Sanctuary , Darjeeling, West Bengal,India. The results reflect dominancy of dicotyledons over monocotyledons in the four studied sites . Rangiroom beat shows higher diversity of species among the four studied sites. Maximum IVI value were recorded by *Viola surpense* (47.17) in Rambhi forest beat, *Fragaria nubicola* (63.87) in Rangiroom forest beat , *Viola betonicifolia* (25.99) in Gaddikhana forest range and *Pilea umbrosa* (35.93) in 6th mile beat respectively. The Berger parker index and evenness index were found to be highest for *Viola surpense* , *Fragaria nubicola*, *Pilea umbrosa* in site I, II, III and IV respectively. The soil characteristics of the four study sites revealed alkaline nature of soil in Rambhi and Rangiroom beat and acidic nature of soil in Gadhikhana and 6th mile beat. The organic carbon % were found to be higher

in the first two studied sites than the next two sites. Therefore ,proper management and conservative measures needs to be implemented for conservation of bioresources in Senchel wildlife Sanctuary of West Bengal, India.

Keywords: Phytodiversity, Importance value index, Species distribution, Senchal

1. Introduction

Wildlife Protected Areas (PAs) in India have had a relatively long history of forest management and exploitation as majority of the PAs were originally reserved or other categories of government owned forests where focus of management was mainly on timber production, meeting the biomass demands of local communities or soil and water conservation (Rodgers & Sawarkar 1988).Several reserved forests having high abundance of wildlife were notified as National Parks (where legally all exploitation of forest resources is prohibited) or Wildlife Sanctuaries (where some exploitation and development may be allowed) during 1970's and 1980's. However, impacts of past management practices on vegetation and wildlife habitats were quite long lasting in many PAs.Such impacts have rarely been documented.

The habitat is of immense value to mankind because the modern material civilization is entirely based on the exploitation and utilization of the existing resources drawn from the environment and created through human efforts. In mountain areas this is more pronounced; terrain inaccessibility, climate in hospitability, soil infertility, and transport availability, scarcity of basic amenities and facilities make life nature oriented. The controlling mechanisms of biodiversity in different ecosystems are mentioned by the theory of species richness which considers resource availability and disturbance as factors for structuring plant communities.

Darjeeling is one of the biodiversity hotspot within Himalayas. It is floristically akin to other parts of the Eastern Himalayas in general and Sikkim Himalaya in particular. Darjeeling hill appears as the matrix encompassing some features of boreal and temperate flora of the eastern and western hemispheres together with certain unique features of Asia in addition to its own unique features.

The patterns and role of species richness in ecosystem function are important in terms of land-use and climate change concerns (Chapin & Korner 1995; Reynolds & Tenhunen 1996; Oechel *et al.* 1997). While there is still debate on the role of species diversity and ecosystem function (Hooper & Vitousek 1997; Patrick 1997), species richness is a frequently measured ecosystem attributes (Magurran 1988) because it characterizes the biodiversity of an area at any scale. Species richness is controlled by a variety of biotic and abiotic parameters (Rannie 1986; Cornell & Lawton 1992; Huston 1994; Pollock *et al.* 1998).

The plant diversity at any site is influenced by species distribution and abundance patterns. A number of factors have been shown to affect the distribution and abundance of plant species, including site conditions, i.e., moisture and nutrient gradients (Day and Monk 1974, Whittaker and Niering 1975, Marks and Harcombe 1981, Host and Pregitzer 1992) and canopy coverage, i.e., light availability (Kull and Zobel l991). However the investigations concerning different types of forests or similar forests located in different areas have given no concrete conclusion for pinpointing the vegetation effect since site condition are changed and it is often impossible to separate the cause from the effect .However, diversity of trees in the Darjeeling foot hill region of Eastern Himalaya was recently studied by (Rai and Das, 2008), Chanda and Palit 2009) revealed the ecological Study on plant diversity and pedological

characteristics in Rangiroom forest beat, Senchal West Zone Forest Range, Darjeeling.

Studies on soils in the Himalayan region are rather scanty (Dhir 1967; Pal *et al* 1984). Available studies on the physical and chemical characteristics and nutrient status of soils under different vegetation in different altitudes of the eastern and north–eastern Himalayas is mainly with reference to Darjeeling Himalayan region (Banerjee *et al* 1985, 1986; Nath *et al* 1983, Das *et al* 1986; Chandran *et al* 1987).A noteworthy contribution in the field of phytosociology was received from Das and Lahiri (1997) which dealt with the ground covering flora in different types of vegetation in Tiger Hill, Darjeeling District. This paper deals with the plant species diversity, structure and composition across various strata within natural forests within the SWS. Distribution of selected indicator taxa and their abundance have been compared. Results are discussed along with the management implications.

2. Material and Methods

2.1 Study Area

Darjeeling Himalaya forms a part of the Eastern Himalayan Ranges and is bounded by Sikkim, Nepal and Bhutan on the north, west and east respectively. The study sites are located in the district of Darjeeling.

The study were conducted in selected sites of SWS viz., The Rambi Beat (26°N and 27°N and 88°E and 88°20´E longitude at an elevation of 2600m);The Rangiroom Beat (26°N and 27°N and 88°E and 88°20´E longitude at an elevation of 2600m); Gaddikhana Forest (26°N and 27°N and 88°E and 88°20´E longitude at an elevation of 2600m); 6th Mile Beat 27o55’ to 28o25’ N latitudes and 81o to 81o25’E longitudes). The Rambi Beat has the status of reserve forests and under the supervision of The Forest Department of Government of West Bengal. The Rangiroom Beat is a part of the Senchel Wildlife Sanctuary, Darjeeling, West Bengal. Administration of this beat is controlled by the Head Quarters at 3rd mile. Gaddikhana Forest is a part of Senchal Wildlife Sanctuary, situated near to Darjeeling, West Bengal The forest is having the sufficient tree cover and wherever required an artificial stocking is done annually. The forest is important for Black bear, Panther, Lesser cat, Goral, Red Legged Falcon. The 6th Mile Beat is a part of the Senchal Wildlife Sanctuary, Darjeeling, West Bengal. The forest has the status of reserve forests and under the supervision of The Forest Department of Government of West Bengal.

2.2 Quadrat and Phytosociological Studies

A total of 4 sites representing various categories of natural forests and plantations were selected for vegetation sampling. At each site 20 quadrats (1 m x 1 m) were laid to quantify various layers. The size of the quadrat used in this study was decided based on the species area curve method following Misra (1968). Individuals of shrubs, climbers and tree seedlings were enumerated within each quadrat. The structure and composition of vegetation across vegetation types have been compared in terms of frequency, density, abundance, and basal area of major species. Importance Value Index (IVI =relative frequency + relative density + relative dominance) and species diversity index ($H^{'}$ = pi ln pi; where, pi= ni/N; and ni = abundance of each species, N= total abundance of all species) were derived from the primary

data separately for each layer following Misra (1968) and Shannon & Weaver (1963) respectively. Berger and Parker Index (D_{BP} = Nmax / N Where Nmax = is the number of individuals in the most species and N= is the total number of all individuals in all species) were weighted toward the abundance of the commonest species. For any information-statistics index, the maximum diversity of a community is found when all species are equally abundant. Community's actual diversity is measured by the formula: Evenness (E) = H / Hmax. Rank Abundance diagrams visually describe the allocation of individuals to species in communities. We ranked and represented 34 species in that forest community in a standard rank abundance diagram. Next, each species were given a number. We then grouped the species in abundance classes of $\log_{10}$.

2.3 Soil Sampling and Analysis

Soil samples were collected from upper surface layers (top 15cm).The samples were properly packed, air-dried, cleaned, crushed and then strained through 2 mm mesh sieves and analyzed. The soil pH were estimated by standard paste technique using pH meter (Rhodes,1982). The organic carbon percentage was measured using potassium dichromate method (Black, 1965). Specific conductance was measured by following the method of Black (1965). Total nitrogen was measured by the standard Kjeldahl procedure (Bremner and Mulvaney, 1982).Extractable phosphorus were determined by using sodium bicarbonate extracts (Olsen *et al*, 1954).

3. Results

3.1 Phytosociology and Species Diversity and Abundance

The predominant forest types in the selected sites of Senchal wildlife sanctuary are subalpine evergreen type. The number of species in a particular forest type varies markedly along the altitudinal range of its growth, which depends on the complex suit of factors that characterize the habitat of individual species. Ecological function of the species involves all kinds of processes, which are inevitably associated with some changes over space, composition and structure are affected at species level. The fundamental capability of ecosystems to evolve, change and recognize themselves is a prerequisite for the sustainability of viable system (Ashby, 1974). The species in a community grow together in a particular environment because they have a similar requirement for existence in terms of environmental factors (Ter Baak, 1987).

Taxonomic survey of the ground cover flora reflects the dominance of dicotyledonous plants over monocots (Table 1). A summary of phytosociological data is summarized in (Table-2). The plant community represents 50 species belonging to 40 genera from 27 families in Rambhi beat. *Viola surpense* was found to be the most frequent, dominant and important species among the plant community of Rambhi beat. The decreasing trend of IVI value was in the order of *Fragaria nubicola*, *Hydrocotyl nepalense ,Calamintha wallichiana, , Stellaria sikkimensi)*. The highest IVI score of *Viola surpense* deserves special mention for its luxuriant occurrence in the study area. The lowest IVI scores were in the following order *Rubia cordifolia, Cinomonum imperssineryium* and *Senecio diversifolius.* The relative

abundance of plants species (n=50) represented in Fig: 1 reveals highest value for *Fragaria nubicola* and *Nasturtium montanum, Viola betonicifolia, Rubia manjith, Rubia cordifolia, Senecio scandens, Vitex negundo, Leucoseptum cannum, Polygonum runcinatum, Cinomonum imperssineryium, Trifolium repens, Berberis insignis* representing lower values. Hierarchial cluster analysis of the species data revealed close association of species by forming numerous small clusters except *Hemipharagma heterophylla* and *Pilea microflora* , *Oxalis corniculata* and *Viola surpense* forming distant cluster (fig 14)

Diversity is the index of the ratio between the number of species and the important value of an individual. Shanon index value is highest in *Viola surpense* followed by *Calamintha wallichiana* and *Fragaria nubicola* and being lowest in *Cinnomonum imperssineryium, Rubia cordifolia* and *Berberis insignis* etc. (Table 3). *Viola surpense* is the most dominant species of the study area. All information-statistics indices are affected by both the number of species and their equitability or evenness. A higher number of species and a more even distribution both increase diversity. The evenness index value is maximum in case of *Viola surpense followed* by *Hydrocotyle nepalense* ,and *Fragaria nubicola* . The minimum value was observed in *Cinomonum imperssineryium , Rubia cordifolia* and *Berberis insignis* etc.

Table 1. A general synoptic account of forest flora of four selected sites of Senchal Wildlife Sanctuary, Darjeeling, West Bengal, India

	Rambhi				Rangiroom beat				Gaddikhana				6th mile			
	D	%	M	%	D	%	M	%	D	%	M	%	D	%	M	%
Families	***24***	***88.88***	***3***	***11.12***	23	82.14	5	17.85	***23***	***88.88***	***3***	***11.12***	***20***	***83.33***	***4***	***16.67***
Genera	***35***	***87.5***	***5***	***12.5***	42	91.30	4	8.69	***33***	***87.5***	***3***	***12.5***	***29***	***91.31***	***4***	***8.69***
Species	***44***	***88***	***6***	***12***	46	92.00	4	8.00	***37***	***88***	***3***	***12***	***30***	***88.24***	***4***	***11.76***

D= Dicotyledones ; M=Monocotyledons

Table 2. Phytosociological attributes of different species of Rambhi beat of Senchal Wildlife sanctuary

Plant Name	D	A	F	FC	A:F	RF	RD	RA	IVI
Nasturtium montanum	0.26	2.00	13.30	A	0.15	1.45	0.43	0.74	2.62
Stellaria sikkimensis	2.30	17.25	13.33	A	1.29	1.45	3.80	6.42	11.67
Stellaria media	1.43	10.75	13.33	A	0.80	1.45	2.36	4.00	7.81
Cardamine hirsuta	0.70	7.00	10.00	A	0.70	1.09	1.15	2.60	4.84
Viola betonicifolia	0.33	2.00	16.66	A	0.12	1.81	0.54	0.74	3.09
Viola surpense	**18.13**	**23.65**	**76.66**	**D**	0.31	**8.36**	**30.01**	**8.80**	**47.17**
Fragaria nubicola	3.13	31.3	10.00	A	3.13	1.09	5.18	11.65	11.92
Geranium nepalense	2.30	4.31	53.33	C	0.08	5.81	3.80	1.60	11.21
Dichroa febrifuga	0.16	5.00	3.33	B	1.5	0.36	0.26	1.86	2.48
Rubus ellipticus	0.46	2.8	16.66	A	0.16	1.81	0.76	1.04	3.61
Gallium mollugo	1.80	6.00	30.00	B	0.2	3.27	2.20	2.23	8.48
Rubia manjith	0.73	2.44	30.00	B	0.08	3.27	1.20	0.90	5.37
Rubia cordifolia	0.03	1.00	3.33	A	0.30	0.36	0.04	0.37	0.77
Gnaphalium luetoalbum	1.30	9.75	13.33	A	0.73	1.45	2.15	3.63	7.23

Ageratum conyzoides	0.20	3.00	6.66	A	0.45	0.72	0.33	1.11	2.16
Artemisia vulgaris	0.36	2.75	13.33	A	0.21	1.81	0.59	1.02	3.42
Senecio scandens	0.06	1.00	3.33	A	0.30	0.36	0.21	0.37	2.06
Senecio diversifolius	0.13	4.00	6.66	A	0.60	0.72	0.09	1.49	1.81
Vitex negundo	0.23	1.75	13.33	A	0.13	1.45	0.71	0.65	3.37
Eupatorium adenophrum	0.43	3.25	40.00	B	0.08	4.36	2.20	1.21	7.80
Hemiphragma heterophylla	1.33	3.33	13.33	A	0.24	1.45	0.38	1.24	2.24
Leucoseptum cannum	0.56	2.42	23.33	B	0.10	2.54	0.92	0.90	4.36
Calamintha wallichiana	3.23	9.7	33.33	B	o.29	3.63	5.34	3.61	12.58
Polygonum runcinatum	1.20	2.57	46.66	C	**0.05**	5.09	1.98	0.95	8.02
Polygonum capitatum	1.26	3.8	33.33	B	0.11	3.63	2.08	1.41	7.12
Cinnamonum imperssineryium	0.03	1.00	3.33	A	0.30	0.36	0.04	0.37	0.77
Pilea umbrosa	0.50	5.00	10.00	A	0.5	1.09	0.82	1.86	3.77
Pilea microflora	0.30	9.00	3.33	A	2.7	0.36	0.49	3.35	4.20
Urtica dioica	0.96	7.25	13.33	A	0.54	1.45	1.58	2.70	5.73
Trifolium repens	0.23	1.40	16.66	A	0.08	1.81	0.38	0.52	2.71
Hydrocotyle japonica	2.30	5.75	40.00	B	0.14	4.36	3.80	2.14	10.3
Hydrocotyle asiatica	1.70	4.25	40.00	B	0.11	4.36	2.81	1.58	8.75
Hydrocotyle nepalensis	4.23	11.54	36.66	B	0.31	4.00	7.00	4.29	15.29
Primula malacoides	1.20	12.00	10.00	A	1.2	1.09	1.98	4.47	7.54
Acer campbeli	0.40	3.00	13.33	A	0.23	1.45	0.66	1.11	3.22
Berberis insignis	0.06	1.00	6.66	A	0.15	0.72	0.99	0.37	2.08
Hypericum hookerianum	0.16	1.25	13.33	A	0.09	1.45	0.26	0.46	2.17
Parachetus communis	0.13	5	13.33	A	0.38	1.45	1.09	1.86	4.40
Asperagus racemosus	0.20	1.33	10.00	A	0.13	1.09	0.21	0.49	1.79
Commelina sikkimensis	0.23	1.75	13.33	A	0.13	1.45	0.38	0.65	2.48
Commelina benghalensis	0.13	1.33	10.00	A	0.13	1.09	0.21	0.49	1.79
Plantago major	1.00	3.33	30.00	B	0.11	3.27	1.65	1.24	6.16
Pouzolzia hirta	0.20	3.00	6.66	A	0.45	0.72	0.33	1.11	2.16
Ophiorrhiza nutans	0.66	4.00	16.66	A	0.24	1.81	1.09	1.49	4.39
Iritonia coarctata	0.16	5.00	3.33	A	1.50	0.36	0.26	1.86	2.48
Paris polyphylla	0.13	1.33	10.00	A	0.13	1.09	0.21	0.49	1.79
Cynodon dactylon	1.13	6.80	16.66	A	0.41	1.81	1.87	2.53	6.21
Poa annua	0.16	1.25	13.33	A	0.09	1.45	0.26	0.46	2.17
Calceolaria mexicana	0.16	2.50	6.66	A	0.38	0.72	0.26	0.93	1.91
Oxalis corniculata	1.53	6.57	23.33	B	0.28	2.54	2.53	0.93	6.00

(D= Density, A= Abundance, F= Frequency, FC= Frequency Class, RF= Relative Frequency, RD= Relative Density, RA= Relative Abundance, IVI = Important Value Index)

Table 3. Diversity Indices of different species of Rambhi beat of Senchal Wildlife sanctuary

Sl. No.	*Name of the Plants*	Shanon Index	Barger Parker	Evenness
1.	*Nasturtium montanum*	-0.022	0.004	7.33
2.	*Stellaria sikkimensis*	-0.120	0.037	40
3.	*Stellaria media*	-0.086	0.023	28.66
4.	*Cardamine hirsuta*	-0.049	0.011	16.33
5.	*Viola betonicifolia*	-0.026	0.005	8.66
6.	*Viola surpense*	-0.360	0.299	120
7.	*Fragaria nubicola*	-0.150	0.051	50
8.	*Geranium nepalense*	-0.120	0.037	40
9.	*Dichroa febrifuga*	-0.015	0.0027	5
10	*Rubus ellipticus*	-0.030	0.007	10
11	*Galium mollugo*	-0.100	0.029	33.33
12	*Rubia manjith*	-0.053	0.012	17.66
13	*Rubia cordifolia*	-0.003	0.0005	1
14	*Gnaphalium luetoalbum*	-0.081	0.021	27
15.	*Ageratum conyzoides*	-0.017	0.003	3.33
16.	*Artemisia vulgaris*	-0.030	0.006	10
17.	*Senecio scandens*	-0.012	0.002	4
18.	*Senecio diversifolius*	-0.006	0.001	2
19.	*Vitex negundo*	-0.035	0.0071	11.66
20.	*Eupatorium adenophrum*	-0.022	0.022	27.66
21.	*Hemiphragma heterophylla*	-0.021	0.0038	7
22.	*Leucoseptum cannum*	-0.042	0.0093	14
23.	*Calamintha wallichiana*	-0.155	0.053	51.66
24.	*Polygonum runcinatum*	-0.075	0.019	25
25.	*Polygonum capitatum*	-0.078	0.020	26
26.	*Cinnamonum imperssineryium*	-0.003	0.0005	1
27.	*Pilea umbrosa*	-0.038	0.008	12.66
28.	*Pilea microflora*	-0.026	0.0049	8.66
29.	*Urtica dioica*	-0.062	0.015	20.66
30.	*Trifolium repens*	-0.021	0.0038	7
31.	*Hydrocotyle japonica*	-0.120	0.037	40
32.	*Hydrocotyle asiatica*	-0.100	0.037	33.33
33.	*Hydrocotyle nepalensis*	-0.180	0.069	60
34.	*Primula malacoides*	-0.070	0.019	23.33
35.	*Acer campbeli*	-0.030	0.0066	10
36.	*Berberis insignis*	-0.007	0.0011	2.33
37.	*Hypericum hookerianum*	-0.015	0.0027	5
38.	*Parachetus communis*	-0.049	0.011	16.33
39.	*Asperagus racemosus*	-0.013	0.0022	4.33
40.	*Commelina sikkimensis*	-0.022	0.004	7.33
41.	*Commelina benghalensis*	-0.012	0.002	4
42.	*Plantago major*	-0.066	0.016	22
43.	*Pouzolzia hirta*	-0.017	0.003	5.66
44.	*Ophiorrhiza nutans*	-0.049	0.011	16.33

45.	*Iritonia coarctata*	-0.017	0.003	5.66
46.	*Paris polyphylla*	-0.013	0.0022	4.33
47.	*Cynodon dactylon*	-0.072	0.018	24
48.	*Poa annua*	-0.017	0.003	5.66
49.	*Calceolaria mexicana*	-0.017	0.003	5.66
50.	*Oxalis corniculata*	-0.092	0.025	30.66

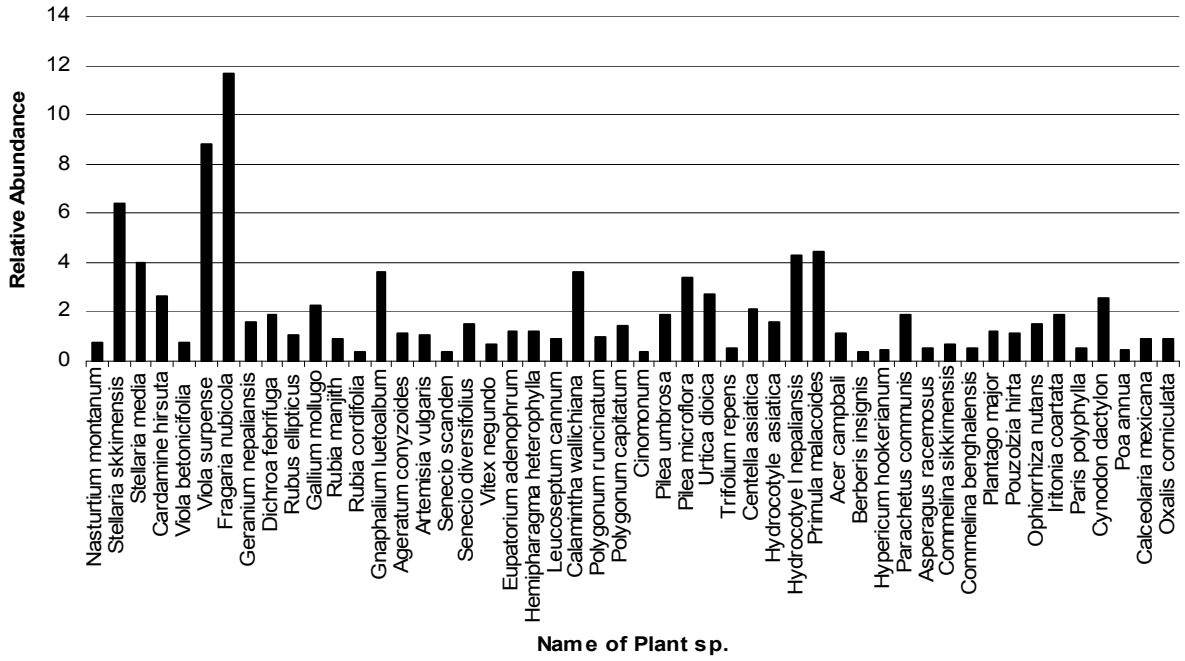

Figure 1. Relative abundance of the plant species (n=50) of Rambi Beat

The vegetation of studied areas showed the presence of evergreen plant species. A summary of phytosociological data is summarized in (Table-4).Among all the listed fifty plant species *Fragaria nubicola* was found leading dominant in most of the stands. *Tritonia crocata, Rubus elipticus* were found in scarce. The IVI values (Table- 4) revealed that the highest value belongs to the species *Fragaria nubicola*. The decreasing trend of IVI value was in the order of – *Cynodon dactylon, Calamintha walichiana, Gentiana ornate*. The highest IVI value of *Fragaria nubicola* reveals that the species was most dominant in that community and the lowest IVI values of *Impatiens urticifolia, Nepeta lamiopsis, Dioscorea bulbifera* represent that they are the rare species of that community. The relative abundance of plants species (n=50) were represented in Fig: 2. Higher Shanon index value were recorded in *Berberis insignis, Dioscorea bulbifera, Impatiens urticifolia* and lowest in *Fragaria nubicola, Gentiana ornate, Hemiphragma heterophylla* etc.(Table 5) Rangiroom beat revealed close association between the different species with *Anaphalis triplinervis* and Clinop*odium umbrosum* and *Dichroa febrifuga* and *Fragaria nubicola* forming distant clusters (Fig 15).

Table 4. Phytosociological attributes of different species of Rangiroom beat of Senchal Wildlife sanctuary

Plant Name	D	A	A:F ratio	F C	R F	R D	R A	IVI
Fragaria nubicola	**31.9**	**34.18**	3.35	**E**	**10.20**	**40.31**	**13.36**	**63.87**
Gentiana ornata	5.3	14.45	3.61	B	4	6.69	5.65	16.34
Hemiphargma heterophylla	0.23	2.33	2.14	A	1.09	0.29	0.91	2.29
Clinopodium umbrosum	6.5	11.47	1.85	C	6.2	8.21	4.48	18.89
Cynodon dactylon	7.1	14.2	2.60	C	5.46	8.97	5.55	19.98
Galium mollugo	1.76	5.88	1.79	B	3.28	2.22	2.29	7.79
Rubus elipticus	0.1	1	0.92	A	1.09	0.12	0.39	1.6
Gnaphalium luteo-album	2.1	5.72	1.43	B	4	2.65	2.23	8.88
Geranium nepalense	0.46	3.5	2.41	A	1.45	0.58	1.36	3.39
Stellaria sikimensis	2.46	6.72	1.68	B	4	3.10	2.62	9.72
Oxalis corniculata	1.66	6.25	2.15	B	2.91	2.09	2.44	7.44
Hydrocotyle nepalensis	0.2	3	4.17	A	0.72	0.25	1.17	2.14
Rumex nepalensis	2.1	12.6	6.92	A	1.82	2.65	4.92	9.39
Polygonum capitatum	2.53	7.6	2.09	B	3.64	3.19	2.19	9.8
Swertia chiralita	0.2	2	1.83	A	1.09	0.25	0.78	2.12
Trifolium repens	1.56	15.66	14.37	A	1.09	1.97	6.12	9.18
Onaenthe thomsonii	0.83	5	2.75	A	1.82	1.04	1.95	4.81
Viola betonicifolia	1.03	3.44	1.05	B	3.28	1.30	1.34	5.92
Osbeckia stellta	1.43	4.3	1.18	B	3.64	1.80	1.68	7.12
Capsella bursapastoris	0.23	2.33	2.14	A	1.09	0.29	0.91	2.29
Hydrocotyl asiatica	0.6	2.25	0.78	B	2.91	0.75	0.87	4.53
Eupatorium adenophrum	0.1	1.5	2.08	A	0.72	0.12	0.58	1.42
Rubia cordifolia	0.46	4.66	4.28	A	1.09	0.58	1.82	3.49
Stellaria media	1.73	7.42	2.91	B	2.55	2.18	2.90	7.63
Polygonum runcinatum	03	4.5	6.25	A	0.72	0.37	1.75	2.84
Pilea umbrosa	0.53	8	11.11	A	0.72	0.66	3.12	4.5
Urtica dioica	0.23	3.5	4.86	A	0.72	0.29	1.36	2.37
Impatiens urticifolia	0.03	1	2.78	A	0.36	0.03	0.39	0.78
Elsholtzia flava	0.66	3.33	1.53	A	2.18	0.83	1.30	4.31
Hydrocotyle himalaica	1.16	5	1.96	B	2.55	1.46	1.95	5.96
Commelina sikkimensis	0.13	2		A	0.72	0.16	0.78	1.66
Hypericum hookerinum	0.06	1		A	0.72	0.07	0.39	1.18
Ophiorrhiza nutans	0.06	2		A	0.36	0.75	0.78	1.89
Anaphalis triplinervis	0.33	5		A	0.72	041	1.95	3.08
Berberis insignis	0.03	1		A	0.36	0.03	0.39	0.78
Dichroa febrifuga	0.46	7		A	0.72	0.58	2.73	4.03
Acer campbelli	0.1	1.5		A	0.72	0.12	0.58	1.42
Plantago erosa	0.16	5		A	0.36	0.20	1.95	3.51
Pouzolzia hirta	0.33	5		A	0.72	0.41	1.95	3.08
Dioscorea bulbifera	0.03	1		A	0.36	0.03	0.39	0.70
Paris polyphylla	0.03	1		A	0.36	0.03	0.39	0.78
Ocimum sanctum	0.5	5		A	1.09	0.63	1.95	3.67
Nepeta cataria	0.03	1		A	0.36	0.03	0.39	0.78
Sonchus arvensis	0.06	1		A	0.72	0.07	0.39	1.18
Lindenbergia grandifilora	0.26	2		A	1.45	0.32	0.78	2.55
Artemisia vulgaris	0.43	3.25		A	1.45	0.54	1.27	3.26
Drymaria diandra	0.1	1.5		A	0.72	0.12	0.58	1.42
Gaultheria fragrantissima	0.26	4		A	0.72	0.32	1.56	2.6
Calceolaria mexicana	0.16	1.66		A	1.09	0.20	0.64	1.93
Iritonia coarctata	0.13	2		A	0.72	0.16	0.78	1.66

(D= Density, A= Abundance, F= Frequency, FC= Frequency Class, RF= Relative Frequency, RD= Relative Density, RA= Relative Abundance, IVI = Important Value Index)

Table 5. Diversity Indices of different species of Rangiroom beat of Senchal Wildlife sanctuary

Name of the Plants	Shanon Index(Hs)	Bergar and Parker(DBP)	Evenness: (E)
Fragaria nubicola	**-0.36**	**0.4022**	**120**
Gentiana ornata	-0.18	0.0668	60
Hemiphargma heterophylla	-0.016	0.0029	5.33
Clinopodium umbrosum	-0.20	0.0819	66.66
Cynodon dactylon	-0.216	0.0895	72
Galium mollugo	-0.084	0.0222	28
Rubus elipticus	-0.008	0.0012	2.66
Gnaphalium luteo-album	-0.095	0.0264	31.66
Geranium nepalense	-0.025	0.0058	9.66
Stellaria sikimensis	-0.107	0.0311	35.66
Oxalis corniculata	-0.08	0.0210	26.66
Hydrocotyle nepalensis	-0.014	0.0025	4.66
Rumex nepalensis	-0.09	0.0264	30
Polygonum capitatum	-0.10	0.0319	33.33
Swertia chiralita	-0.014	0.0025	4.66
Trifolium repens	-0.07	0.0197	23.33
Onaenthe thomsonii	-0.04	0.0105	13.33
Viola betonicifolia	-0.056	0.0130	18.66
Osbeckia stellta	-0.072	0.0180	24
Capsella bursapastoris	-0.016	0.0029	5.33
Hydrocotyle asiatica	-0.036	0.0075	12
Eupatorium adenophrum	-0.008	0.0012	2.66
Rubia cordifolia	-0.029	0.0058	9.66
Stellaria media	-0.08	0.0218	26.66
Polygonum runcinatum	-0.020	0.0037	6.66
Pilea umbrosa	-0.033	0.0067	11
Urtica dioica	-0.010	0.0029	3.33
Impatiens urticifolia	-0.003	0.0004	1
Elsholtzia flava	-0.04	0.0084	13.33
Hydrocotyle himalaica	-0.06	0.0147	20
Commelina sikkimensis	-0.01	0.0016	3.33
Hypericum hookerinum	-0.005	0.0008	1.66
Ophiorrhiza nutans	-0.005	0.0008	1.66
Anaphalis triplinervis	-0.022	0.0042	7.33
Berberis insignis	-0.003	0.0004	1
Dichroa febrifuga	-0.02	0.0058	6.66
Acer campbelli	-0.008	0.0012	2.66
Plantago erosa	-0.01	0.0021	3.33
Pouzolzia hirta	-0.02	0.0042	6.66
Dioscorea bulbifera	-0.003	0.0004	1
Paris polyphylla	-0.003	0.0004	1
Ocimum sanctum	-0.03	0.0063	10
Nepeta cataria	-0.003	0.0004	1
Sonchus arvensis	-0.005	0.0008	1.66
Lindenbergia grandifilora	-0.018	0.0033	6
Artemisia vulgaris	-0.028	0.0054	9.33
Drymaria diandra	-0.008	0.0012	2.66
Gaultheria fragrantissima	-0.0018	0.0033	6
Calceolaria mexicana	-0.012	0.0021	4
Iritonia coarctata	-0.01	0.0016	3.33

The plant community of Gaddikhana forest range were represented by 40 species belonging to 36 genera from 26 families. *Viola betonicifolia* was found to be the most frequent, dominant and important species in the community. In the forest the ground vegetation was very thick and the forest floor was moist in nature. The proportions of dicotyledonous to monocotyledons species are about12.99:1 (Table-1.)For the herbaceous ground vegetation in the study area, the phytosociological attributes were summarized in Table 6. The decreasing trend of IVI value was in the order of – *Pilea umbrosa* ,*Rubus calycinus* ,*Nepeta lamiopsis* .The highest IVI value of *Viola betonicifolia* reveals that the species was most dominant in that community and the Lowest IVI values of *Trifolium repens, Rubia cordifolia* represent that they are the rare species of that community.Shannon index value were highest for *Viola betonicifolia* followed by *Pilea umbrosa, Rubus calycinus* and lowest in *Acer campbelli, Cardamine hirsuta* etc. (Table 7). Thus, *Viola surpense* is the most dominant species of the study area.On the other hand the evenness index value is maximum in case of *Viola betonicifolia* followed by *Pilea umbrosa, Rubus calycinus*, *Polygonum capitatum* and minimum is of *Cardamine hirsute, Acer campbelli* etc. Data pertaining to fig 3 reveals higher relative abundance for *Fragaria nubicola* and *Nepeta lamiopsis.*Distant clustering of plant species were observed between *Drymeria cordata* and *Nasturtium montanum* and *Primula malacoides* and *Nepeta lamiopsis* . (Fig16)

Table 6. Phytosociological attributes of different species of Gaddikhana of Senchal Wildlife sanctuary

Plant Name	D	A	F	A:F ratio	RF	RD	RA	IVI
Plantago major	1.15	5.75	20	0.28	1.76	1.91	2.98	6.65
Geranium nepalense	2.65	3.78	70	**0.05**	6.19	4.42	1.96	12.57
Pilea umbrosa	7.05	9.40	75	0.13	6.63	11.75	4.87	23.25
Rubus ellipticus	2.05	4.72	55	0.09	4.86	3.41	1.93	10.20
Virburnium cordifolium	1.50	2.50	60	0.04	5.30	2.50	1.29	9.09
Viola surpense	2.15	5.37	40	0.13	3.53	3.58	2.78	9.71
Viola betonicifolia	**7.95**	**8.36**	**95**	0.09	**8.40**	**13.26**	**4.33**	**25.99**
Hydrocotyle japonica	2.90	6.44	45	0.14	3.98	4.83	3.34	12.15
Polygonum runcinatum	4.30	6.14	70	0.09	6.19	7.17	3.18	16.54
Dichroa febrifuga	0.85	2.12	40	**0.05**	3.53	1.41	1.10	5.86
Urtica dioca	0.20	4.00	5	0.8	0.44	0.33	2.07	2.84
Galium mollugo	0.50	3.33	15	0.22	1.32	0.83	1.72	3.87
Gnaphalium luetoalbum	0.55	3.66	15	0.24	1.32	0.91	1.89	4.12
Lecanthus nubicola	0.90	3.00	30	0.1	2.65	1.50	1.55	5.70
Fragaria nubicola	1.15	11.5	10	1.15	0.88	1.91	5.96	8.75
Cardamine hirsuta	0.05	1.00	5	0.2	0.44	0.08	0.51	1.03
Astilbe rivularis	0.25	5.00	5	1	0.44	0.41	2.59	3.44
Poa annua	1.10	3.14	35	0.09	3.09	1.83	1.62	6.54
Polygonum capitatum	1.90	3.80	50	0.08	4.42	3.16	1.97	9.55
Rubia cordifolia	0.10	2.00	5	0.4	0.44	0.16	1.03	1.63
Rubus calycinus	4.90	6.53	75	0.09	6.63	8.17	3.38	18.18
Stellaria media	2.45	4.45	55	0.08	4.86	4.08	2.30	11.24
Pouzolzia hirta	1.95	6.50	30	0.22	2.65	3.25	3.37	9.27
Impatiens sulcata	4.00	8.88	45	0.19	3.98	6.67	4.60	15.25
Cynodon dactylon	0.85	5.66	15	0.38	1.32	1.41	2.93	5.66

Ageratum conyzoides	0.15	3.00	5	0.6	0.44	0.25	1.53	2.24
Drymeria cordata	0.15	3.00	5	0.6	0.44	0.25	1.53	2.24
Paris polyphylla	0.40	1.60	25	0.06	2.21	0.66	0.83	3.70
Vitex negundo	0.20	1.33	15	0.09	1.32	0.33	0.69	2.34
Cinnamonum impressineyium	0.05	1.00	5	0.2	0.44	0.88	0.51	1.83
Primula malacoides	0.25	5.00	5	1	0.44	0..41	2.59	3.44
Trifolium repens	0.10	1.00	10	0.1	0.88	0.16	0.51	1.55
Hemiphragma heterophylla	0.80	4.00	20	0.2	1.76	1.33	2.07	5.16
Ophiorrhiza nutans	0.25	2.00	5	0.4	0.44	0.41	1.03	1.88
Nepeta lamiopsis	1.40	28.00	5	5.6	0.44	2.33	14.52	17.29
Nasturtium montanum	2.05	10.25	20	0.51	1.76	3.41	5.31	10.48
Oxalis corniculata	0.25	2.50	10	0.25	0.88	0.41	1.29	2.58
Acer campbelli	0.05	1.00	5	0.2	0.44	0.88	0.51	1.83
Rubia manjith	0.15	1.00	15	0.07	1.32	0.25	0.51	2.08
Hypericum hookerianum	0.30	2.00	15	0.13	1.32	0.50	1.03	2.85

(D= Density, A= Abundance, F= Frequency, FC= Frequency Class, RF= Relative Frequency, RD= Relative Density, RA= Relative Abundance, IVI = Important Value Index)

Table 7. Diversity Indices of different species of Gaddikhana forest of Senchal Wildlife sanctuary

Name of the Plants	**Shanon Index**	**Barger Parker**	**Evenness**
Plantago major	-0.075	0.0192	15
Geranium nepalense	-0.137	0.0443	27.4
Pilea umbrosa	**-0.251**	**0.1178**	**50.2**
Rubus ellipticus	-0.115	0.0342	23
Virburnium cordifolium	-0.092	0.025	18.4
Viola surpense	-0.117	0.035	23.4
Viola betonicifolia	-0.267	0.132	53.4
Hydrocotyle japonica	-0.145	0.048	29
Polygonum runcinatum	-0.187	0.071	37.4
Dichroa febrifuga	-0.059	0.014	11.8
Urtica dioca	-0.017	0.003	3.4
Galium mollugo	-0.038	0.008	7.6
Gnaphalium luetoalbum	-0.042	0.009	8.4
Lecanthus nubicola	-0.062	0.015	12.4
Fragaria nubicola	-0.075	0.019	15
Cardamine hirsuta	-0.005	0.0008	1
Astilbe rivularis	-0.022	0.004	4.4
Poa annua	-0.072	0.018	14.4
Polygonum capitatum	-0.107	0.031	21.4
Rubia cordifolia	-0.006	0.001	1.2
Rubus calycinus	-0.203	0.081	40.6
Stellaria media	-0.128	0.04	25.6
Pouzolzia hirta	-0.11	0.032	22
Impatiens sulckata	-0.179	0.066	35.8
Cynodon dactylon	-0.059	0.014	11.8
Ageratum conyzoides	-0.012	0.002	2.4
Drymeria cordata	-0.012	0.002	0.4
Paris polyphylla	-0.03	0.006	6
Vitex negundo	-0.017	0.003	3.4
Cinnamonum impressineyium	-0.005	0.0008	1
Primula malacoides	-0.022	0.004	4.4

Trifolium repens	-0.006	0.001	1.2
Hemiphragma heterophylla	-0.056	0.013	11.2
Ophiorrhiza nutans	-0.006	0.001	1.2
Nepeta lamiopsis	-0.086	0.023	17.2
Nasturtium montanum	-0.114	0.034	22.8
Oxalis corniculata	-0.022	0.004	4.4
Acer campbelli	-0.005	0.0008	1
Rubia manjith	-0.012	0.002	2.4
Hypericum hookerianum	-0.026	0.005	5.2

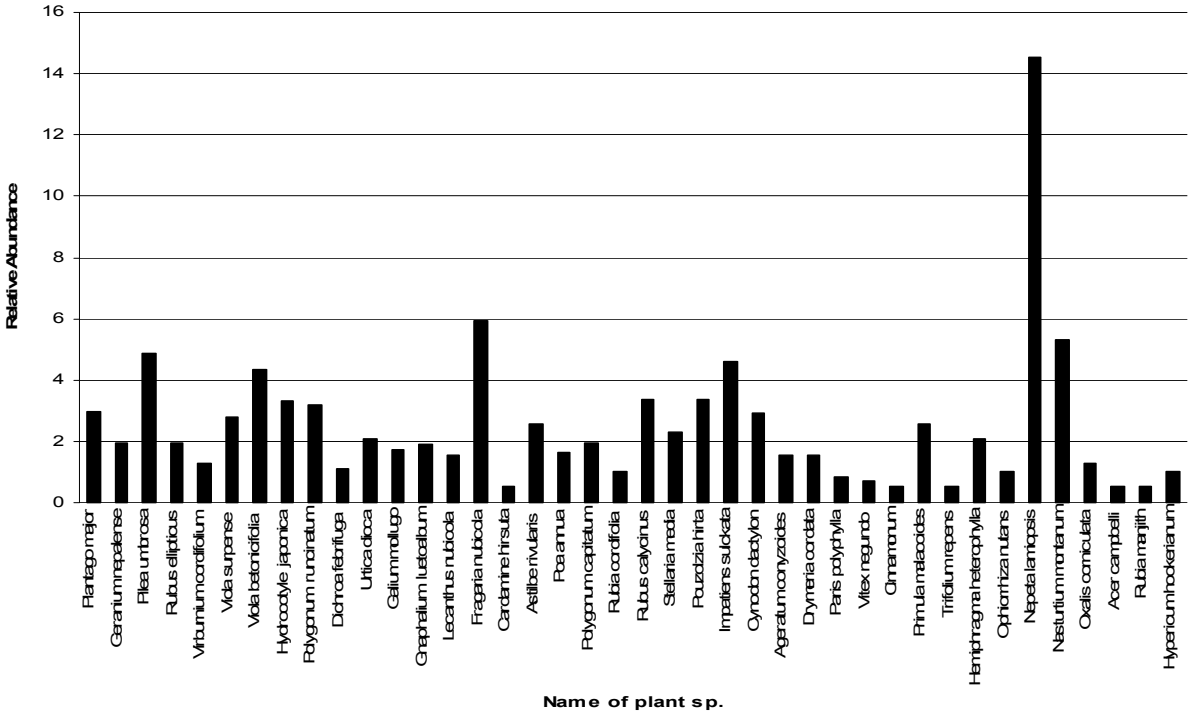

Figure 3. Relative abundance of the plant species (n=40) of Gaddikhana Forest

The plant community of 6th mile beat were represented by 34 species. Among the different observed species in the present study site *Acer campbelli*. *Pilea umbrosa* were found to be the most frequent, dominant and important species in the community. In the forest the ground vegetation was very thick and the forest floor was moist in nature. The proportions of dicotyledons to monocotyledons species are about 7.5:1 (Table-1) For the herbaceous ground vegetation in the study area, the frequency, density, abundance were summarized in Table 8. On the basis of IVI scores, which give an idea regarding the relative importance of species and sociobiological structure of the community, *Pilea umbrosa* appears to be the dominant species. The decreasing trend of IVI score was in the order of *Viola betonicifolia*, *Rubus calycinus, Polygonum runcinatum*, *Ophiorrhiza nutans*. The highest IVI score of *Pilea umbrosa* deserves special mention for its luxuriant occurrence in the study area. The low IVI scores of *Lindenbergia grandifilora, Primula melacoides* and *Oxalis corniculata* indicate that these are rare species in the study area. The value of Shanon index was high for *Pilea umbrosa*, *Viola betonicifolia* and *Polygonum runcinatum* and low for *Lindenbergia grandifilora*, *Oxalis corniculata*, *Acer campbelli* (Table 9). Thus, *Pilea umbrosa* was the

most dominant species in the study area and reveals its extensive distribution. The evenness index value is high in case of *Pilea umbrosa* followed by *Viola betonicifolia, Rubus calycinus*, *Polygonum runcinatum*, *Geranium nepalense* and low was in case of *Primula melacoides*, *Lindenbergia grandifilora*, *Oxalis corniculata*. Higher relative abundance value were recorded for *Pilea umbrosa*, *Viola betonicifolia.*(Fig-4) Hierarchial cluster analysis of the species data of 6th mile beat revealed numerous group clustering between *Hydrocotyle nepalense* and *Commelina sikkimensis* , *Rubus calycinus* and *Viola bentonicifolia* , *Ophiorhizza nutans* and *Pilea umbrosa* , *Viola bentonicifolia and Iritonia coacrtata* (Fig 17).

Rank abundance diagrams visually describe the allocation of individuals to species in communities. A more complete description of a community could be obtained by plotting the proportional abundance of every species against its rank of abundance. Data represented in fig (5,6 and 7) reveals higher proportion of frequency class 0.6-1for Rangiroom beat, a homogenized frequency class distribution (0-2) for Gaddikhana forest range and higher proportion of frequency class 0.51 to 1.52 for 6th mile beat.

Table 8. Phytosociological attributes of different species of 6th mile beat of Senchal Wildlife sanctuary

Plant Name	D	A	F	A:F ratio	RF	RD	RA	IVI
Polygonum runcinatum	6.95	8.17	85	0.09	8.58	10.19	8.17	21.21
Geranium nepalense	3.8	4.47	85	**0.05**	8.58	5.57	4.47	16.73
Hydrocotyle nepalensis	3.1	4.66	45	0.10	4.54	3.08	4.66	10.31
Galium mollugo	1.9	4.47	40	0.11	4.04	2.78	4.47	9.4
Pilea umbrosa	**12.7**	**13.36**	**95**	0.14	**9.59**	**18.63**	**13.36**	**35.93**
Viola betonicifolia	9.35	10.38	90	0.12	9.90	13.71	10.38	28.48
Lecanthus peduncularis	0.2	4	5	0.8	0.50	0.29	4	2.98
Plantago erosa	1.6	5.33	30	0.17	3.03	2.34	5.33	8.28
Fragaria nubicola	1.75	5.83	30	0.19	3.03	2.56	5.83	8.78
Gnaphalium affine	1.35	9	15	0.6	1.51	1.98	9	8.41
Rubus elipticus	0.5	1.66	30	0.06	3.03	0.73	1.66	4.66
Dichroa febrifuga	1.2	4.8	25	0.19	2.52	1.75	4.8	6.89
Stelaria media	2.95	9.83	30	0.33	3.03	4.32	9.83	12.75
Acer campbelli	0.2	2	10	0.2	1.01	0.29	2	2.39
Pauzolzia hirta	0.15	3	5	0.6	0.50	0.22	3	2.36
Virburnium cordifolium	0.7	2	35	0.06	3.53	1.02	2	5.64
Rubus calycinus	7.45	8.27	90	0.09	9.09	10.93	8.27	24.54
Galinsuga perviflora	0.3	3	10	0.3	1.01	0.44	3	3.09
Trifolium repens	0.25	2.5	10	0.25	1.01	0.36	2.5	2.83
Primula melacoides	0.05	1	5	0.2	0.50	0.07	1	1.11
Commelina sikkimensis	0.05	6.5	10	0.65	1.01	0.36	6.5	4.93
Impatiens urticifolia	1.75	8.75	20	0.44	2.02	2.56	8.75	9.37
Lindenbergia grandifilora	0.05	1	5	0.2	0.50	0.07	1	1.11
Chenopodium album	0.75	3	25	0.12	2.52	1.10	3	5.26
Ophiorrhiza nutans	5.95	9.9	60	0.17	6.06	8.73	9.9	20.21
Iritonia coarctata	0.8	16	5	3.2	0.50	1.17	16	10.43

Arisaema graffithi	0.35	3.5	10	0.35	1.01	0.51	3.5	3.43
Hemiphargma heterophyllum	0.6	4	15	0.27	1.51	0.88	4	4.58
Cynodon dactylon	0.15	3	15	0.2	0.05	0.22	3	2.36
Drymaria diandra	0.3	2	15	0.13	1.51	0.44	2	3.04
Chrysanthemum pyrethroides	1.05	4.2	25	0.17	2.52	1`.54	4.2	6.36
Cardamine hirsuta	0.4	8	5	1.6	0.05	0.58	8	5.46
Polygonum nepalensis	0.4	4	10	0.4	0.01	0.58	4	3.69
Oxalis corniculata	0.1	1	10	0.1	0.01	0.14	1	1.69

(**D**= Density, **A**= Abundance, **F**= Frequency, **FC**= Frequency Class, **RF**= Relative Frequency, **RD**= Relative Density, **RA**= Relative Abundance, **IVI** = Important Value Index)

Table 9. Diversity Indices of different species of 6th mile island of Senchal Wildlife sanctuary

Name of the Plants	**Shanon Index**	**Barger Parker**	**Evenness**
Polygonum runcinatum	-0.23	0.101	46
Geranium nepalense	-0.15	0.055	30
Hydrocotyle nepalensis	-0.1	0.03	20
Galium mollugo	-0.09	0.027	18
Pilea umbrosa	**-0.31**	**0.184**	**62**
Viola betonicifolia	-0.27	0.136	54
Lecanthus peduncularis	-0.012	0.002	2.4
Plantago erosa	-0.086	0.023	17.2
Fragaria nubicola	-0.092	0.025	18.4
Gnaphalium affine	-0.075	0.019	15
Rubus elipticus	-0.034	0.007	6.8
Dichroa febrifuga	-0.069	0.017	13.8
Stelaria media	-0.133	0.042	26.6
Acer campbelli.	-0.006	0.001	1.2
Pauzolzia hirta	-0.012	0.002	2.4
Virburnium cordifolium	-0.046	0.01	9.2
Rubus calycinus	-0.024	0.108	48
Galinsuga perviflora	-0.022	0.004	4.4
Trifolium repens	-0.017	0.003	3.4
Primula melacoides	-0.005	0.0007	1
Commelina sikkimensis	-0.042	0.009	8.4
Impatiens urticifolia	-0.092	0.025	18.4

Lindenbergia grandifilora	-0.005	0.0007	1
Chenopodium album	-0.046	0.01	9.2
Ophiorrhiza nutans	-0.21	0.086	42
Iritonia coacrtata	-0.049	0.011	9.8
Arisaema graffithi	-0.026	0.005	5.2
Hemiphargma heterophyllum	-0.038	0.008	7.6
Cynodon dactylon	-0.012	0.002	2.4
Drymaria diandra	-0.022	0.004	4.4
Chrysanntemum pyrethroides	-0.062	0.015	12.4
Cardamine hirsuta	-0.026	0.005	5.2
Polygonum nepalensis	-0.026	0.005	5.2
Oxalis corniculata	-0.006	0.001	1.2

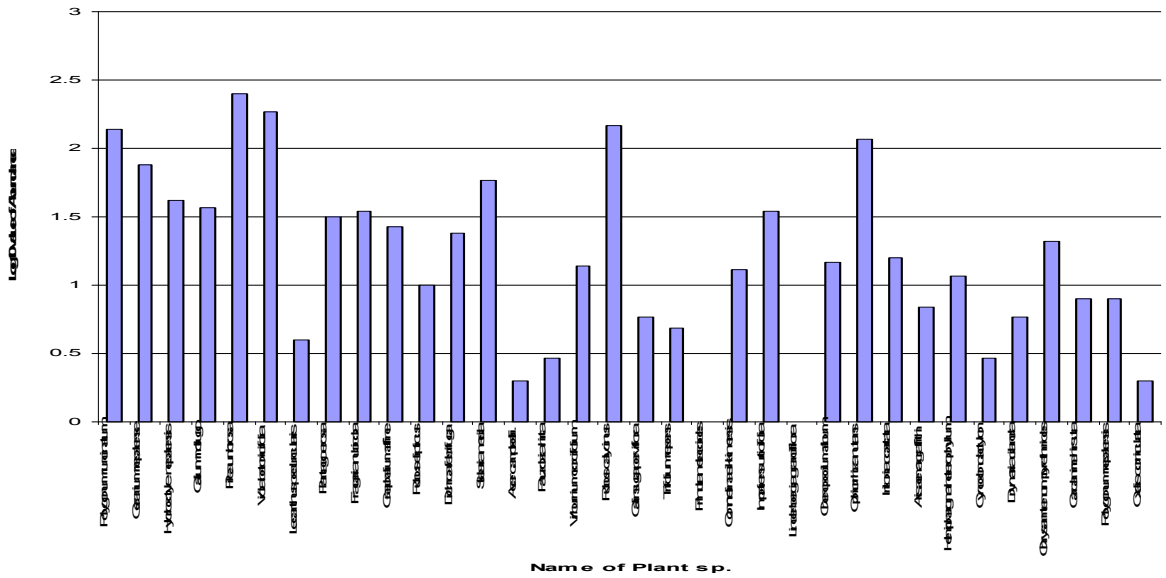

Figure 4. Relative abundance of the plant species (n=50) of 6th Mile Beat forest.

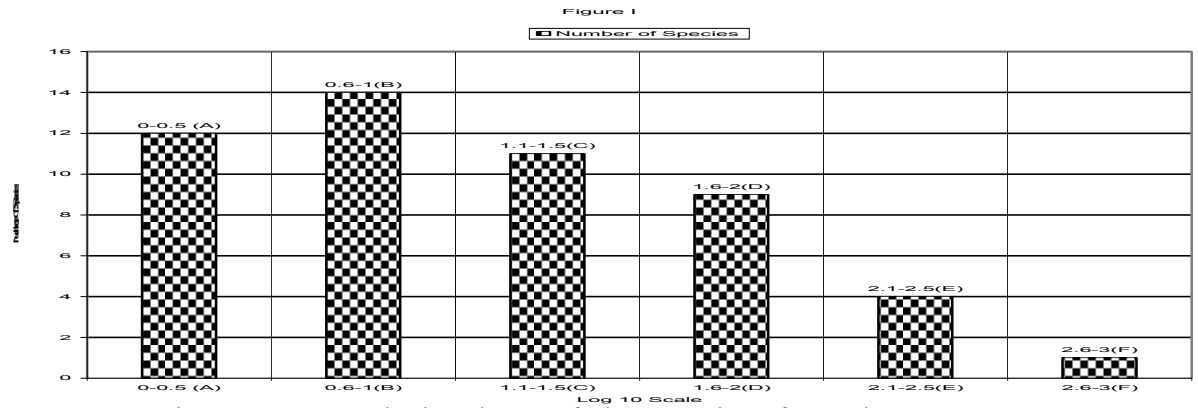

Figure 5. Log-rank abundance of plant species of Rangiroom Forest

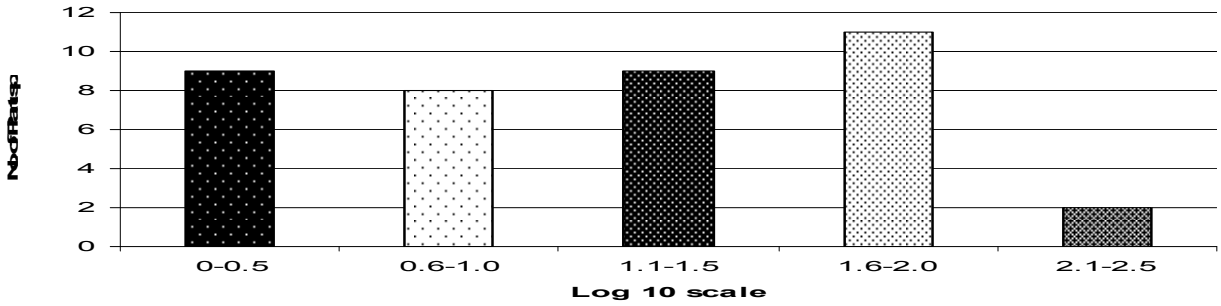

Figure 6. Log-rank abundance of plant species of Gaddikhana Forest

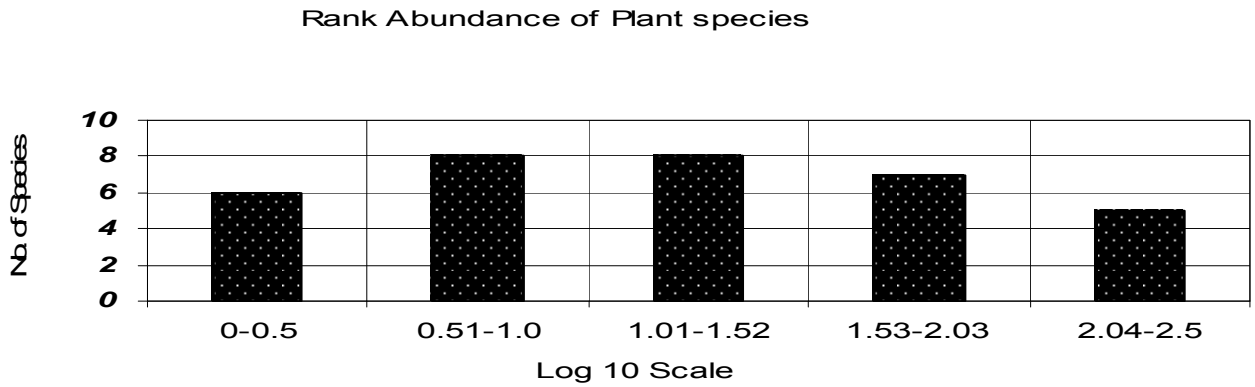

Figure 7. Log-rank abundance of plant species of 6th Mile Beat Forest

3.2 Pedological Characteristics

Soil factors include all the physical, chemical and biological properties of the soil. The nature of the soil profile, soil pH and the nutrient cycle between the soil and the trees are some of the important dimensions in determining the site quality. The pH of the soil ranged from 7.03 to 8.24 for Rambhi beat,7.23 to7.96 for Rangiroom beat, clearly indicating that the soil is alkaline in nature and there is not much variation in the pH values of different soil samples (Table 10). The pH of the soil samples Gaddikhana forest and 6th mile beat revealed acidic nature and there

is not much variation in the pH values of different soil samples (Table 10) .The conductivity value of pedons of Rambhi and Rangiroom beat were relatively higher in comparison to other studied sites (Table 10). The soil available P ranged between 1.72 to 2.82 g/kg for Rambhi beat;1.4 to 2.92 g/kg for Rangiroom beat; 1.97 to 2.78 g/kg for Gaddikhana forest;1.63 to 2.20 g/kg for 6 mile beat. The level of total nitrogen were found to be higher in Rangiroom beat and Gaddikhana forest in comparison to other two studied sites.(Table 10) The soil analyzed for percentage organic carbon revealed elevated level of organic carbon(%) in Rambhi beat and Rangiroom beat in comparison to Gaddikhana and 6 mile beat (Table: 10). Hierarchial cluster analysis of the pedological data revealed close association of organic carbon and nitrogen forming cluster for Rambhi beat.pH and N , conductivity and organic carbon forming closely spaced clusters in Rangiroom beat.pH and organic carbon, nitrogen and phosphorous forming close clusters for Gaddikhana forest range and phosphorous and organic carbon forming close clusters for 6th mile beat.(Fig 5,6,7 and 8) Box plot of the 10 pedons of each studied sites revealed much wider variation of soil pH for Rambhi and 6th mile island among the 10 pedons. Soil conductivity reflected much wider variation among the different pedons of Rambhi beat.Soil phosphate phosphorous results revealed least variation among the 10 pedons of Gaddikhana forest range .Pedons of Rangiroom beat and Gaddikhana forest range showed significant variation among the 10 pedons in comparison two two other sites. Organic carbon did not showed significant variation among the pedons of four studied sites.(Fig 9,10,11,12 and 13)

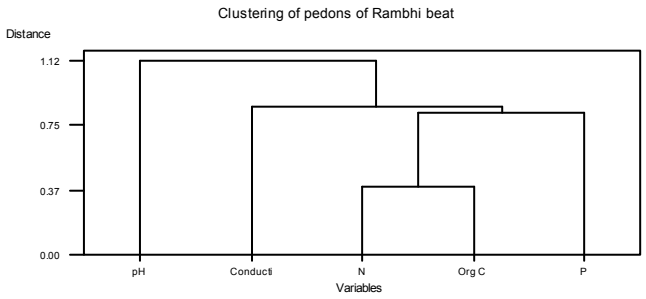

Figure 5. Clustering of pedons of Rambhi beat

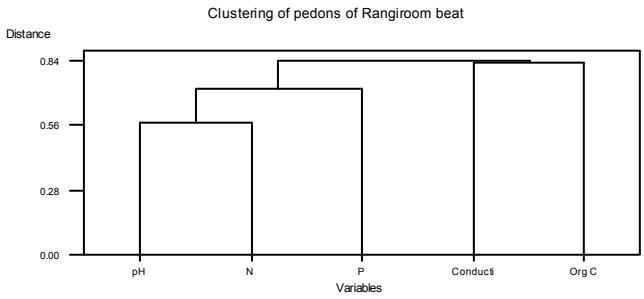

Figure 6. Clustering of pedons of Rangiroom beat

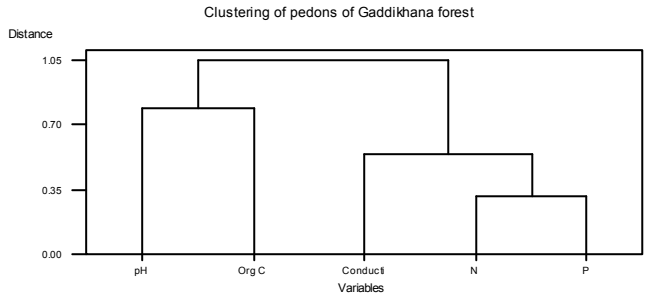

Figure 7. Clustering of pedons of Gaddikhana forest

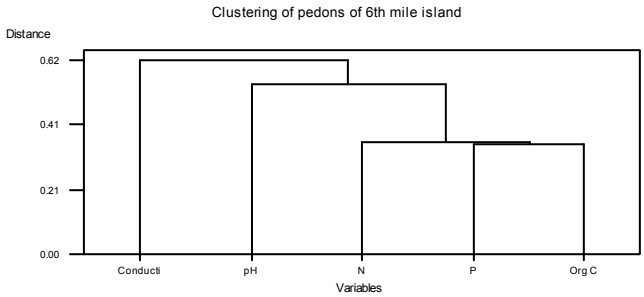

Figure 8. Clustering of pedons of 6th mile beat

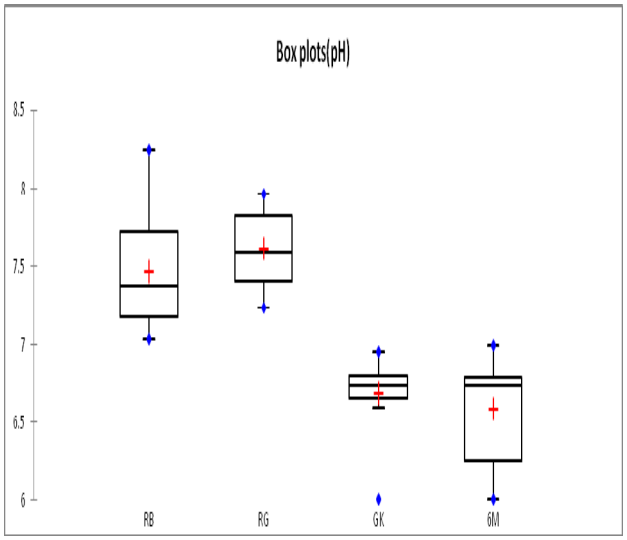

Figure 9. Box plot of soil pH for four beats SWS

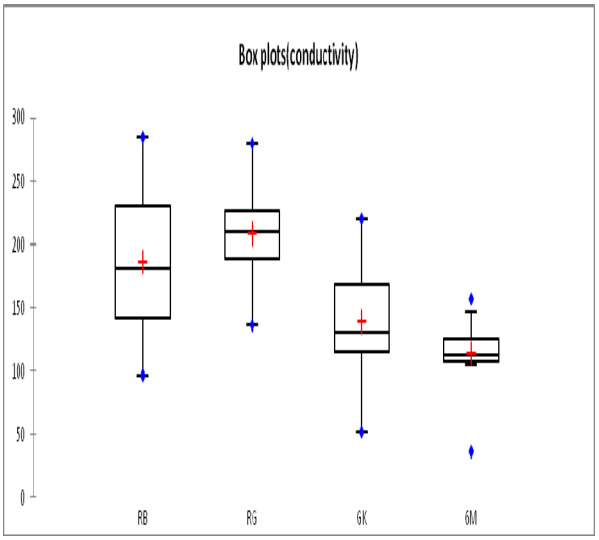

Figure 10. Box plot of soil conductivity for four beats SWS

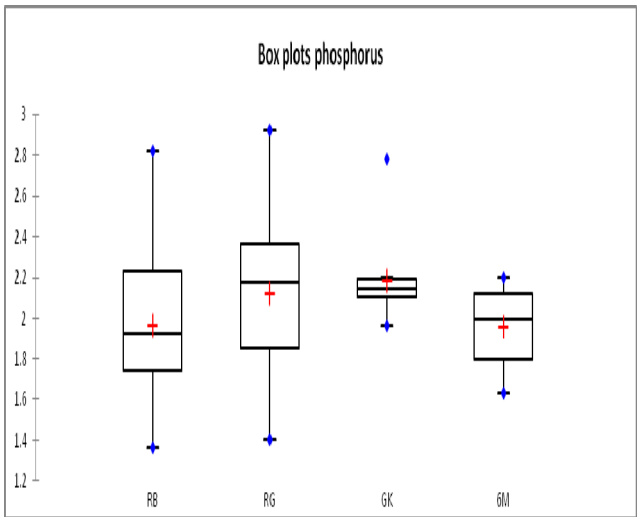

Figure 11. Box plot of soil phosphate phosphorous for four beats of SWS

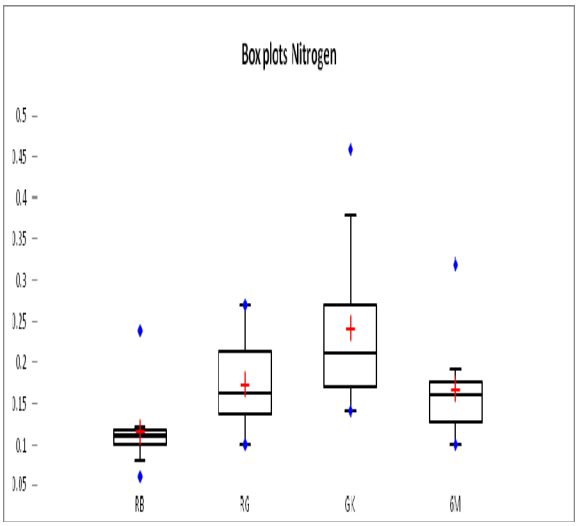

Figure 12. Box plot of soil nitrogen for four beats of SWS

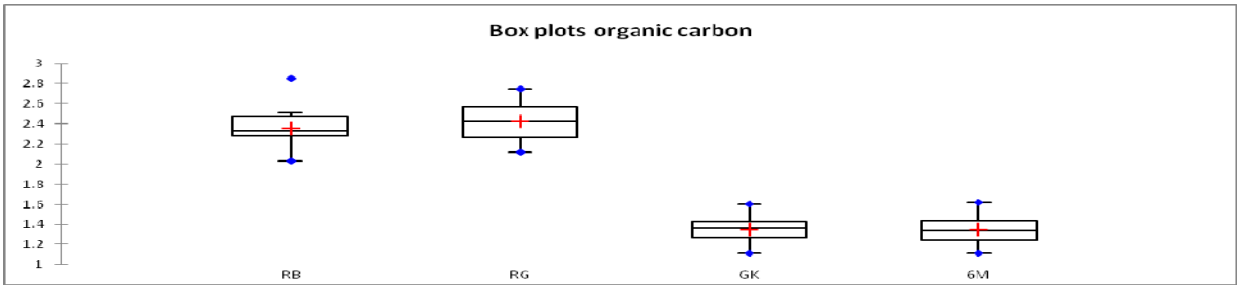

Figure 13. Box plot of soil organic carbon for four beats of SWS

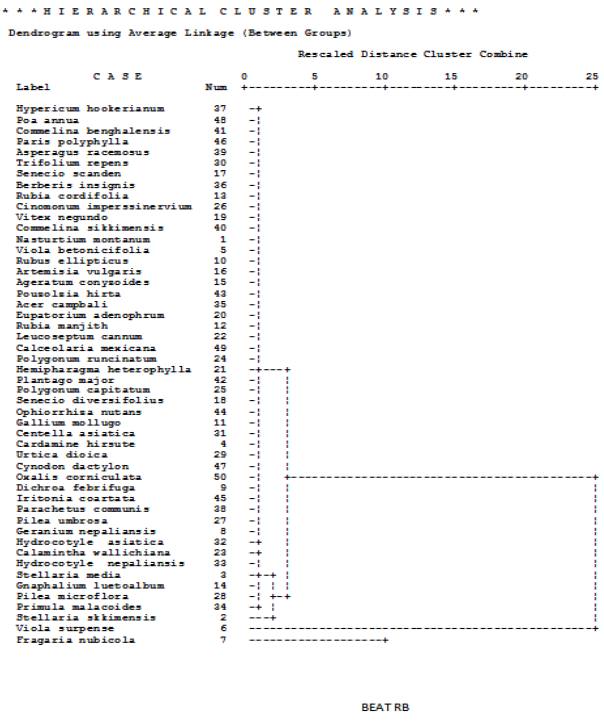

Figure 14. Clustering of plant species for Rambi beat

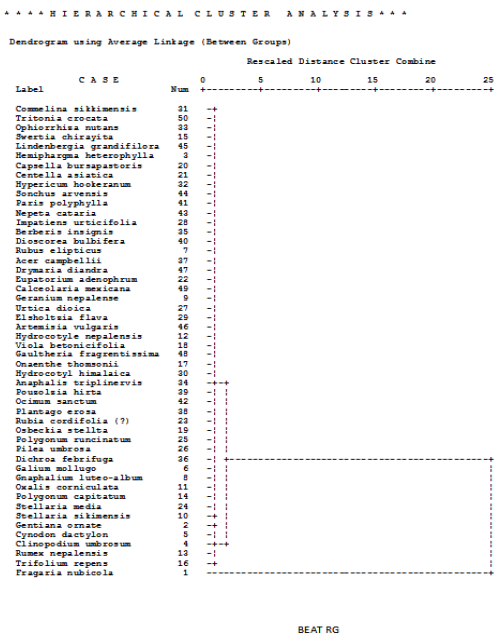

Figure 15. Clustering of plant species for Rangiroom beat

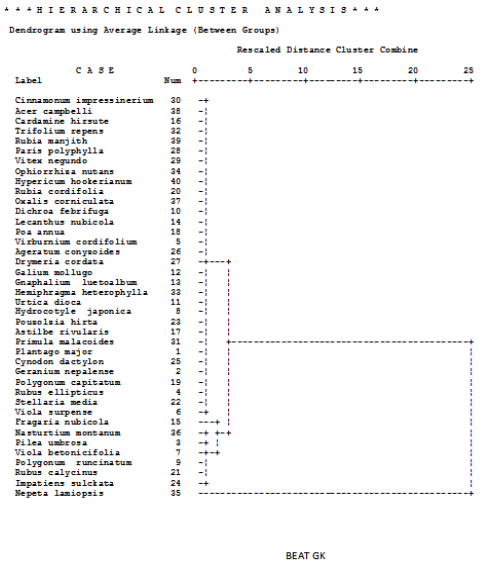

Figure 16. Clustering of plant species for Gaddikhana forest range

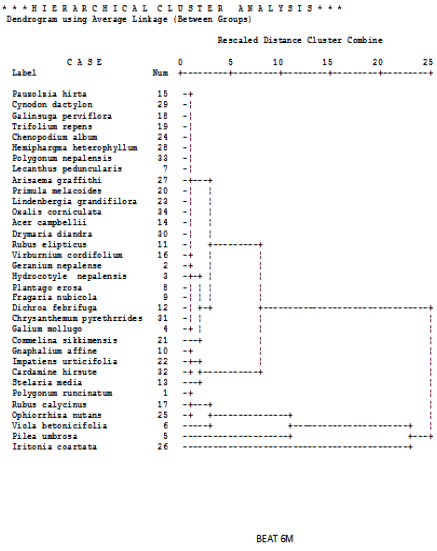

Figure 17.Clustering of plant species for 6th mile island

4. Discussion

In order to assess ecological knowledge of the native flora in Eastern Himalayas in general and Sikkim Himalaya in particular., aquantitative phytosociological study in different was carried out. Importance value index (I.V.I.) for each plant species was determined to quantify the importance of each species.The vegetation of the studied sites is composed of evergreen vegetation. The disturbance is mainly due to the extensive cutting of tress for fuel and for

fodder, overgrazing, removal of economically important trees, defective forest management and some other biotic interferences. These activities are responsible in converting natural vegetation to semi natural vegetation. An important component of any ecosystem is the species it contains. Species also serves as good indicators of the ecological condition of a system (Morgenthal, *et al.,* 2001). A list of all species collected during the study was compiled. The floristic composition of different area was also compared. The species composition of the four studied sites was considerably different. Vegetation analysis gives the information necessary to determine the name of community and provide data that can be used to compare it with other communities. Four to five plant communities: *Viola surpense* , *Fragaria nubicola, Viola betonicifolia* and *Pilea umbrosa* were observed as a leading dominant. The communities with strong single species dominance has been attributed to grazing, species competition, seed predation, disease, stability and niche diversification (Whittaker and Levin 1977, Harper 1977). The rarer plant species with poor representation in our samples need proper attention from plant biologists to determine their conservation status and key functions. *Nasturtium montanum, Dichroa febrifuga, Rubia cordifolia, Cinomonum imperssineryium,* in Rambhi forest beat; *Eupatorium adenophrum, Rubus elipticus, Impatiens urticifolia, Berberis insignis, Dioscorea bulbifera, Paris polyphylla, Nepeta cataria* in Rangiroom beat, *Cardamine hirsute, Cinnamonum impressineyium, Trifolium repens, Acer campbelli, Rubia manjith* in Gaddikhana forest range, *Primula melacoides, Lindenbergia grandifilora, Oxalis corniculata in* 6th mile beat. The communities in the study area were heterogeneous. The absence of certain frequencies classes in the communities reflected the heterogeneity of the vegetation, which is either due to biotic disturbance or the floral poverty. The result obtained by Raunkiaer (1934) may be regarded only as possibilities to be confirmed by other alternative approaches. The ratio of abundance to frequency for different species was calculated to elicit the distributional patterns. This ratio indicates regular (0.025), random (0.025-0.05) and contagious (>0.05) distributions (Curtis and Cottam 1956). In our present investigation most of the studied plant species were contagious in distribution except *Polygonum runcinatum* for Rambhi beat, *Geranium nepalense* and *Dichroa febrifuga* for Gaddikhana forest , *Geranium nepalense* for 6th mile island showing random distribution.

The concept of species diversity relates simply to “richness” of a community or geographical area in species. At the simplest level of examination, species diversity corresponds to the number of species present. Species diversity is considered to be an important attribute of community organization and allowed comparison of the structural characteristics of the communities. It is often related to community dynamics stability, productivity, integration, evolution, structure and competition. The idea of displacement of one species through competition with other is net prime importance. The ecology of different plant communities from different sites of Senchel wildlife sanctuary showed variation in nature, structure, composition of vegetation and soil characteristics. Most of the species were evergreen in nature. The majority of individuals of plant population were seen in danger. Various types of activities have modified the plant cover over wide areas. There is a need to develop plant-protected areas. Scientific information relating to the composition of vegetation can be helpful for proper rehabilitation of the affected area because this forms the basic element for the conservation of important and endangered flora and fauna of any region. Protection of the

natural flora from overgrazing is necessary, especially during the time when the desirable plants set their seeds. Protection is essential to maintain the desirable forage plant species in a good proportion, to avoid invader plant species and to rehabilitate the destroyed natural flora (Arshad, *et al.,* 2002). We must carry out our efforts to make a list of the plant species, which can be lost from the natural environment, otherwise it will leads to desertification. Desertification associated with human activities has been recognized over the past two decades as one of the important facets of ongoing global environmental change (Verstraete and Schwartz, 1991; UNEP,1997; Huenneke, *et al.,* 2002) and Species loss can alter the goods and services provided by ecosystems (Hooper, *et al.,* 2005).

The variable rate of frequency class distribution at four studied sites of Senchel wildlife sanctuary may be explained by a common biological explanation pattern which implies most dominant species appeared to colonize a new area appropriates a fraction of the available resources and by competitive interaction, preempts that fraction. The second species then preempts a similar fraction of the remaining resource and so on with further colonists.

Soil pH gives some measure of general level of fertility (Wilde 1954). Grubb (1963) noted low pH (4.2) with poor exchangeable potassium in Montane Forest soil. Acidic nature of different pedons of Gadikhana forest and 6 mile beat may be attributed towards the acidifying effect of intense decomposition products of organic residues accumulated on the forest floor since remote past. Higher level of conductivity of different pedons of Rambhi and Rangiroom beat maybe attributed towards higher decomposition rate of leaf litter along with higher mineralization rate of the pedons of respective study sites.

The present study indicate significantly lower organic-C in Gaddikhana and 6 mile beat than remaining sites, and it may result due to (a) by prominent deforestation by people for fuel purpose (b) intensive cattle grazing, and (c) heavily eroded surface area (unpublished observation). All these three factors may attribute to low input of organic matter into the soil. The contact between the plant residues and microbes in erosional soil is reduced and may result in lower decomposition. Thus, inputs of organic matter decreases and output of soil organic matter increases in erosional soils. According to Srivastava & Singh (1991), deforestation (conversion of forest into cropland) may result in loss of 51.2% organic-C in the Vindhyan plateau. Higher level of total nitrogen in the different pedons of Rangiroom beat and Gaddikhana forest may be attributed towards low vegetation demand for the nutrients and increase in supply due to microbial cell death (Jaramillo & Sanford 1985).Level of soil phosphate phosphorous were found to be higher for Rambhi and Rangiroom beat might be attributed towards physico-chemical release of inorganic and organic phosphorous by organic acids through the action of lower molecular weight organic anions such as oxalate which can replace phosphorous sorbed at metal hydroxide surfaces through ligand exchange reactions and dissolved metal oxide surfaces that sorb phosphorous (Fox *et al*, 1990) under higher decomposition rate of litter.

The differential responses of the different pedons of the forest areas under study to different parameters are possibly an outcome of their unique abiotic composition, the interactions between biotic and abiotic components and between themselves and the prevailing climatic

condition. This information can be used in future for laying out schemes optimization of forest ecosystems.

The reconstruction of plant communities on disturbed sites with a species composition similar to that of the natural area will require allocation of more financial inputs. The saving and establishment of plant communities one of the major tasks facing by ecologist. Extensive work on the development of vegetation depends upon good indigenous vegetation recovery. Preservation of these communities especially within disturbed sites is more generally, demands a unique and pressing conservation challenge. extensive cutting of tress for fuel and for fodder, overgrazing, removal of economically important trees, defective forest management and some other biotic interferences affecting the nature, structure and composition of plant communities. Periodical ecological survey, knowledge of vegetation and their relationship with soil characteristic can be helpful for future development project Plant ecological surveys of all the disturbed and threatened areas on permanent basis are required to know their current biodiversity situation and future continuity status. The impact of anthropogenic alteration of habitats in Senchal forest has to be taken into account. The policymakers should focus their conservation efforts in the fragile ecosystem. Since species diversity is important to maintain heterogeneity of a stable ecosystem, the diversity is to be preserved through appropriate measures. Since this forest is likely to have generous impact on socio-economic conditions of local stakeholders, its ecorestoration and protection is of utmost importance.

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