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RESEARCH ARTICLE

SPATIAL PATTERN, DIVERSITY AND PHYTOSOCIOLOGICAL ANALYSIS OF WOODY PLANT SPECIES IN PONDA WATERSHED, RAJOURI, J&K, INDIA

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ABSTRACT

The phytosociology is one of the important aspect for analyzing the structure and composition of vegetation and its dynamics. In the present study, we analyzed spatial pattern, diversity and phytosociology of woody plants species in Ponda Watershed, Rajouri, Jammu and Kashmir. Quantitative analysis on species distribution and diversity in addition to phytosociological attributes were done in two landuse classes i.e. agricultural and forest area. In all, 40 sampled plots each of 20 m × 20 m size for trees and 5m × 5m size for shrubs in forest area and 50m × 50m size plots for trees and 10m × 10m size for shrubs in agriculture fields were laid. A total of 72 woody plant species were identified from the study area comprising of 46 trees and 26 shrubs. The dominant tree species in forest was *Pinus roxburghii* with IVI of 150.65, whereas, agriculture field showed *Ziziphus mauritiana* as dominant tree species with IVI of 44.98. Among shrubs, *Carissa opaca* was dominant in both landuse classes with IVI of 140.46 in forest and 65.27 in agriculture field. Contagious distribution of plants (trees and shrubs) was common in study area. The phytosociological studies reveal that Importance value index, density and basal area were high in forest area, where as species richness and diversity was high in agriculture area with Shannon-Wiener's, Margalef's and Menhinick's index value of 3.25, 7.13 and 2.16 for trees followed by 2.53, 3.13 and 0.86 for shrubs, respectively. Simpson's index of dominance was also high in forest.

INTRODUCTION

Vegetation is complex in nature and its structure and composition differs from place to place because of varying climatic condition and topography (Singh, 2006; Raturi, 2012). High mountain ranges are considered as hotspots of phytodiversity due to their climatic complexity, location within floristic region, frequency and amount of natural disturbances. The number of species in mountain area depends on these different factors. The Himalayas encompass diverse and characteristic vegetation distributed over a wide range of climatic and topographical variation (Dhaulkhandi *et al.,* 2008). It ranges from tropical dry deciduous forests in the foothills to alpine meadows above timberline (Singh and Singh, 1992). Both structure and diversity of vegetation have strong functional role in controlling ecosystem process like biomass production, cycling of water and nutrient (Gower *et al.,* 1992). Phytosociological analysis and population structure of forests in Himalayan subtropical regions have been studied by various workers such as Ahmed *et al*. (2006); Kharkwal (2009); Rawat and Chandhok (2009); Todoria *et al.* (2010); Kharkwal and Rawat, 2010; Gurarni *et al.* (2010); Gairola *et al.* (2011); Shaheen *et al.* (2011). Significant work in the field of phytosociology and phytodiversity has also been done in the past few decades in the Himalayan state of Jammu and Kashmir by many workers including Kour (2001); Sudan, 2007); Sharma *et al.* (2008); Dangwal *et al*. (2012); Sharma and Raina (2013). Rajouri is one of the hilly districts of Jammu and Kashmir and is rich in floral wealth. It has two regions with characteristic topography and climate *i.e*., the temperate and subtropical regions, former include northern part and later southern part of the district. The district has diverse relief and rainfall patterns showing general gradient in relative relief from North to south followed by generally decreases in rainfall in the same lineament (Rashid *et al*., 2008). The rich phytodiversity of the area can be attributed to physiographic diversity. Therefore, conservation and scientific management of biodiversity for socio-economic development, betterment of soil, livestock and human has great significance (Gurarni *et al*., 2010). A sound understanding of phytosociology and the richness of species is necessary for appropriate conservation and restoration of the biological diversity. Thus, keeping this in view present study was carried out to analyze the structure, composition, distribution and diversity of woody vegetation in Ponda watershed of district Rajouri.

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MATERIALS AND METHODS

The study area *i.e.,* Ponda Watershed selected for present investigation lies in Rajouri Forest Range, Rajouri, Jammu and Kashmir. It is located between 33^0 50′ to 33^0 30′ N latitude and

74^0 to 74^0 10′E longitudes and spread over an area of 81 km^2 with altitude range of 800m to 1000m asl (Fig.1).

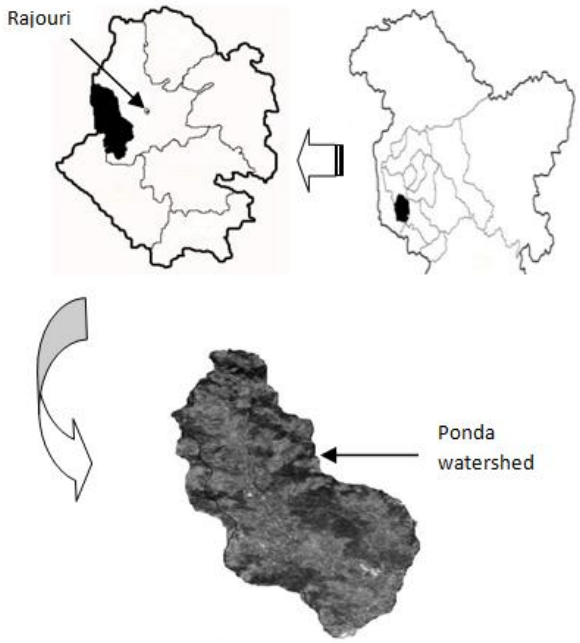

Fig.1 Location map of Ponda Watershed

Stratified random sampling has been carried out with forty quadrats covering different sites of the study area over a period of one year from June 2011 to May 2012. Phytosociological analysis was carried out using 20m x 20 m and 5m x 5m size quadrat for trees and shrubs in forest area, respectively. Whereas, in agriculture area, quadrat size of 50m x 50m for trees and 10m x 10m for shrubs were used. In each quadrat, all plants having cbh ≥ 30 cm were treated as trees and individually measured at breast height, *i.e*. 1.37 m from the ground. Field data was analyzed for abundance, density and frequency (Curtis and McIntosh, 1950) in each landuse class. The sum of the relative values, *viz*, frequency, density and dominance used for importance value index (Curtis, 1959). The basal area was calculated by using following formula.

$$\text{Basal area} = \frac{(cbh)^2}{4\pi}$$

Where, CBH = circumference at breast height

Abundance to frequency ratio for different species was calculated to know the distribution pattern of the species. If, <0.025 it showed regular distribution, between 0.025-0.05 indicates random distribution and >0.05 indicates contagious distribution. Species diversity and concentration of dominance was computed by using Shannon-Weaver (1949) and Simpson indices (1949), respectively. Species richness was calculated using Menhinick's Index (1964) and Margalef's Index (1968).

RESULTS AND DISCUSSION

In the study area, a total of 46 trees and 26 shrub species were encountered which belonging to 36 families and 59 genera with *Pinus roxburghii* as the most dominant species. A study conducted by Dangwal *et al.* (2012) in Nowshera block, Rajouri district also reported a total of 41 woody plants which comprised of 29 trees and 12 shrubs. Muhammad *et al.* (2012) while investigating the position of *Pinus roxburghii* in the forests of Kotli Hills, Azad Jammu and Kashmir recorded a total of 97 plant species out of which 12 were tree, 18 were shrubs and the remaining 67 were herb species.

Phytosociological Analysis

The phytosociological analysis carried out in the study area revealed that *Pinus roxburghii* was the tree species with maximum density values followed by *Mallotus philippensis* (Table 1). Dangwal *et al*. (2012) also reported *Pinus roxburghii* as the dominated tree species from the forest of block Nowshera of district Rajouri having similar conditions as of the study area, however with very low density (3.9-7.9 individuals/ha). Almost similar results were obtained by Nizami *et al.* (2009) in sub-tropical pine forest of Pakistan. Shaheen *et al.* (2011) and Muhammad *et al.* (2012) also reported *Pinus roxburghi* as dominant tree species from Bagh district and Kotli Hill, Pakistan, respectively. The tree density recorded in forests of study area was 468.75 individuals/ha which was in range of 307.8-376.5 individuals/ha as reported from disturbed sub-tropical forest of Uttarakhand Himalaya (Arya and Ram, 2011) and lesser Himalayas of Pakistan (Shaheen *et al*., 2011). However it is quite low as compared to other studies conducted elsewhere in sub-tropical forests (Ahmed *et al*., 2006; Sharma *et al*., 2008; Gurarni *et al.*, 2010).

The results of the study also show that in agriculture land the frequency and density of trees was very less as compared to the forest area wherein, *Ziziphus mauritiana* has been observed a tree species with highest frequency and density values followed by *Grewia optiva*. Among the shrubs, in forest and agriculture land, highest frequency and density value have been recorded for *Carissa opaca* (Table 2 and Table 4). Sharma, (2003) and Dangwal *et al*. (2012) also reported *Carissa opaca* to be the most frequent shrub of Jammu district and block Nowshera of district Rajouri respectively. In present study, the total basal area of the tree species was found to be 85.33m^2 ha^{-1} with 69.70 m^2 ha^{-1} for *Pinus roxburghii* (Table 1). Anthropogenicaly disturbed sub-tropical forest of Bagh district of Pakistan also reported tree basal area of 69.10 m^2ha^{-1} (Shaheen *et al.* (2011). The results of the study reveal that in agriculture lands, *Ziziphus mauritiana* has been observed to be the tree species with highest basal area followed by *Dalbergia sisoo* (Table 3).

In case of shrub species, in forest sites the total basal area was found to be 25.42 m^2 ha^{-1} with highest basal area of 16 m^2 ha^{-1} for *Carissa opaca* In case of agriculture lands, again *Carissa opaca* was the major shrub species with highest basal area (Table 4). Importance Value Index (IVI) for *Pinus roxburghii* was observed to be maximum 150.65.These findings are similar to the observations made by Kumar and Sharma (2014); Dangwal *et al*. (2012) in their study conducted in district Rajouri. The results regarding IVI of shrub in study area show that *Carissa opaca* in both landuse classes recorded highest IVI and these findings are in consonance with the work done by Sharma (2003) and Dangwal *et al*. (2012) where they also found maximum IVI value for *Carissa opaca.*

Table 1. Spatial Pattern and Phytosociological Parameters for Tree in Forests of study area

S.No	Name of the species	B.A (m^2/ha)	D (tree/ha)	A/F ratio	IVI
1	*Butea monosperma* (Lam.) Taub.	0.176	2.5	0.10	2.89
2	*Cassia fistula* Linn.	1.882	30	0.07	17.21
3	*Callistemon lanceolatus* (Sm.)	0.080	3.75	0.60	1.97
4	*Phyllanthus emblica* Geartn.	0.343	10	0.10	6.84
5	*Ficus palmata* Forssk.	0.225	30	0.13	13.11
6	*Ficus racemosa* Linn.	0.267	7.5	0.048	7.29
7	*Grewia optiva* Drumm.exBurret.	0.181	3.75	0.15	3.16
8	*Lannea coromandelica* (Houtt.) Merr.	0.068	2.5	0.10	2.76
9	*Mallotus philippensis* (Lam.) Muell.Arg.	7.279	42.5	0.10	26.19
10	*Olea cuspidate* Royle	2.617	27.5	0.17	14.32
11	*Phoenx acaulis* Rosb.ex Buch.Ham.	0.875	27.5	0.08	14.43
12	*Pinus roxburghii* Sarg	69.70	222.5	0.08	150.65
13	*Pyrus pashia* Buch. Ham.ex.D.Don	1.045	33.75	0.044	20.26
14	*Syzgium cumini* (L.) Skeels.	0.047	3.75	0.06	4.07
15	*Woodfordia fruitcosa* (L.) Kurz.	0.216	12.5	0.12	7.22
16	*Bauhinia variegata* Linn.	0.322	8.75	0.05	7.63
	Total	**85.33**	**468.75**	**-**	**300**

Table 2. Spatial Pattern and Phytosociological Parameters for Shrub in Forests of study area

S.No	Name of species	B.A (m^2/ha)	D(shrub/ha)	A/F ratio	IVI
1	*Justicia adhatoda* Linn.	1.053	456	0.069	20.86
2	*Berberis lycium* Royle.	0.854	484	0.068	19.33
3	*Carissa opaca* Stapf.	16.00	2760	0.041	140.46
4	*Flacourtia indica* (Burm. f.)Merr	0.835	184	0.111	13.33
5	*Gymnosporia royleana* Wall. Ex M.A.Lawson.	1.169	336	0.074	22.32
6	*Ziziphus oxyphylla* Edgew	0.557	68	0.172	6.01
7	*Ipomoea carnea* Jacq.	1.203	352	0.165	23
8	*Nerium indicum* Mill.	0.507	112	0.224	9.17
9	*Punicia granatum* Linn.	0.230	44	0.115	3.51
10	*Rubus ellipticus* Smith.	0.598	56	0.058	6.19
11	*Zanthoxylum armatum* DC.	0.287	32	0.222	3.24
12	*Dodonaea viscose* Jacq.	0.247	64	0.054	4.46
13	*Prinsepia utilis* Royle	0.404	56	0.070	4.94
14	*Randia tetrasperma* (Wall. ex Roxb.) Benth. & Hook.f. ex Brandis	0.122	20	0.041	1.62
15	*Debregeasia salicifolia* (D.Don) Rendle	0.590	116	0.197	10.33
16	*Ziziphus nummularia* (Burm. f.) Wight& Arn.	0.750	144	0.555	11.23
	Total	**25.42**	**5284**	**-**	**300**

Table 3. Spatial Pattern and Phytosociological Parameters for Tree in Agriculture

S.No	Name of species	B.A (m^2/ha)	D (tree/ha)	A/F ratio	IVI
1	*Ziziphus mauritiana* Lam.	1.223	15.2	0.077	44.98
2	*Grewia optiva* Drumm.exBurret.	0.823	8.8	0.088	28.85
3	*Bombax ceiba* Linn.	0.720	4.2	0.065	20.62
4	*Morus nigra* Linn.	0.101	1.8	0.072	6.42
5	*Eucalyptus citriodora* Linn	0.239	2.2	0.044	10.14
6	*Celtis australis* Linn.	0.055	1.2	0.048	4.98
7	*Pinus roxburghii* Sarg.	0.031	0.4	0.10	2.048
8	*Pyrus pashia* Buch.Ham.ex.D.Don	0.070	2.2	0.061	6.96
9	*Pyrus communis* Linn.	0.020	0.8	0.088	2.89
10	*Morus alba* Linn.	0.156	3	0.083	9.282
11	*Dalbergia sisoo* Roxb.	1.001	3.4	0.136	22.45
12	*Juglans regia* Linn.	0.003	0.4	0.10	1.596
13	*Mangifera indica* Linn.	0.077	1.4	0.087	5.052
14	*Acacia catechu* Wild.	0.366	3.4	0.136	12.52
15	*Toona ciliata* M Roemer.	0.148	2.6	0.053	9.216
16	*Psidium guajava* Linn.	0.065	2.6	0.072	7.38
17	*Prunus armeniaca* Linn.	0.041	0.6	0.15	2.436
18	*Prunu persica* Linn.	0.021	0.8	0.088	2.906
19	*Prunus domestica* Linn.	0.009	0.2	0.20	0.927
20	*Callistemon lanceolatus* (Sm.)	0.012	0.8	0.20	2.24
21	*Olea ferruginea* Royle	0.139	3.8	0.077	10.523
22	*Cassia fistula* Linn.	0.010	1	0.062	3.514
23	*Leucaena leucocephala* (Lam.) de Wit.	0.018	1.2	0.075	3.875
24	*Phyllanthus emblica* Geartn..	0.018	1	0.062	3.643
25	*Ficus religiosa* Linn.	0.322	0.4	0.10	6.591
26	*Salix alba* Linn.	0.015	1	0.111	3.055
27	*Ficus palmata* Forssk.	0.031	1.8	0.072	5.34

……Continue

28	*Ficus racemosa* Linn.	0.019	0.8	0.088	2.88
29	*Woodfordia fruitcosa* (L.) Kurz.	0.104	2.6	0.072	7.99
30	*Ficus carica* Linn.	0.045	0.6	0.15	2.506
31	*Malus domestica* Borch.	0.016	0.6	0.15	2.045
32	*Populus ciliate* Wall.Ex Royle	0.111	0.8	0.088	4.32
33	*Citrus limon* Burm.f	0.026	1.8	0.05	5.79
34	*Citrus medica* Linn	0.017	1.2	0.075	3.86
35	*Ulmus wallichiana* Planch.	0.034	0.4	0.10	2.094
36	*Mallotus philippensis* (Lam.) Muell.Arg.	0.023	1.2	0.048	4.484
37	*Phoenx acaulis* Rosb.ex Buch. Ham.	0.140	1.6	0.10	6.27
38	*Albezia chinensis* (Osbeck) Merr	0.008	0.6	0.066	2.46
39	*Melia azedarach* Linn.	0.036	1.2	0.048	4.688
40	*Bauhinia variegata* Linn.	0.012	0.6	0.066	2.517
41	*Eriobotrya japonica* (Thumb.) Lindl	0.0026	0.2	0.20	0.822
42	*Thevetia peruviana* (Pers.) K.Schum	0.0024	0.2	0.20	0.818
43	*Grevillea robusta* A. Cunn.ex R.Br.	0.006	0.2	0.20	0.872
44	*Citrus sinensis* Linn.	0.037	2	0.125	5.15
	Total	**6.394**	**82.8**	**-**	**300**

Table 4. Spatial Pattern and Phytosociological Parameters for Shrub in Agriculture area

S.No	Name of species	B.A (m^2/ha)	D (shrub/ha)	A/F ratio	IVI
1	*Mimosa rubicaulls* (rall)	0.028	5	0.55	2.52
2	*Justicia adhatoda* Linn.	0.056	46	0.095	16.62
3	*Prinsepia utilis* Royle.	0.131	14	0.172	10.17
4	*Berberis lyceum* Royle.	0.066	79	0.049	27.98
5	*Carissa opaca* Stapf.	0.493	157	0.037	65.27
6	*Flacourtia indica* (Burm. f.)Merr.	0.029	13	0.203	5.76
7	*Gymnosporia royleana* Wall. Ex M.A.Lawson.	0.081	35	0.056	16.6
8	*Elaeagnus umbellate* Linn.	0.130	38	0.045	20.22
9	*Ipomoea carnea* Jacq.	0.142	29	0.128	14.94
10	*Musa pradisica* Linn	0.381	7	1.75	16.57
11	*Nerium indicum* Mill.	0.034	11	0.224	5.29
12	*Rosa brunonii* Lindl.	0.014	2	0.5	1.51
13	*Rubus ellipticus* Smith.	0.109	32	0.051	17.17
14	*Punicia granatum* Linn	0.140	12	0.12	10.5
15	*Colebrookea oppositifolia* Sm	0.022	7	0.28	3.57
16	*Calotropis procera* R.Br	0.015	4	0.444	2.18
17	*Randia tetrasperma* Sm	0.188	21	0.093	15.37
18	*Debregeasia salicifolia* (D.Don) Rendle	0.024	19	0.527	5.98
19	*Zanthoxylum armatum* DC	0.005	3	0.333	1.61
20	*Vitex negundo* Linn.	0.332	16	0.094	19.53
21	*Ziziphus oxyphylla* Edgew	0.159	41	0.065	20.64
	Total	**2.580**	**591**	**-**	**300**

Spatial Pattern

The distribution pattern of different trees and shrub species in study area was mainly contagious in both the land use classes (Table1-4). Among trees in forest of the study area, only *Ficus racemosa* and *Pyrus pashia* show random distribution whereas, among shrubs, *Gymnosporia royleana* and *Ipomoea carnea* were randomly distributed. Similarly in agriculture land both trees and shrubs showed contagious distribution pattern except four trees (*Eucalyptus citriodora, Celtis australis, Mallotus philippensis and Melia azedarach*) and three shrub (*Berberis lyceum, Carissa opaca and Elaeagnus umbellata*) which showed their random distribution (Kumar and Bhat, 2006; Kumar and Thakur, 2008; Pokhriyal *et al.,* 2013). Odum (1971) also stressed that contagious distribution is the commonest pattern in nature and it is due to small significant variations in the environment. Regular distribution occurs were severe competition between the individuals exists.

Diversity Analysis

In the study area, species diversity was found higher in agriculture land as compared to forest of study area. Agriculture lands showed higher Shannon-Wiener's (H') diversity Index value of 3.25 for trees and 2.53 for shrubs (Fig 2) followed by forest area with Shannon index (H') value of 1.93 for trees and 1.80 for shrubs (Fig 3). Whereas Simpson's index of dominance (Ds) recorded highest in forest for both trees (0.25) and shrubs (0.30). Species richness values of Margalef's index (Da) and Menhinick's index (Db) were found to be 7.13 and 2.16 for trees, 3.13 and 0.86 for shrubs in agriculture fields, respectively. The highest Shannon index in agriculture land was due to cultivation of different type of fruit species which increases the diversity of area (Kumar and Sharma, 2014). The tree diversity index analyzed for the forest sites of study area was lower than that reported by the earlier workers (Uperti *et al*., 1985; Sharma, 2003; Sharma, 2008; Mishra *et al.,* 2011; Singh, 2012 and Dangwal *et al.,* 2012) which may be due to pressure from different biotic disturbance. Diversity of fodder and fruit trees form a good proportion of the biodiversity in this watershed. A panorama of the biodiversity emerged in this study, which is of both direct value and indirect value for the livestock and mountain communities living in the region (Rashid and Sharma, 2012).

Conclusion

The phytosociological analysis of these forest communities reveals that there is a big gap between the values of various

parameters like IVI, density, frequency, abundance *etc.* There are many tree species having very low values of IVI and other parameters and these species deserve more attention for conservation. Thus the biodiversity of the studied watershed is under great anthropogenic pressure.

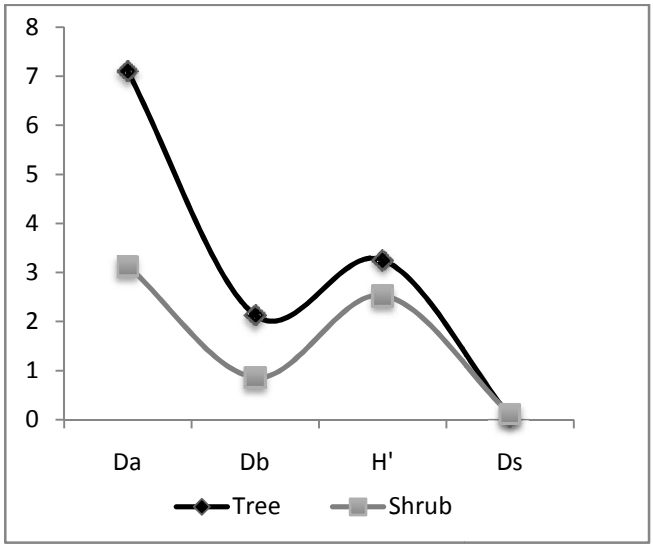

Fig. 2 Diversity indices in Agriculture fields of study area

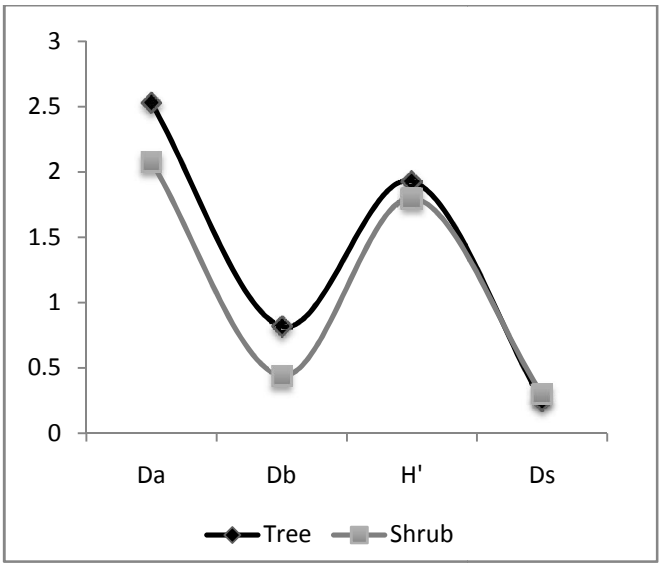

Fig. 3 Diversity indices in Forests of study area

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