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ALTITUDINAL VARIATION IN COMMUNITY STRUCTURE OF KANDI FOREST RANGE IN NORTH WESTERN HIMALAYAS OF KASHMIR

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ABSTRACT

Changes in vegetation composition and structure with respect to altitude was investigated in Kandi Range of Kamraj Forest Division in Kashmir. Three altitudinal gradients viz., lower (1600-2000 m), middle(2000-2400 m) and upper(2400-2800 m) were delineated within the selected Forest Range. The vegetative analysis revealed presence of 61 plant species (5 trees, 17 shrubs and 39 grasses and herbs). *Pinus wallichiana* and *Cedrus deodara* were the dominant and co-dominant trees species and *Indigo feraheterantha* shrub species represented the entire forest range but *Viburnum nudum* was restricted to upper altitude only. Similarly, among the undergrowth species *Ranunculus hirtellus* and *Cuminum cyminum* were the most dominant species throughout the Forest Range. The diversity index and concentration of dominance anged between 0.178-0.322 and 0.009 - 0.405 respectively. Similarly, middle and upper altitude recorded maximum (1.143 herbs) and minimum (0.157 trees) Richness indexes respectively. But, Evenness index ranged between 0.073 (on middle altitude in herbs)-0.435 (on upper altitude in trees). The results further state a prominent altitudinal variation in distribution pattern of species (44 lower and 32 upper altitudes)with increasing altitude.The holistic view of the floristic diversity suggests that this Forest Range in vulnerable to anthropogenic disturbances and needs immediate attention for conservation and sustainable management.

KEY WORDS
Phytosociology
Diversity index
Species richness
Kandi forest range.

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INTRODUCTION

Forests occupy the central importance in ecology and as such need to be quantified for their variability to describe ecosystems (Chersetl, 1989).These ecosystems provide niches for large number of species with greater variability in life traits and strategies like dispersal, regeneration, establishment and growth (Lavorel *et al*., 1997). The nature of ecological communities is a fundamental issue in ecology and understanding the forest structure and its composition is a pre-requisite to describe forest dynamics and various ecosystem processes. (Elourard *et al*., 1997).It is in this endeavour that the management and utility of forests require accurate information on their compositional dimensions and its spatial distribution (Noss, 1990; Tilman *et al*., 1997; Lu *et al*., 2004).

The phytosociological study deals with the structure and function of the plant communities and exposes the relationship between different species growing together in it. Without understanding the structure of a community, it is impossible to know its functioning. Thus a lot of phytosociological studies have been conducted throughout the world to understand the structure of different forest communities (Campbell *et al*., 1986; Timilsina *et al*., 2007; Top *et al*., 2009; Sambare *et al*., 2011; Erenso *et al*., 2014). Several phytosociological studies have also been performed in Indian tropical forests like Western India (Sharma and Upadhyaya, 2002; Panchal and Pandey, 2004; Krishna *et al*., 2014). Plant species composition and diversity have been widely accomplished in order to perform effective management and logical exploitation of forests (Aubert *et al*., 2003; Huang *et al*., 2003) which contribute not only to the production objectives, but also to conservation of biodiversity and environment (Parthasarathy, 2001).This type of ecological knowledge is fundamental for conservation and sustainable utilization of fragile mountain ecosystems. Under the backdrop of aforesaid facts, present study is one of the attempts to understand the altitudinal variation invegetation structure and composition of Kandi Forest Range in Zangli Forest Division of Kashmir valley.

MATERIALS AND METHODS

Study site

The study was conducted in the Kandi Forest Range of Zangli Forest Division of North Circle (Fig.1).This forestrange lies between the geographical co-ordinates of 34°21´ to 34°26.05´ N latitude and 74°21´ to 74°32´ E longitudes. Spread over an area of 100.69 km^{2}this forest range extends from 1600 m at the floor to2800m at the ridge.

Precipitation varies between 500 to 833 mm and increases with the increase in altitude. While summers are moderate with average temperature of 25°C and occasional rains, the winter season witnesses a frequent snowfall and remain schilled often at sub-zero temperatures. The Forest is dominated by the shale/

slate types of rocks that reflect the lithology of underlying sediments. The various geological formations formed within the Kandi forest range included Karewas and alluvium, Triasics, Panjal series, Nutnusa formation and Sagipora formation with limestone, slate, lava flows and highly friable arenaceous shale as their lithology. The area is characterized by alluvium soils in the lower elevations and lacustrian at higher elevations (Anonymous, 1981).The entire Kandi Forest Range was divided into three altitudinal gradients Lower (1600-2000m), Middle (2000 - 2400m) and Upper (2400 - 2800 m) to study its floral diversity.

Methods

Vegetation structure analysis

Laying of quadrats

The working plan of the selected Forest Range was examined, but no two candidate sites were found sufficiently similar. Almost every altitudinal gradient varied considerably in slope and aspects and thus quadrates on a particular altitude were laid on places with similar geographical position. Using a sampling intensity of 0.048%, forty eight (48) sampling plots (16 at each altitude) each measuring 0.1 ha (20m x 50m) were laid on all the three altitudes to study the composition and structure of vegetation. A Global Positioning System (GPS) was trailed to aid in location of each plot with respect to itslatitude, longitude and altitude(Anitha *et al.*, 2010; Uma shanker, 2001). The vegetation sampling was done by quadrate method Misra (1968) and at each altitude 10 x 10m quadrates were defined in 20 x 50m plot within which phytosociology of trees species was recorded. The vegetation composition of understory species was recorded using 5x5m and 1x1m quadrates for shrubs and herbs respectively.

Plant identification

Significant taxonomic reservoirs (Norton, 1979; Mccann, 1987; Duigam, 1991 and Scarlett *et al.*, 1992) were used for plant identification. Specimens which were difficult to identify at the species level were identified by expert taxonomists at Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Shalimar, Srinagar and University of Kashmir.

Important community parameters such as frequency, density, abundance, basal area and importance value index (IVI) of all the plant species were worked out by following Muller–Dombois and Ellenberg (1974). The diversity index, richness index concentration of dominance and similarity index were determined as per procedures prescribed by Whittaker (1972) and Shannon and Wiener (1963);Margalef (1958); Simpson (1949); Pielou (1966) and Sorensen (1948). The spatial distribution patterns of various species on different altitudinal gradients were studied using abundance to frequency (A/F) ratio (Whitford, 1949).

RESULTS

Floristic composition of study area

The vegetation survey conducted indicated that the area is floristically rich, supporting many plant species, of diverse taxonomic and ecological significance. The data presented in Table (1 and 2) shows that the selected forest range hosts 25 families (23 Angiosperms and 02 Gymnosperms), 53 Genera (50 Angiosperms and 03 Gymnosperms) and 61 species (58 Angiosperms and 03 Gymnosperms). Out of 61 species identified in the study area 39 were herbs, 17 shrubs and 5 trees. Rosaceae was the dominant family with 15 species followed by Asteraceae (7), and Lamiaceae (5).

The vertical distribution of flora in the lower altitude represented forty four (44) species belonging to twenty three (23) families. The number of species and families for other two altitudinal gradients was in the order of 44 and 19 at middle and 32 and 15 at upper altitude. The species richness on lower altitude comprised of 40 genera belonging to 29 families(05 trees, 15 shrubs and 24 herbs). The middle altitude was represented by 37 genera belonging to 19 families(03 trees, 09 shrubs and 32 herbs). The upper altitude recorded the least richness of 27 genera belonging to 27 families represented by 02 trees, 05 shrubs and 25 herbs (Table 2).

Density

The total density of trees, shrubs and herbs was highest (161550 individual ha^{-1}) on middle altitude followed by upper altitude (151830 individual ha^{-1}) and the lowest (138935 individualha^{-1}) on lower altitude. Contrary to this the density oftrees was maximum (967 individual ha^{-1}) on lower altitude, followed by middle altitude (723 individual ha^{-1}) and the lowest (607 individual ha^{-1}) on upper altitude (Table. 2). *While Pinus wallichiana* contributed maximum density (420 & 417 individual ha^{-1}) on middle and upper altitudes, Cedrus*deodara* exhibited maximum density (549 individual ha^{-1}) on lower altitude. The lowest density (36 individual ha^{-1}) was recorded for *Juglan sregia* and *Morus spp.* on lower altitude (Annexure I). In case of shrubs, the total density was maximum (4033

Table 1: Family, genera and species recorded on different altitudinal gradients of Kandi Forest Range

Family	No of genera	No of Species
Apiaceae	1	1
Apocynaceae	1	1
Asteraceae	8	8
Berberidaceae	1	1
Boraginaceae	1	1
Caryophllaceae	3	3
Cupressaceae	1	1
Fabaceae	4	4
Geraniaceae	1	2
Hamamelidaceae	1	1
Hypericaceae	1	1
Juglandaceae	1	1
Lamiaceae	5	5
Moraceae	1	1
Oleaceae	1	1
Onagraceae	1	1
Oxalidaceae	1	1
Pinaceae	2	2
Plantaginaceae	1	1
Poaceae	4	4
Ranunculaceae	2	2
Rosaceae	7	15
Scrophulariaceae	1	1
Violaceae	1	1
Total 25	53	61

Table 2: Overall diversity index (H), Concentration of Dominance (C), Richness index (R) and Evenness Index (E) of different life forms across different altitudes of Kandi forest range

Altitude (m)	Life form	Species richness (S)	No. of Genera	No. of Families	Density (individuals ha^{-1})	Basal area ($m^2\ ha^{-1}$)	(H)	(C)	(R)	(E)
Lower	Tree	05	05	04	967	87.43	0.252	0.254	0.244	0.297
	Shrub	15	11	11	4033	-	0.214	0.020	1.089	0.093
	Herb	24	24	14	133935	-	0.201	0.010	1.040	0.083
Middle	Tree	03	03	02	732	30.66	0.322	0.254	0.194	0.428
	Shrub	09	06	04	718	-	0.283	0.083	0.602	0.198
	Herb	32	28	13	160100	-	0.178	0.011	1.143	0.073
Upper	Tree	02	02	01	607	60.54	0.304	0.291	0.157	0.435
	Shrub	05	04	04	356	-	0.213	0.405	0.300	0.177
	Herb	25	21	22	150867	-	0.188	0.009	0.891	0.088

Table 3: Similarity Index (%) of tree, shrub and herb species between different altitudes

Altitudes		Middle altitude (2000-2400m)				Upper Altitude (2400-2800 m)			
		A	T	S	H	A	T	S	H
Lower Altitude (1600-2000 m)	A	65	-	-	-	48	-	-	-
	T		75	-	-	-	57	-	-
	S			67		-	-	40	-
	H				54	-	-	-	46
Middle altitude (2000-2400m)	A					61	-	-	-
	T						80	-	-
	S							57	-
	H								46

A – All species, T – Trees, S – Shrubs, H – Herbs.

individual ha^{-1}) on lower altitude and minimum (356 individual ha^{-1}) on upper altitude. The highest density (607 individuals ha^{-1}) was recorded for *Parrotiopsis jacquemantiana* (on lower altitude) followed by 188 individuals ha^{-1} for *Indigo feraheterantha* (on middle altitude) and 124 individuals $ha^{-1}$for *Crataegus ambigua* (on upper altitude). Similarly, in case of herbs the total density was maximum (160100 individual ha^{-1}) on middle altitude and minimum (133935 individual ha^{-1}) on lower altitude (Table 2). Among these species *Potentilla spp*, *Lolium perenen* and *Cuminum cyminum* were the most dominant on upper, middle and lower altitude with respective density of 22911, 18675 and 15867 individual ha^{-1} (Annexure I).

Basal area

The total basal area of tree species was maximum (60.54 $m^2\ ha^{-1}$) on upper altitude and minimum ($29.53 m^2 ha^{-1}$) on middle altitude (Table 2). On upper altitude *Pinus wallichiana* and *Cedrus deodara* shared maximum (76 and 24 %) of basal area. On middle altitude, species like *Robinia pseudoacacia* along with two prominent coniferscontributed17 % to the basal area to the stand. Similarly on lower altitude while *Pinuswallichiana* and Cedrus*deodara*, together contributed 61 and 36 % of basal area, the prominent broad leaved species *Robinia pseudoacacia, Juglans regia* and *Morus spp.* respectively shared 0.93, 0.54 and 0.76 % of the total basal area (Annexure I).

Importance value index

Pinus wallichiana was the most dominant species on upper and middle altitude with maximum IVIof 204 and 162%. *Cedrus deodara* was the most prominent species on lower altitude with IVI of103%. The shrub layer at upper, middle and lower altitudinal gradients was dominated by *Cotoneaster falconeri,* and *Parrotiopsis jacquemantiana* with IVI values of 66, 56 and 39% respectively. Among the herb strata the maximum IVI was recorded or *Viola odorata* (34%), *Ranunculus hirtellus* (20%) and *Loliumperenen* (15%) on upper, middle and lower altitudes respectively (Annexure I). The dominance-diversity curve (Figure 3) for trees, shrubs and herbs shows that,at all the three altitudes of Kandi forest very few species had a high IVI value.

Diversity indices

The Shannon-Weiner diversity index(H′) for the trees was maximum (0.322) on middle altitude and minimum (0.252) on lower altitude. The diversity index of shrubs was again maximum (0.283) on middle al and minimum (0.213) on upper altitude. Contrary to this herbs exhibited maximum diversity index (0.201) on lower altitude and minimum (0.178) on middle altitude (Table 2). The Simpson's dominance index for tree species was was 0.291 on upper altitude 0.254 on middle and lower altitudes. For shrubs, the Simpson's dominance index was maximum (0.405) on upper altitude and minimum (0.020) on lower altitude. For herbs, the Simpsons index value was maximum (0.011) on middle and minimum (0.009) on upper altitude.

The species richness index was found to befluctuating within the altitudinal gradient and varied among all the life forms.Tree species exhibited maximum richness index of 0.244 on lower altitude followed by 0.194 and 0.157 on middle and upper altitudes re spectively. The shrubs exhibited maximum (1.089) richness index on lower altitude followed by middle (0.602) and upper altitude (0.300). The herbs portrayed maximum

Table 4: Distribution pattern of tree, shrub and herb species at the three study stands

Species No.	Species	Family	Altitudes Lower	 Middle	 Upper
Tree Species					
1	*Cedrus deodara*	Pinaceae	0.030 (R)	0.033 (R)	0.035 (R)
2	*Pinus wallichiana*	Pinaceae	0.045 (R)	0.038 (R)	0.030 (R)
3	*Robinia pseudoacacia*	Fabaceae	0.020 (Re)	0.020 (Re)	-
4	*Juglans regia*	Juglandaceae	0.030 (R)	-	-
5	*Morus spp*	Moraceae	0.020 (Re)	-	-
Total	0.029 (R)	0.030 (R)	0.033 (R)		
Shrub species					
1	*Berberis lyceum*	Berberidaceae	0.030 (R)	0.060 (C)	-
2	*Cotoneaster accuminatus*	Rosaceae	0.075 (C)	-	-
3	*Cotoneaster falconeri*		0.030 (R)	0.043 (R)	0.075 (C)
4	*Cotoneaster horizantalis*		0.050 (R)	-	-
5	*Crataegus ambigua*		0.040 (R)	0.040 (R)	0.040 (R)
6	*Crataegus songarica*		0.030 (R)	0.040 (R)	0.040 (R)
7	*Indigofera heterantha*	Fabaceae	0.070 (C)	0.053 (C)	0.260 (C)
8	*Jasminum officinale*	Oleaceae	0.035 (R)	-	-
9	*Juniperus communis*	Cupressaceae	0.030 (R)	-	-
10	*Nerium indicum*	Apocynaceae	0.055 (C)	-	-
11	*Parrotiopsis jacquemantiana*	Hamamelidaceae	0.067 (C)	0.065 (C)	-
12	*Rabdosia rugosa*	Lamiaceae	0.035 (R)	-	-
13	*Rosa brunonii*	Rosaceae	0.067 (C)	-	-
14	*Rosa canina*		-	0.030 (R)	-
15	*Rosa webbiana*		0.045 (R)	0.070 (C)	-
16	*Rubus armeniacus*		0.140 (C)	-	-
17	*Viburnum nudum*	Adoxaceae	-	-	0.080 (C)
Total	0.053 (C)	0.050 (R)	0.099 (C)		
Herb & Grass Species					
1	*Anemone tetrasepala*	Ranunculaceae	0.050 (R)	-	-
2	*Artimesia bsinthum*	Asteraceae	-	0.060 (C)	-
3	*Aster spp*		0.070 (C)	0.030 (R)	0.037 (R)
4	*Bothriochloa pertusa*	Poaceae	-	0.160 (C)	0.190 (C)
5	*Chrysanthemum spp*	Asteraceae	-	0.110 (C)	0.190 (C)
6	*Cichorium intybus*		0.057 (C)	-	-
7	*Cirsium falconeri*		-	0.050 (R)	-
8	*Clinopodium vulgare*	Lamiaceae	0.110 (C)	0.057 (C)	-
9	*Cuminum cyminum*	Apiaceae	0.073 (C)	-	-
10	*Cynodon dactylon*	Poaceae	0.260 (C)	0.300 (C)	-
11	*Cynoglossum glochidiatum*	Boraginaceae	0.030 (R)	0.030 (R)	0.190 (R)
12	*Dianthus angulatus*	Caryophllaceae	-	0.080 (R)	0.190 (R)
13	*Epilobium spp*	Onagraceae	-	0.080 (R)	0.055 (R)
14	*Erigeron spp*	Asteraceae	0.150 (R)	0.220 (R)	0.117 (R)
15	*Festuca pratensis*	Poaceae	0.210 (R)	0.300 (R)	0.250 (R)
16	*Fragaria nubicola*	Rosaceae	0.060 (R)	0.050 (C)	0.060 (R)
17	*Geranium rotundifolia*	Geraniaceae	-	0.040 (R)	0.030 (R)
18	*Geranium wallichianum*		-	0.070 (C)	0.070 (C)
19	*Geum coccineum*	Rosaceae	-	0.070 (C)	0.100 (C)
20	*Geum elatum*		0.080 (C)	0.080 (C)	0.080 (C)
21	*Geum spp.*		-	0.050 (R)	0.040 (R)
22	*Hypericum perfoatum*	Hypericaceae	0.087 (C)	-	0.055 (C)
23	*Lespedeza cuneata*	Fabaceae	0.050 (R)	0.055 (C)	0.077 (C)
24	*Lolium perenen*	Poaceae	0.090 (C)	0.097 (C)	0.060 (C)
25	*Lychnus cornaria*	Caryophllaceae	-	0.040 (R)	0.053 (C)
26	*Marrubium vulgare*	Lamiaceae	0.045 (R)	-	-
27	*Matricaria chamomilla*	Asteraceae	0.040 (R)	0.070 (C)	-
28	*Oxalis corniculata*	Oxalidaceae	0.060 (C)	0.060 (C)	-
29	*Picrishiercioides*	Asteraceae	0.035 (R)	-	-
30	*Plantago lanceolata*	Plantaginaceae	0.070 (C)	0.050 (R)	0.055 (C)
31	*Potentilla reptens*	Rosaceae	-	0.040 (R)	0.055 (C)
32	*Potentilla spp*		-	0.055 (C)	0.100 (C)
33	*Ranunculus hirtellus*	Ranunculaceae	-	0.110 (C)	0.105 (C)
34	*Scutellaria prostrata*	Lamiaceae	-	0.100 (C)	0.050 (R)
35	*Silene spp*	Caryophllaceae	0.035 (R)	-	-
36	*Thymus serpyllum*	Lamiaceae	0.135 (C)	0.050 (R)	0.070 (C)
37	*Trifolium repens*	Fabaceae	0.080 (C)	0.065 (C)	-
38	*Verbascum thapsus*	Scrophulariaceae	0.030 (R)	0.080 (C)	0.075 (C)
39	*Viola odorata*	Violaceae	0.130 (C)	0.075 (C)	0.075 (C)
Total		0.085 (C)	0.087 (C)	0.093 (C)	
Re = Regular, R = Random, C = Clumped.					

(1.143) richness index on middle altitude and minimum (0.891) on upper altitude (Table 2). The evenness index of tree species was maximum (0.435) on upper altitude and minimum (0.297) on lower altitude). The shrub species

Annexure 1: Structure and composition of trees, shrubs and herbs in the three studied stands (Density in ha^{-1}and basal area in m^2 ha^{-1}).

Spp. no.	Tree species	Lower			Middle			Upper		
		Density	B.A	IVI	Density	B.A	IVI	Density	B.A	IVI
1	*Cedrus deodara*	549	53.71	103	245	12.29	110	190	14.69	96
2	*Pinus wallichiana*	317	31.78	47	420	16.86	162	417	45.85	204
3	*Robinia pseudoacacia*	29	0.81	50	-	-	28	-	-	-
4	*Juglans regia*	36	0.47	44	67	1.51	-	-	-	-
5	*Morus spp*	36	0.66	57	-	-	-	-	-	-
Total	967	87.43	300	732	30.66	300	607	60.54	300	
	Shrub species									
1	*Berberis lycium*	285	-	19	82	-	8	-	-	0
2	*Cotoneaster accuminatus*	230	-	8	0	-	0	-	-	0
3	*Cotoneaster falconeri*	256	-	15	166	-	56	-	-	66
4	*Cotoneaster horizantalis*	100	-	2	0	-	0	-	-	17
5	*Crataegus ambigua*	502	-	19	33	-	3	124	-	10
6	*Crataegussongarica*	44	-	3	75	-	5	-	-	19
7	*Indigofera heterantha*	348	-	35	188	-	82	33	-	0
8	*Jasminum officinale*	296	-	11	0	-	0	38	-	0
9	*Juniperus communis*	140	-	3	0	-	0	40	-	0
10	*Nerium indicum*	350	-	11	0	-	0	-	-	0
11	*Parrotiopsis jacquemantiana*	607	-	39	87	-	27	-	-	0
12	*Rabdosia rugosa*	302	-	13	0	-	0	-	-	0
13	*Rosa brunonii*	229	-	16	25	-	2	-	-	0
14	*Rosa canina*	-	-	-	33	-	14	-	-	0
15	*Rosa webbiana*	64	-	4	29	-	4	-	-	0
16	*Rubus armeniacus*	280	-	3	0	-	0	-	-	0
17	*Viburnum nudum*	-	-	-	0	-	0	121	-	87
Total	4033		200	718		200	356		200	
	Herb & Grass Species									
1	*Anemone tetrasepala*	5367	-	7	-	-	-	-	-	-
2	*Artimesia bsinthum*	-	-	-	5525	-	5	-	-	-
3	*Aster spp*	2500	-	12	1250	-	2	2400	-	4
4	*Bothriochloachloa pertusa*	-	-	-	5625	-	5	4267	-	7
5	*Chrysanthemum spp*	-	-	-	3850	-	4	4533	-	8
6	*Cichorium intybus*	5600	-	7	-	-	-	-	-	-
7	*Cirsium falconeri*	-	-	-	8750	-	10	-	-	-
8	*Clinopodium vulgare*	2100	-	3	3750	-	5	-	-	-
9	*Cuminum cyminum*	15867	-	13	-	-	-	-	-	-
10	*Cynodon dactylon*	5433	-	5	2325	-	2	-	-	-
11	*Cynoglossum glochidiatum*	1467	-	3	625	-	2	556	-	2
12	*Dianthus angulatus*	-	-	-	6450	-	12	5622	-	16
13	*Epilobium spp*	-	-	-	2500	-	5	2978	-	6
14	*Erigeron spp*	7867	-	13	9600	-	6	13489	-	13
15	*Festuca pratensis*	9800	-	9	11075	-	10	10089	-	16
16	*Fragaria nubicola*	4433	-	6	18225	-	11	18133	-	14
17	*Geranium rotundifolia*	-	-	-	1350	-	3	1089	-	3
18	*Geranium wallichianum*	-	-	-	2950	-	4	2622	-	7
19	*Geum coccineum*	-	-	-	2600	-	3	1889	-	3
20	*Geum elatum*	1667	-	3	725	-	1	644	-	2
21	*Geum spp.*	-	-	-	4150	-	5	3267	-	7
22	*Hypericum perfoatum*	7100	-	10	-	-	-	-	-	-
23	*Lespedeza cuneata*	6333	-	10	2300	-	3	2222	-	5
24	*Lolium perenen*	14133	-	15	18675	-	9	15689	-	13
25	*Lychnus cornaria*	-	-	-	1250	-	3	1178	-	4
26	*Marrubium vulgare*	7367	-	11	-	-	-	-	-	-
27	*Matricaria chamomilla*	3367	-	5	625	-	1	-	-	-
28	*Oxalis corniculata*	5200	-	7	2225	-	3	-	-	-
29	*Picrishiercioides*	3633	-	11	-	-	-	-	-	-
30	*Plantago lanceolata*	1467	-	2	2550	-	2	2778	-	4
31	*Potentilla reptens*	-	-	-	850	-	10	644	-	2
32	*Potentilla spp*	-	-	-	14300	-	14	22911	-	18
33	*Ranunculus hirtellus*	-	-	-	3575	-	4	16800	-	20
34	*Scutellaria prostrata*	-	-	-	5825	-	5	5689	-	8
35	*Silene spp*	5200	-	9	-	-	-	-	-	-
36	*Thymus serpyllum*	3133	-	10	1700	-	5	1111	-	3
37	*Trifolium repens*	6267	-	7	4900	-	7	-	-	-
38	*Verbascum thapsus*	2367	-	15	1975	-	3	4000	-	7
39	*Viola odorata*	6267	-	7	8025	-	34	6267	-	7
Total		133935	-	200	160100	-	200	150867	-	200
Total of trees, shrubs and herbs		138935			161550			151830		

displayed maximum evenness (0.198) on middle and minimum (0.093) on lower altitude. The herb sex habited maximum (0.088) evenness on upper minimum (0.073) on middle altitude.

The overall species similarity was highest (65%) between lower and middle altitudes (Table 3). The trees, shrubs and herbs exhibited 75, 67 and 54% similarity between these altitudes. On the other hand, lower and upper altitudes shared least (48%) similarity with each other. Trees, shrubs and herbs showed a similarity of 57, 40 and 46% respectively, between these two altitudes. Upper and middle altitudes displayed overall similarity of 61% with trees, shrubs and herbs exhibiting a similarity of 80, 57 and 46% respectively between these two altitudes.

Distribution pattern

The distribution pattern of all the species along the altitudinal gradient is summarized in Table 4. About 55% of the total species recorded from lower altitude exhibited random, 31% clumped and 13% regular distribution pattern. At middle altitude 53% species had random 36% clumped and 11% displayed regular distribution. At higher altitude while 59% of the total recorded species displayed random and 41% exhibited clumped distribution pattern (Fig. 4).

DISCUSSION

The holistic view of the vegetation data (Table 1) envisages that in all 61 plant species recorded from the three altitudinal gradients belonged to 53 genera which were represented by 25 families. Though this number seems to be less as compared to those reported from other temperate forests (Semwal, 2010; Bharali *et al*., 2011 and Zegeye *et al*., 2011), the plant species abundance reported from the study area is much greater than that documented from Manang Valley, Nepal (Ghimire *et al*., 2008), temperate/subalpine coniferous forests of Arunachal Pradesh (Behera *et al*., 2002) and temperate old growth evergreen broad leaved forests in Japan (Manabe *et al*., 2000). The plant species richness in this study was much greater than reported (19, 40 and 45) from Southern Manang Valley, Nepal (Ghimire *et al*., 2008), temperate/ subalpine coniferous forest of Subansiri District of Arunachal Pradesh (Behera *et al*., 2002) and temperate old growth evergreen broad leaved forest in Japan (Manabe *et al*., 2000). Out of the total 61species recorded from three altitudes of Kandi Range, 5 were trees, 17 were shrubs and 39 were grasses and herbs. However, Paul (2008) has reported 26 tree, 40 shrub and 56 herb species from temperate forest of Western Arunachal Pradesh. Further, the species composition of the study area followed a similar trend of herbs>shrubs >trees as reported by Dar, (2011) in Branwar temperate coniferous forests of Kashmir which comprised 5 tree, 7 shrub and 64 grass and herb species. Paul, (2008) also reported the identical trend from temperate broadleaved *Rhododendron* forest of Western Arunachal Pradesh, but with higher representation of trees (26), shrubs (40) and grasses and herbs (56). Species richness along the altitudinal gradient was 44, 44 and 32 on lower, middle and upper altitudes respectively. This variation in species richness along the vertical gradient may be attributed to the microclimate and edaphic characteristics. The overall pattern of species richness shows inverse relationship with increasing altitude. Kharkwal *et al*., (2005) and Goirala *et al*., (2008) have also reported a similar pattern of decreasing species richness along the altitudinal gradient in temperate and alpine zone of Central and Western Himalayas respectively. Several other workers (Kitayama, 1992, Odl and & Birks, 1999, Wang *et al*., 2007 and Ghimire *et al*., 2008) have also reported similar pattern of decreasing species richness along the altitudinal gradient .Ellu&Obua (2005) and Sharma *et al*., (2009) have also reported that the distribution and species richness pattern of different species are largely regulated by the altitude and climatic factors.

The tree density in the present study ranged between 607 to 967 individual ha^{-1} which is within the range of 652 to 1228 individual ha^{-1} reported by Kumar *et al*. (2009) in Garhwal Himalayas 420 to1640 individual ha^{-1}in temperate forests of Kuma on Himalaya (Saxena& Singh, 1982). But, the values (440 to 936.67 individual ha^{-1}) of our study were higher than reported by Omesh *et al*. (2015).The density of shrubs reported from the study area is well within the range of 504 to 3576 individual ha^{-1} reported by Paul (2008) from temperate forest of Western Arunachal Pradesh but lower than that reported by Koirala (2004) from Tinjure -Milke region, Nepal. The density of herb species ranged between 133935 to 160100 individual ha^{-1} which is higher than the range of 14380 to 45000 individual ha^{-1} reported from Himalayas of Arunachal (Paul, 2008) but less than 112000 to 668000 individual ha^{-1} from Bhoramdeo Wildlife Sanctuary, Chhattisgarh (Jhariya and Oraon, 2012). The higher density and species richness of herbs and shrubs is related to opening

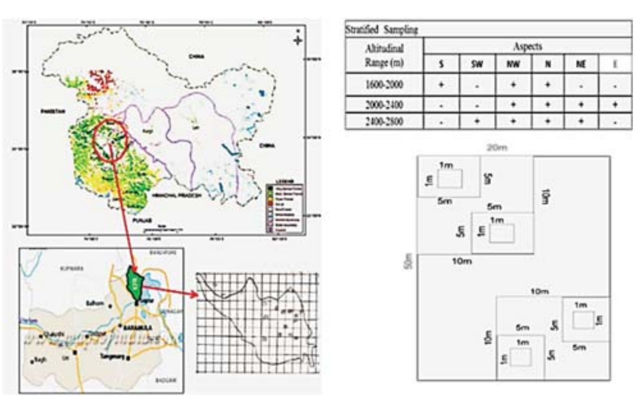

Figure 1: Map showing location of the Kandi Forest Range of Kamraj Forest Division and sampling design

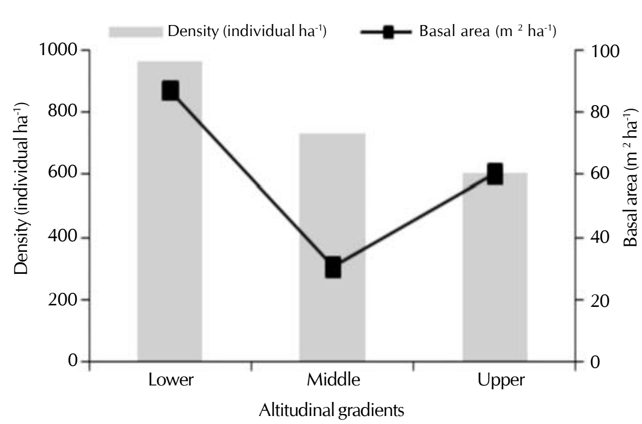

Figure 2: Stand density (ha^{-1}) and basal area (m^2 ha^{-1}) of tree species on three study stands

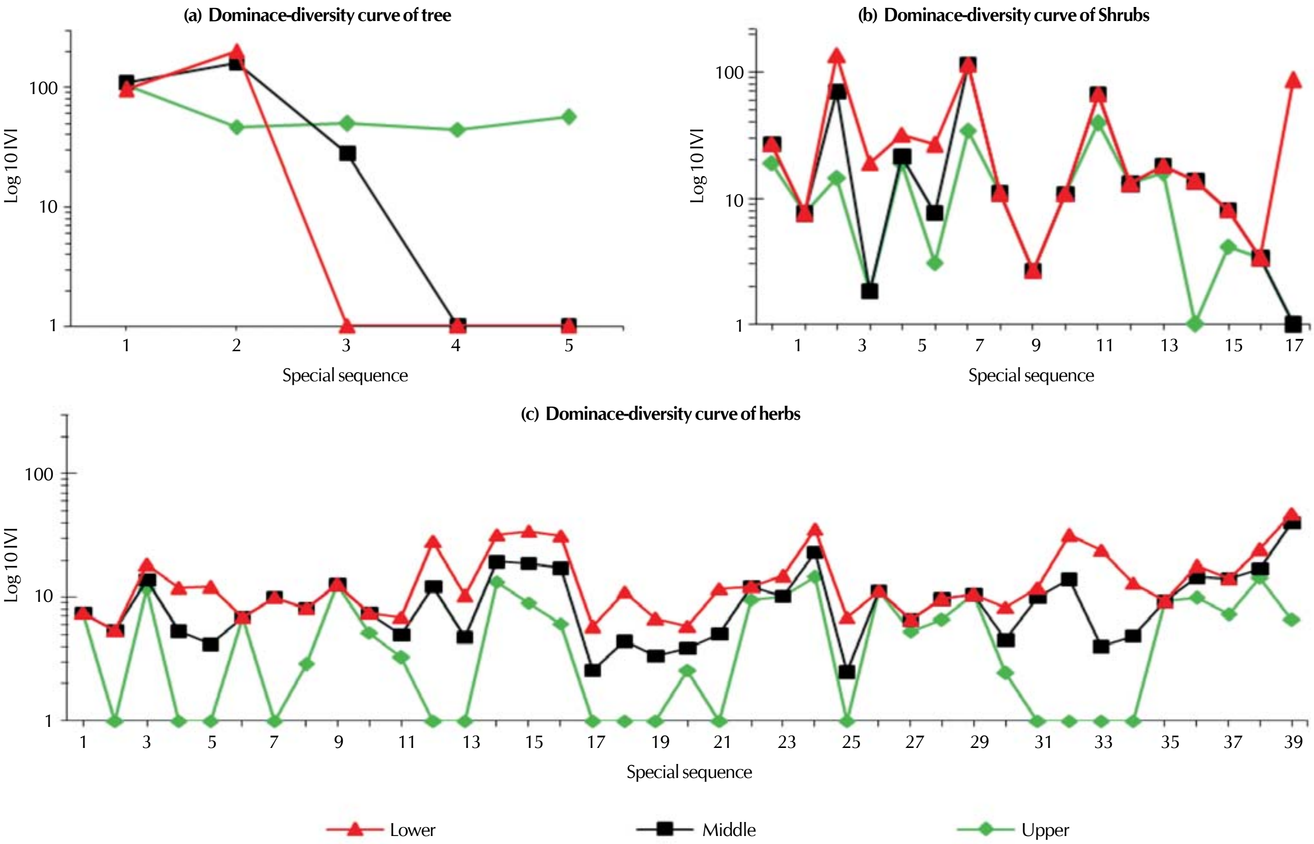

Figure 3: Dominance-diversity curve of (a) tree, (b) shrub and (c) herb species on three study stands

of canopy due to heavy illicit felling in this forest range. The difference in environmental factors and soil characteristics along the altitudinal gradient may also have played their role and induced variation in species diversity and density.

The basal area recorded in the study area varied between 29.53 to 87.43 m^2 ha^{-1} which is within the rangeof9.38 to 137.45 m^2 ha^{-1} reported by Paul (2008) from Arunachal Himalaya as well as 17.9 to 180.1 m^2 ha^{-1} reported from temperate forest of Himalaya (Sharma and Baduni, 2000; Ram *et al*., 2004) and 19.35 to 54.40m^2 ha^{-1}reported from Terai-Bhabar Region of Central Himalaya (Omesh *et al*., 2015).The maximum(87.43 m^2 ha^{-1}) basal area was recorded from lower altitude while minimum(30.66m^2 ha^{-1}) from middle altitude. The lower basal area on middle altitude could be due to less density and sparse distribution due to heavy illicit deforestation of tree species and higher basal area in lower altitude may be due to higher density of mature trees.

The maximum IVI of tree species on upper, middle and lower altitudes was recorded for *Pinuswallichiana* (204) *Cedrus deodara* (110) and *Morus spp* (57) In case of shrubs *Viburnum nudum*(upper), *Indigo fera heterantha* (middle) and *Parrotiopsis jacquemantiana* (lower) recorded maximum IVI of 87, 82 and 39 respectively and for herbs Ranunculus *hirtellus*, *Viola odorata* and *Lolium perenen* were most dominant species on upper, middle and lower altitudes with IVI of 34, 20 and 15% respectively. The IVI values of dominant plant associations are higher than that reported by Majila and Kala, (2010) from temperate forest of Uttarakhand.

The species richness combined for all life forms and average Margalef index of richness was maximum (44 and 2.372) across the lower altitudinal gradient and minimum(32 and 1.347) at upper altitude (Table. 2). A similar pattern of decrease in species richness with increase in altitude has also been reported by Burni, 1995 and Kumar & Ram, 2005. The values of species richness index were within the range of 1.03-1.24 for trees, 0.43-0.59 for shrubs and 1.62-2.25 for herbs reported by

Sanjeeb *et al*. (2011) in temperate forests of Arunachal Pradesh.

Species richness index is one of the main traits of communities because it influences their stability, productivity and susceptibility to invasion (Duffy *et al*. 2007; Gamfeldt and Hillebr and, 2008). The species richness index in Kandi Forest Range were in the order of herb > shrub > tree. Further, while species richness index of tree and shrub species was maximum in lower altitude, for herb it was highest on middle altitude. Kumar & Ram, (2005) and Sharma *et al*. (2009) have also reported inverse relation of tree species richness index with increasing altitude. The values of species richness index recorded in the present study fall well within the range of 1.03-1.24 for trees, 0.43-0.59 for shrubs and 1.62-2.25 for herbs reported by Sanjeeb *et al*. (2011) in Temperate mixed forests of Arunachal Pradesh.

The average plant diversity index (H) was 0.293, 0.237 and 0.189 for tree, shrubs and herbs (Table. 2). These values were lower than the range (1.16 to 4.75) reported for temperate

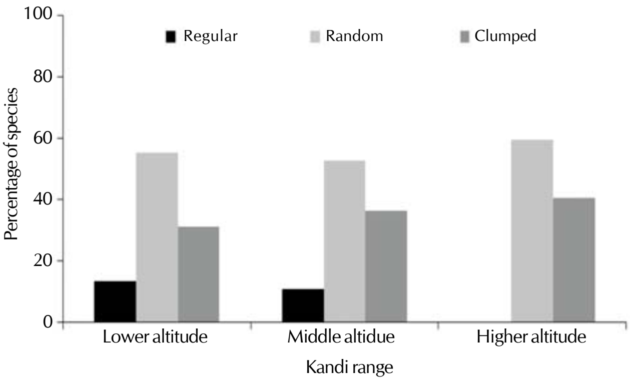

Figure 4: Species distribution pattern on different altitudes of kandi forest range

forests (Knight, 1975 and Monk, 1967; Liyun *et al.*, 2006).Comparing these values with the present study, the species diversity were far low. But, the values of Shannon – Wiener Index varies from 2.35 to 3.13 for tropical forest ecosystem of Chhattisgarh (Jhariya and Oraon, 2012). The decrease in species diversity of the Kandi forest may be due to the over-exploitation and habitat destruction. Pavon *et al*. (2000) has also reported that the diversity of life forms usually decreases with increasing altitude and very few life forms remain at extreme altitudes. The variation in diversity with altitude can be attributed to differences in resource availability on various altitudinal gradients.

The average values of concentration of dominance for trees, shrubs and herbs were lower and in respective order of 0.266, 0.169 and 0.010 for the entire forest range (Table 2) indicating that this phyto-sociological attribute is inversely related with diversity to be associated with advancement in increased habitat stability (Mc Naughton, 1967). The decrease in concentration of dominance with increase in species diversity on disturbed ecosystems has also been reported by Pandey and Singh, (1985). The values of "C" recorded in present study are almost in consonance with the range reported for temperate forests (Singh and Singh, 1986 and Whittaker, 1965).

The species evenness is of great importance to determine the ecosystem functioning. High evenness can increase invasion resistance and productivity and at the same time reduce total extinction rates (Smith *et al*., 2004). Evenness index of trees species was found to be much higher on upper altitude compared to the other two altitudinal ranges (Table 2). The evenness index of shrubs and herbs recorded in the present study on the higher side as compared to those reported by Paul (2008) from Western Himalaya in Arunachal.The variation in evenness index reveals that the altitude imposes a significant impact on the turnover of species. The range of evenness index values recorded in the present study fall within the lower limit of the values recorded for temperate forests of Himalaya and other parts of the world (Bahera *et al*., 2002; Paul, 2008).

High similarity in species composition was recorded between lower and middle altitudes while, it was less between lower and upper altitudes. The high similarity could be attributed to the presence of some species which have wide altitudinal adaptation. Further there was a gradual change in similarity between these two altitudinal gradients. The similarity between trees at lower and upper altitudes was very low which could be due to and rapid turn over of tree species at lower altitude. Murphy and Logo (1986) has suggested that the differences in the species composition and physiognomy of vegetation might be due to soil characteristics and other habitat conditions.

Most of the species exhibited random and clumpy or contagious distribution (56 and 36%) as compared to very few (8 %) which exhibited regular distribution.The critical examination of results revealed that none of the species displayed regular distribution on upper altitude(Table 4).Paul (2008) has also reported clumpy distribution pattern of plant species from temperate broad leaved forest of Western Arunachal Pradesh.The contagious distribution pattern has been reported by many workers (Mehta *et al*., 1997, Kumar and Bhatt, 2006; Singh *et al*., 2009) from temperate forest of Garhwal Himalayas. Semwal (2010) has reported that with few exceptions random distribution is a common feature in temperate forest of Kedarnath Wildlife Sanctuary in Central Himalaya. Panchal and Pandey (2004) have argued that random distribution is a common pattern under uniform environmental conditions whereas, the regular distribution occurs where severe competition exists between the individuals.

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