

Phytosociological characterization of forested vegetation in the sub-tropical region of Darjiling Himalaya, India

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[Received Revised 29.11.2012; Accepted 01.12.2012]

Abstract

The present study examined the floristic diversity, dominance and abundance to frequency ratio of tree, shrub and herb species in the sub-tropical vegetation in Darjiling Himalaya and the dominant species recorded from these three layers were *Schima wallichii* (IVI-37.64), *Eupatorium adenophorum* (IVI-34.93) and *Oplismenus compositus* (IVI-21.72) respectively. The maximum species diversity (Shannon-Wiener Index) was marked for herbs (3.357) followed by shrubs (3.130) and lowest for the trees (2.927). The highest concentration of dominance was recorded for tree species (0.085) and lowest for herbs (0.052). Most of the species were randomly distributed whereas some showed clumped distribution.

Key words: Darjiling Himalaya, Sub-tropical, Dominance

INTRODUCTION

The Darjiling part of the Eastern Himalaya (26° 27' 05" to 27° 13' 10" N latitude and 87° 59' 30" to 88° 53' E) is forming a spur of the Singalila range in the Himalaya Hotspot covering an area of about 3149 sq km and looking like an inverted wedge. The climatic and edaphic isolation of this sub-Himalayan region have resulted in the high percentage of endemism (Bhujel & Das 2002; Das 2004; Rai 2006). Bhujel (1996) has classified the vegetation of Darjiling Hills into five major types with further down to phenological/associational sub-types. Differences in the micro-climatic conditions, inter-specific competition and available space have resulted into the development of mosaic of forest types where the species diversity is well known (Cowan & Cowan 1929; Dash 1947; Grierson & Long 1983; Spur & Burnes 1980; Das 1995). Due to the variation in altitude, different climatic zones are available which creates favourable environment for the development and evolution of the species and their migration in different tiers (Das 2004). The present investigation was conducted in the sub-tropical part of the Darjiling Himalaya within an altitudinal range of about 800 – 1600 m a.m.s.l. This region receives an annual rainfall of about 385 cm in Kurseong and 344 cm in Darjiling area (Das 2004) with maximum precipitation during June to August and maintains a moderate weather year round.

MATERIALS AND METHODS

The phytosociological studies in this region was carried out during the years 2009 – 2010 through nested quadrat sampling method 20 x 20 m plot for trees, 5 x 5 m sample plot for

shrubs/climbers and 1x 1m for recording ground covers (Mishra 1966; Malhotra 1973; Das & Lahiri 1997; Rai *et al* 2011). The collected voucher specimens were processed into mounted herbarium sheets following the conventional methodology (Jain & Rao 1977) and were identified and deposited at the NBU Herbarium.

The collected field-data were analyzed using the formula as suggested by Mishra (1966), Phillips (1959), Das & Lahiri (1997) and Ghosh (2006). The species diversity was determined using Shannon-Weiner's Index (1963) and species richness by using Menhinick's Index (1964). The concentration of dominance (CD) was computed by Simpson's Index (1949). The Dominance-diversity curve for different habit groups was drawn on the basis of determined IVI.

RESULTS AND DISCUSSION

In this sub-tropical region, a total of 39 species were recorded in the tree layer. The dominant and co-dominant species were *Schima wallichii* and *Cupressus corneyana* showing their values of IVI of 37.64 and 24.17 respectively, the highest values of density was also recorded for *Schima wallichii*. 40 species of shrubs and climbers were recorded in the shrub-layer. The highest IVI score was attained by *Eupatorium adenophorum* (IVI 34.93) followed by *Eupatorium odoratum* (IVI 20.68). The abundance to frequency ratio was highest for *Jasminum nepalense*, *Smilax ovalifolia* and *Solanum torvum*. In the herb layer, 59 species were investigated through the process among which the dominant species was *Oplismenus compositus* and the co-dominant was *Oplismenus burmanii* scoring IVI values of 21.72 and 20.28 respectively. The maximum density and the abundance to frequency ratio in the herb layer were recorded respectively for *Oplismenus compositus* and *Pteris biaurita*. The details of the determined phytosociological values are recorded in Table 1.

Table 1: Phytosociological analysis of the recorded species [D = Density; RA = Relative Abundance; RD = Relative Density; RF = Relative Frequency; IVI = Importance Value Index; A/F = Abundance/Frequency]

[Section I: TREE SPECIES]

Plant name [Family]; Voucher specimen	D	RA	RD	RF	IVI	A/F ratio
<i>Actinodaphne longipes</i> Kostermans [Lauraceae]; S. Moktan & AP Das 0062	1.88	5.26	10.35	6.72	22.33	0.15
<i>Ailanthus integrifolia</i> Lamarck [Simaroubaceae]; S. Moktan & AP Das 0008	0.36	2.27	1.98	2.99	7.24	0.14
<i>Alangium chinense</i> Lamarck [Alangiaceae]; S. Moktan & AP Das 0038	0.08	1.01	0.44	1.49	2.94	0.13
<i>Albizia chinensis</i> (Osbeck) Merrill [Mimosaceae]; S. Moktan & AP Das 0053	0.48	1.34	2.64	6.72	10.70	0.04
<i>Albizia gamblei</i> Prain [Mimosaceae]; S. Moktan & AP Das 0109	0.04	1.01	0.22	0.75	1.97	0.25
<i>Albizia procera</i> (Roxburgh) Bentham [Mimosaceae]; S. Moktan & AP Das 0005	0.08	2.02	0.44	0.75	3.20	0.5
<i>Alcimandra cathcartii</i> (Hooker f. & Thomson) Dandy [Magnoliaceae]; S. Moktan & AP Das 0143	0.08	1.01	0.44	1.49	2.94	0.13
<i>Betula alnoides</i> D. Don [Betulaceae]; S. Moktan & AP Das 0019	0.4	3.36	2.20	2.24	7.80	0.28
<i>Bombax ceiba</i> Linnaeus [Bombacaceae]; S. Moktan & AP Das 0068	0.52	1.87	2.86	5.22	9.96	0.07
<i>Brassaiopsis mitis</i> Clarke [Araliaceae]; S. Moktan & AP Das 0083	0.48	2.42	2.64	3.73	8.79	0.12
<i>Castanopsis indica</i> (Roxburgh) A.DC. [Fagaceae]; S. Moktan & AP Das 0072	0.32	2.02	1.76	2.99	6.76	0.13
<i>Chukrasia tabularis</i> Jussieu [Meliaceae]; S. Moktan & AP Das 0071	0.08	2.02	0.44	0.75	3.20	0.5
<i>Cinnamomum tamala</i> (Hamilton) Nees & Ebermaier [Lauraceae]; S. Moktan & AP Das 0174	0.08	2.02	0.44	0.75	3.20	0.5

Plant name [Family]; Voucher specimen	D	RA	RD	RF	IVI	A/F ratio
<i>Cryptomeria japonica</i> (Linnaeus f.) D. Don [Taxodiaceae]; <i>S. Moktan & AP Das 0084</i>	0.16	2.02	0.88	1.49	4.39	0.25
<i>Cupressus corneyana</i> Carriere [Cupressaceae]; <i>S. Moktan & AP Das 0185</i>	2.08	7.49	11.45	5.22	24.17	0.27
<i>Duabanga grandiflora</i> (DC.) Walpers [Sonneratiaceae]; <i>S. Moktan & AP Das 0069</i>	0.24	3.02	1.32	1.49	5.84	0.38
<i>Engelhardtia spicata</i> Blume [Juglandaceae]; <i>S. Moktan & AP Das 0022</i>	0.24	2.02	1.32	2.24	5.58	0.17
<i>Erythrina variegata</i> Linnaeus [Fabaceae]; <i>S. Moktan & AP Das 0127</i>	0.12	1.01	0.66	2.24	3.91	0.08
<i>Eurya acuminata</i> DC. [Theaceae]; <i>S. Moktan & AP Das 0027</i>	0.24	2.02	1.32	2.24	5.58	0.17
<i>Ficus auriculata</i> Laureiro [Moraceae]; <i>S. Moktan & AP Das 0030</i>	0.08	1.01	0.44	1.49	2.94	0.13
<i>Ficus nerifolia</i> J.E. Smith [Moraceae]; <i>S. Moktan & AP Das 0119</i>	0.12	1.51	0.66	1.49	3.67	0.19
<i>Ficus religiosa</i> Linnaeus [Moraceae]; <i>S. Moktan & AP Das 0024</i>	0.08	1.01	0.44	1.49	2.94	0.13
<i>Gmelina arborea</i> Roxburgh [Verbenaceae]; <i>S. Moktan & AP Das 0007</i>	0.12	3.02	0.66	0.75	4.43	0.75
<i>Holarrhena pubescens</i> (Buchanan-Hamilton) G. Don [Apocynaceae]; <i>S. Moktan & AP Das 0026</i>	0.52	4.37	2.86	2.24	9.47	0.36
<i>Leucosceptrum cannum</i> Smith [Lamiaceae]; <i>S. Moktan & AP Das 0011</i>	0.52	2.62	2.86	3.73	9.22	0.13
<i>Litsea elongata</i> (Nees) Hooker f. [Lauraceae]; <i>S. Moktan & AP Das 0075</i>	0.08	2.02	0.44	0.75	3.20	0.5
<i>Macaranga denticulata</i> (Blume) Mueller [Euphorbiaceae]; <i>S. Moktan & AP Das 0108</i>	0.2	2.52	1.10	1.49	5.11	0.31
<i>Magnifera sylvatica</i> Roxburgh [Anacardiaceae]; <i>S. Moktan & AP Das 0148</i>	0.04	1.01	0.22	0.75	1.97	0.25
<i>Mangifera indica</i> Linnaeus [Anacardiaceae]; <i>S. Moktan & AP Das 0037</i>	0.16	1.34	0.88	2.24	4.46	0.11
<i>Michelia doltsova</i> DC. [Magnoliaceae]; <i>S. Moktan & AP Das 0025</i>	0.08	2.02	0.44	0.75	3.20	0.5
<i>Ostodes paniculata</i> Blume [Euphorbiaceae]; <i>S. Moktan & AP Das 0021</i>	1	5.04	5.51	3.73	14.28	0.25
<i>Pandanus furcatus</i> Roxburgh [Pandanaeae]; <i>S. Moktan & AP Das 0057</i>	1.56	5.62	8.59	5.22	19.43	0.2
<i>Phyllanthus emblica</i> Linnaeus [Euphorbiaceae]; <i>S. Moktan & AP Das 0220</i>	0.04	1.01	0.22	0.75	1.97	0.25
<i>Quercus griffithii</i> Miquel [Fagaceae]; <i>S. Moktan & AP Das 0129</i>	0.04	1.01	0.22	0.75	1.97	0.25
<i>Schima wallichii</i> (DC.) Korthals [Theaceae]; <i>S. Moktan & AP Das 0020</i>	3.68	6.18	20.26	11.19	37.64	0.1
<i>Styrax serrulatus</i> Roxburgh [Styracaceae]; <i>S. Moktan & AP Das 0006</i>	0.08	2.02	0.44	0.75	3.20	0.5
<i>Syzygium tetragonum</i> (Wight) Walpers [Myrtaceae]; <i>S. Moktan & AP Das 0160</i>	0.4	2.02	2.20	3.73	7.95	0.1
<i>Tectona grandis</i> Linnaeus [Verbenaceae]; <i>S. Moktan & AP Das 0002</i>	1.08	6.80	5.95	2.99	15.74	0.42
<i>Wrightia arborea</i> (Dennstaedt) Mabblerley [Apocynaceae]; <i>S. Moktan & AP Das 0010</i>	0.32	2.69	1.76	2.24	6.69	0.22

[Section II: SHRUBS & CLIMBERS]

Plant name [Family]; Voucher specimen	D	RA	RD	RF	IVI	A/F ratio
<i>Abrus pulchellus</i> Thwaites [Fabaceae]; <i>S. Moktan & AP Das 0211</i>	0.36	2.41	3.73	4.46	10.60	0.18
<i>Aconogonum molle</i> (D. Don) Hara [Polygonaceae]; <i>S. Moktan & AP Das 0033</i>	0.1	2.34	1.04	1.27	4.65	0.63
<i>Ardisia solanacea</i> Roxburgh [Myrsinaceae]; <i>S. Moktan & AP Das 0074</i>	0.06	1.41	0.62	1.27	3.30	0.38
<i>Argyrea hookeri</i> Clarke [Convolvulaceae]; <i>S. Moktan & AP Das 0091</i>	0.14	3.28	1.45	1.27	6.01	0.88
<i>Argyrea roxburghii</i> Choisy [Convolvulaceae]; <i>S. Moktan & AP Das 0016</i>	0.04	1.87	0.41	0.64	2.93	1.00
<i>Artemisia dubia</i> Besser [Asteraceae]; <i>S. Moktan & AP Das 0059</i>	0.32	2.50	3.32	3.82	9.64	0.22

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Plant name [Family]; Voucher specimen	D	RA	RD	RF	IVI	A/F ratio
<i>Bambusa nutans</i> Wallich [Poaceae]; <i>S. Moktan & AP Das 0035</i>	0.24	2.81	2.49	2.55	7.85	0.38
<i>Brugmansia suaveolens</i> (Willdenow) Berchtold & Presl [Solanaceae]; <i>S. Moktan & AP Das 0015</i>	0.08	1.25	0.83	1.91	3.99	0.22
<i>Cassia floribunda</i> Cavanilles [Caesalpiniaceae]; <i>S. Moktan & AP Das 0098</i>	0.12	2.81	1.24	1.27	5.33	0.75
<i>Cyclea bicristata</i> (Griffith) Diels [Menispermaceae]; <i>S. Moktan & AP Das 0112</i>	0.02	0.94	0.21	0.64	1.78	0.50
<i>Debregeasia longifolia</i> (Burmam f.) Weddell [Urticaceae]; <i>S. Moktan & AP Das 0023</i>	0.14	2.19	1.45	1.91	5.55	0.39
<i>Desmodium heterocarpon</i> (Linnaeus) DC. [Fabaceae]; <i>S. Moktan & AP Das 0177</i>	0.16	3.75	1.66	1.27	6.68	1.00
<i>Dioscorea bulbifera</i> Linnaeus [Dioscoreaceae]; <i>S. Moktan & AP Das 0165</i>	0.16	1.87	1.66	2.55	6.08	0.25
<i>Dioscorea hispida</i> Dennstedt [Dioscoreaceae]; <i>S. Moktan & AP Das 0070</i>	0.12	1.41	1.24	2.55	5.20	0.19
<i>Eupatorium adenophorum</i> Sprengel [Asteraceae]; <i>S. Moktan & AP Das 0061</i>	1.88	5.87	19.50	9.55	34.93	0.21
<i>Eupatorium odoratum</i> Linnaeus [Asteraceae]; <i>S. Moktan & AP Das 0014</i>	0.96	5.62	9.96	5.10	20.68	0.38
<i>Flemingia stricta</i> Roxburgh [Fabaceae]; <i>S. Moktan & AP Das 0076</i>	0.1	2.34	1.04	1.27	4.65	0.63
<i>Flueggea virosa</i> (Willdenow) Voigt [Euphorbiaceae]; <i>S. Moktan & AP Das 0115</i>	0.12	2.81	1.24	1.27	5.33	0.75
<i>Jasminum nepalense</i> Sprengel [Oleaceae]; <i>S. Moktan & AP Das 0065</i>	0.06	2.81	0.62	0.64	4.07	1.50
<i>Lantana camara</i> Linnaeus [Verbenaceae]; <i>S. Moktan & AP Das 0064</i>	0.62	4.84	6.43	3.82	15.10	0.43
<i>Maesa chisia</i> D. Don [Myrsinaceae]; <i>S. Moktan & AP Das 0045</i>	0.24	1.25	2.49	5.73	9.47	0.07
<i>Maesa macrophylla</i> (Wallich) A.DC. [Myrsinaceae]; <i>S. Moktan & AP Das 0041</i>	0.18	1.69	1.87	3.18	6.74	0.18
<i>Melastoma malabathricum</i> Linnaeus [Melastomataceae]; <i>S. Moktan & AP Das 0058</i>	0.16	1.87	1.66	2.55	6.08	0.25
<i>Meyna spinosa</i> Link [Rubiaceae]; <i>S. Moktan & AP Das 0193</i>	0.02	0.94	0.21	0.64	1.78	0.50
<i>Mikania micrantha</i> Kunth [Asteraceae]; <i>S. Moktan & AP Das 0095</i>	0.66	5.15	6.85	3.82	15.82	0.46
<i>Mimosa himalayana</i> Gamble [Mimosaceae]; <i>S. Moktan & AP Das 0118</i>	0.28	4.37	2.90	1.91	9.19	0.78
<i>Mussaenda roxburghii</i> Hook.f. [Rubiaceae]; <i>S. Moktan & AP Das 0199</i>	0.04	1.87	0.41	0.64	2.93	1.00
<i>Natsiatum herpeticum</i> Arnott [Icacinaceae]; <i>S. Moktan & AP Das 0013</i>	0.06	0.94	0.62	1.91	3.47	0.17
<i>Phlogacanthus thyriformis</i> (Hardwicke) Mabblerley [Acanthaceae]; <i>S. Moktan & AP Das 0085</i>	0.08	1.87	0.83	1.27	3.98	0.50
<i>Psilanthus bengalensis</i> (Schultes) Leroy [Rubiaceae]; <i>S. Moktan & AP Das 0017</i>	0.24	1.61	2.49	4.46	8.55	0.12
<i>Pterygota alata</i> (Roxburgh) R. Brown [Sterculiaceae]; <i>S. Moktan & AP Das 0192</i>	0.04	1.87	0.41	0.64	2.93	1.00
<i>Smilax ovalifolia</i> Roxburgh [Smilacaceae]; <i>S. Moktan & AP Das 0121</i>	0.06	2.81	0.62	0.64	4.07	1.50
<i>Solanum torvum</i> Swartz [Solanaceae]; <i>S. Moktan & AP Das 0012</i>	0.06	2.81	0.62	0.64	4.07	1.50
<i>Solanum viarum</i> Dunal Clarke [Solanaceae]; <i>S. Moktan & AP Das 0100</i>	0.04	1.87	0.41	0.64	2.93	1.00
<i>Stephania japonica</i> (Thunberg) Miers [Menispermaceae]; <i>S. Moktan & AP Das 0178</i>	0.32	1.87	3.32	5.10	10.29	0.13
<i>Tetrastigma planicaule</i> (Hooker f.) Gagnepain [Vitaceae]; <i>S. Moktan & AP Das 0101</i>	0.48	2.50	4.98	5.73	13.21	0.15
<i>Tetrastigma serrulatum</i> (Roxburgh) Planchon [Vitaceae]; <i>S. Moktan & AP Das 0203</i>	0.36	1.87	3.73	5.73	11.34	0.11
<i>Thladiantha cordifolia</i> (Blume) Cogniaux [Cucurbitaceae]; <i>S. Moktan & AP Das 0099</i>	0.32	3.00	3.32	3.18	9.50	0.32
<i>Thunbergia fragrans</i> (Roxburgh) [Acanthaceae]; <i>S. Moktan & AP Das 0209</i>	0.1	2.34	1.04	1.27	4.65	0.63
<i>Tithonia diversifolia</i> (Hemsley) A. Gray [Asteraceae]; <i>S. Moktan & AP Das 0089</i>	0.1	2.34	1.04	1.27	4.65	0.63

[Section III: HERBS]

Plant name [Family]; Voucher specimen	D	RA	RD	RF	IVI	A/F ratio
<i>Adiantum philippense</i> Linnaeus [Adiantaceae]; S. Moktan & AP Das 0206	0.07	1.13	0.72	1.45	3.30	1.25
<i>Aeschynanthus hookeri</i> C.B. Clarke [Gesneriaceae]; S. Moktan & AP Das 0031	0.02	0.38	0.16	0.97	1.50	0.63
<i>Ageratum houstonianum</i> Miller [Asteraceae]; S. Moktan & AP Das 0093	0.72	3.39	7.20	4.83	15.42	1.13
<i>Begonia hatacoa</i> D. Don [Begoniaceae]; S. Moktan & AP Das 0194	0.03	0.75	0.32	0.97	2.04	1.25
<i>Bidens pilosa</i> Linnaeus [Asteraceae]; S. Moktan & AP Das 0140	0.08	1.88	0.80	0.97	3.65	3.13
<i>Biophytum reinwardtii</i> (Zuccarini) Klotzsch [Oxalidaceae]; S. Moktan & AP Das 0227	0.06	1.32	0.56	0.97	2.84	2.19
<i>Boehmeria macrophylla</i> Hornemann [Urticaceae]; S. Moktan & AP Das 0106	0.29	1.51	2.88	4.35	8.73	0.56
<i>Capillipedium assimile</i> (Steudel) A. Camus [Poaceae]; S. Moktan & AP Das 0219	0.12	1.41	1.20	1.93	4.54	1.17
<i>Commelina suffruticosa</i> Blume [Commelinaceae]; S. Moktan & AP Das 0081	0.30	3.48	2.96	1.93	8.38	2.89
<i>Costus speciosus</i> (J. Koenig) Smith [Costaceae]; S. Moktan & AP Das 0189	0.01	0.38	0.08	0.48	0.94	1.25
<i>Crassocephalum crepidioides</i> (Benth) S. Moore [Asteraceae]; S. Moktan & AP Das 0154	0.03	0.75	0.32	0.97	2.04	1.25
<i>Cyperus cyperoides</i> (Retzius) O. Kuntze [Cyperaceae]; S. Moktan & AP Das 0217	0.06	1.51	0.64	0.97	3.11	2.50
<i>Dicliptera bupleuroides</i> Nees [Acanthaceae]; S. Moktan & AP Das 0170	0.02	0.56	0.24	0.97	1.77	0.94
<i>Drymaria cordata</i> (Linnaeus) Roemer & Schultes [Caryophyllaceae]; S. Moktan & AP Das 0195	0.06	1.32	0.56	0.97	2.84	2.19
<i>Dryopteris sikkimensis</i> (Beddome) O. Kuntze [Dryopteridaceae]; S. Moktan & AP Das 0046	0.24	1.88	2.40	2.90	7.18	1.04
<i>Elastostema lineolatum</i> Wight [Urticaceae]; S. Moktan & AP Das 0163	0.02	0.75	0.16	0.48	1.40	2.50
<i>Elephantopus scaber</i> Linnaeus [Asteraceae]; S. Moktan & AP Das 0218	0.02	0.75	0.16	0.48	1.40	2.50
<i>Emelia sonchifolia</i> (Linnaeus) DC. [Asteraceae]; S. Moktan & AP Das 0048	0.06	1.32	0.56	0.97	2.84	2.19
<i>Equisetum diffusum</i> D. Don [Equisetaceae]; S. Moktan & AP Das 0080	0.04	1.88	0.40	0.48	2.77	6.25
<i>Galinsoga parviflora</i> Cavanilles [Asteraceae]; S. Moktan & AP Das 0094	0.03	1.51	0.32	0.48	2.31	5.00
<i>Globba racemosa</i> Smith [Zingiberaceae]; S. Moktan & AP Das 0146	0.60	3.14	6.00	4.35	13.49	1.16
<i>Hedychium ellipticum</i> Smith [Zingiberaceae]; S. Moktan & AP Das 0171	0.01	0.38	0.08	0.48	0.94	1.25
<i>Impatiens trilobata</i> Colebrooke [Balsaminaceae]; S. Moktan & AP Das 0210	0.18	1.73	1.84	2.42	5.99	1.15
<i>Isachne globosa</i> (Thunberg) O. Kuntze [Poaceae]; S. Moktan & AP Das 0141	0.07	1.69	0.72	0.97	3.38	2.81
<i>Lepidagathis incurva</i> Buchanon-Hamilton ex D. Don [Acanthaceae]; S. Moktan & AP Das 0107	0.25	1.95	2.48	2.90	7.32	1.08
<i>Nephrolepis auriculata</i> Linnaeus [Nephrolepidaceae]; S. Moktan & AP Das 0173	0.74	5.84	7.44	2.90	16.17	3.23
<i>Neyraudia zollingeri</i> (Buese) Hooker f. [Poaceae]; S. Moktan & AP Das 0111	0.04	1.88	0.40	0.48	2.77	6.25
<i>Oplismenus burmanii</i> (Retzius) P. Beauvois [Poaceae]; S. Moktan & AP Das 0079	0.99	3.11	9.92	7.25	20.28	0.69
<i>Oplismenus compositus</i> (Linnaeus) P. Beauvois [Poaceae]; S. Moktan & AP Das 0018	1.14	4.49	11.44	5.80	21.72	1.24
<i>Oxalis corniculata</i> Linnaeus [Oxalidaceae]; S. Moktan & AP Das 0116	0.15	1.79	1.52	1.93	5.24	1.48
<i>Peliosanthes griffithii</i> Baker [Convallariaceae]; S. Moktan & AP Das 0186	0.02	0.75	0.16	0.48	1.40	2.50

Plant name [Family]; Voucher specimen	D	RA	RD	RF	IVI	A/F ratio
<i>Peperomia pellucida</i> (Linnaeus) Kunth [Piperaceae]; S. Moktan & AP Das 0208	0.03	1.51	0.32	0.48	2.31	5.00
<i>Peristrophe speciosa</i> (Roxburgh) Nees [Acanthaceae]; S. Moktan & AP Das 0158	0.05	1.13	0.48	0.97	2.58	1.88
<i>Persicaria chinensis</i> (Linnaeus) H. Gross [Polygonaceae]; S. Moktan & AP Das 0198	0.03	0.75	0.32	0.97	2.04	1.25
<i>Persicaria microcephala</i> (D. Don) H. Gross [Polygonaceae]; S. Moktan & AP Das 0078	0.27	2.56	2.72	2.42	7.70	1.70
<i>Persicaria runcinata</i> (D. Don) H. Gross [Polygonaceae]; S. Moktan & AP Das 0102	0.11	1.76	1.12	1.45	4.33	1.94
<i>Phaseolus coccineus</i> Linnaeus [Fabaceae]; S. Moktan & AP Das 0222	0.02	0.56	0.24	0.97	1.77	0.94
<i>Phymatosorus cuspidatus</i> D. Don [Polypodiaceae]; S. Moktan & AP Das 0183	0.25	2.92	2.48	1.93	7.33	2.42
<i>Physalis divaricata</i> D. Don [Solanaceae]; S. Moktan & AP Das 0162	0.10	2.26	0.96	0.97	4.19	3.75
<i>Pilea scripta</i> (D. Don) Weddel [Urticaceae]; S. Moktan & AP Das 0152	0.06	1.32	0.56	0.97	2.84	2.19
<i>Piper peepuloides</i> Roxburgh [Piperaceae]; S. Moktan & AP Das 0188	0.02	1.13	0.24	0.48	1.85	3.75
<i>Polystichum lentum</i> (D. Don) T. Moore [Dryopteridaceae]; S. Moktan & AP Das 0082	0.67	2.64	6.72	5.80	15.15	0.73
<i>Pouzolzia hirta</i> (Blume) Hasskarl [Urticaceae]; S. Moktan & AP Das 0092	0.26	2.48	2.64	2.42	7.54	1.65
<i>Pteris biaurita</i> Linnaeus [Pteridaceae]; S. Moktan & AP Das 0097	0.07	3.39	0.72	0.48	4.59	11.25
<i>Pupalia atropurpurea</i> Moquin [Amaranthaceae]; S. Moktan & AP Das 0215	0.08	1.88	0.80	0.97	3.65	3.13
<i>Rhopalephora scaberrima</i> (Blume) R. Faden [Commelinaceae]; S. Moktan & AP Das 0151	0.17	2.64	1.68	1.45	5.76	2.92
<i>Rhynchoglossum obliquum</i> Blume [Gesneriaceae]; S. Moktan & AP Das 0077	0.04	0.94	0.40	0.97	2.31	1.56
<i>Rubia charaefolia</i> Wallich ex G. Don [Rubiaceae]; S. Moktan & AP Das 0164	0.05	0.75	0.48	1.45	2.68	0.83
<i>Saccharum arundinaceum</i> Retzius [Poaceae]; S. Moktan & AP Das 0089 0114	0.10	1.63	1.04	1.45	4.12	1.81
<i>Selaginella monospora</i> Spring [Selaginellaceae]; S. Moktan & AP Das 0200	0.12	1.41	1.20	1.93	4.54	1.17
<i>Setaria palmifolia</i> (J. Koenig) Stapf [Poaceae]; S. Moktan & AP Das 0133	0.02	1.13	0.24	0.48	1.85	3.75
<i>Sida rhombifolia</i> Linnaeus [Malvaceae]; S. Moktan & AP Das 0224	0.14	1.60	1.36	1.93	4.89	1.33
<i>Spermacoce latifolia</i> Aublet [Rubiaceae]; S. Moktan & AP Das 0073	0.58	3.01	5.76	4.35	13.12	1.11
<i>Strobilanthus himalayana</i> J.R.I. Wood [Acanthaceae]; S. Moktan & AP Das 0136	0.03	1.51	0.32	0.48	2.31	5.00
<i>Tectaria griffithii</i> (Baker) C. Christensen [Dryopteridaceae]; S. Moktan & AP Das 0205	0.02	0.75	0.16	0.48	1.40	2.50
<i>Triumfetta rhomboidea</i> Jacquin [Tiliaceae]; S. Moktan & AP Das 0066	0.14	1.13	1.44	2.90	5.47	0.63
<i>Urena lobata</i> Linnaeus [Malvaceae]; S. Moktan & AP Das 0153	0.05	1.13	0.48	0.97	2.58	1.88
<i>Urtica dioica</i> Linnaeus [Urticaceae]; S. Moktan & AP Das 0056	0.03	0.75	0.32	0.97	2.04	1.25
<i>Vallisneria spiralis</i> (L.) Oakes [Mosses]; S. Moktan & AP Das 0172	0.02	0.75	0.16	0.48	1.40	2.50

Species diversity and Concentration of Dominance (CD)

In the present study area, the maximum diversity values (3.357) were shown by herbs followed by shrubs which showed diversity value of 3.130. In the tree layer the diversity values recorded was 2.927. The concentration of dominance for herbs was found to be the lowest

(0.052) and that for the trees was the highest (0.085). The species richness was highest for trees and lowest for herbs. The diversity indices for the species showed that the dominance and diversity are inversely related (Table-2).

Table 2. Determined Diversity & Dominance Indices for different habit-groups

Layers	Species diversity	Species Richness	Concentration of Dominance (CD)
Tree	2.927	1.830	0.085
Shrub	3.130	1.822	0.070
Herb	3.357	1.669	0.052

Dominance-diversity curves

The Dominance-diversity curves plotted between Importance Value Index and species sequence of trees, shrubs and herbs indicate relationship between different species (Fig. 1).

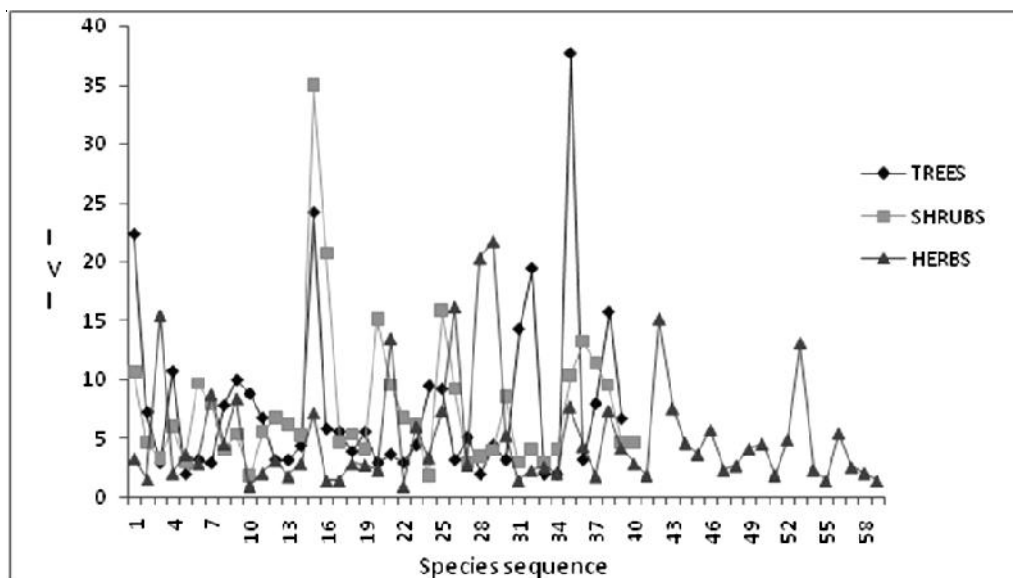


Figure 1. Dominance–diversity curve for Trees, Shrubs and Herbs

In the present study of the sub-tropical region of Darjiling Himalaya, the maximum number of species belonged to the family Asteraceae followed by Poaceae and Acanthaceae. The total density for trees, shrubs and herbs were recorded as 18.16, 9.64 and 10.0 respectively. The abundance to frequency ratio indicates that species of trees, shrubs and herbs were quite healthily distributed. Some tree species showed a very high richness whereas some were sparsely populated. Species such as *Schima wallichii* and *Cupressus corneyana* showed maximum density whereas species like *Albizzia gamblei*, *Magnifera sylvatica*, *Phyllanthus emblica* and *Quercus griffithii* showed minimum density values. The shrub layer showed a good number of species composition except few species like *Cyclea bicristata* and *Meyna spinosa* which were less densely distributed. The ground cover in this region also showed high diversity with species of *Oplismenus* whereas species of *Peristrophe* and *Piper* possessed low diversity indices. The herbaceous vegetation may help in the conservation of nutrients as it forms the major part of the overall vegetation. This study may provide useful information for studying the community ecology of the Darjiling Himalaya in this region.

Acknowledgements

The financial assistance provided by the University Grant Commission to the first author is sincerely acknowledged.

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