Dynamics and Characterization of Herbaceous Vegetation in Three Forest Communities in a Subtropical Dry Deciduous Forest in Jammu, Jammu and Kashmir

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Abstract: The investigations on the herbaceous vegetation in terms of its composition and diversity were conducted in three different forest communities in a sub-tropical forest of Jammu Siwaliks. These included Northern dry mixed deciduous forests (SB/C2), Himalayan sub-tropical scrub (9C1/D31) and Himalayan sub-tropical Pine forest (9C1/a) in an altitudinal range of 300 m asl to 990 m asl. The community analysis was performed using stratified random sampling involving 0.01 % of the total area for each community. 750 quadrats of 1 m² each were laid for various phytosociological parameters and diversity indices to reveal the community structure, species richness, diversity and evenness for the terrestrial herbs in different forest types. A total of 266 species belonging to 201 genera and 64 families were recorded from the forest. The vegetation analysis revealed the dominance of Cynodon dactylon Pers (SIV = 12.75, 4.25%), Ageratum conyzoides L. (18.03, 6.01%) and Cynodon dactylon Pers. (23.07, 7.69%) as herbaceous elements in northern dry mixed deciduous forests, Himalayan sub-tropical scrub and Himalayan sub-tropical Pine forest respectively. The northern dry mixed deciduous forest occupying 27.3 % of the study area revealed maximum herb species richness and diversity as indicated by the higher values obtained for Shannon-Wiener’s index, Margalef’s index and Simpson’s index of dominance.

Keywords: Subtropical vegetation, community analysis, stratified random sampling, vegetation analysis, herbaceous elements

1. Introduction

The herbaceous layer significantly contributes to the diversity of forests. The forest understorey is heterogeneous and dynamic habitat with bulk of species contributing to ecosystem functioning and sustenance. It is indeed a high stress environment where the vital resources that influence the growth of vegetation especially the sunlight, water and nutrients are the major limiting factors. Still few favourable factors influence the luxuriant growth of under storey which defines the structure and dynamics of future communities. Since understorey defines the future species composition and structure of the canopy, its thorough understanding is crucial to forest management. Despite a growing awareness that the herbaceous layer serves a special role in maintaining the structure and function of forests, this stratum remains an underappreciated aspect of forest ecosystems (Gilliam, 2006). The ecology of the herbaceous layer has been the focus of numerous studies (Gilliam & Roberts, 2003; Roberts, 2004; Whigham, 2004 and Gilliam et al., 2006). Herbaceous layer in the forests determines the spatio-temporal distribution and dynamics of woody seedlings through regeneration (Maguire & Forman, 1983) and regulates the recruitment of woody plants directly and indirectly. It offers better protection to soil (Gilliam, 1988) and influences nutrient cycling and energy flow in the ground stratum (Scheller & Mladenoff, 2002 and Das et al., 2008). Grasses are beneficial in binding soil particles thus reducing soil erosion and water loss and finally maintaining the soil structure (Sagar et al., 2008) besides providing shelter for microbial communities (Singh et al., 2006).

There have been some important contributions on vegetation analysis, phytosociology and community structure in certain Himalayan forest types (Kunwar & Sharma, 2004; Gairola et al., 2008; Kharakwal, 2009; Todoria et al., 2010 and Tynsong & Tiwari, 2011). The forest diversity patterns and governing environmental as well as anthropogenic variables in the Himalayan sub-tropical region have been studied in the past by phyto-sociologists (Rao et al., 1990; Sharma & Kumar, 1992; Varghese & Menon, 1998; Sharma, 2003; Ilorkar & Khatri, 2003; Jhangir, 2004; Kunwar & Sharma, 2004; Negi & Nautiyal, 2005; Ahmed et al., 2006; Naithani et al., 2006; Raghubanshi & Tripathi, 2009; Krishnamurthy et al., 2010; Tripathi et al., 2010; Ekka and Behera, 2011; Joshi, 2012; Sahi et al., 2012; Gairola and Soni, 2013; Sinha & Sinha, 2013; Shaheen et al., 2011; Gupta & Kumar, 2014; Sharma & Kant, 2014 a & b and Shukla & Chakarvarty, 2014). Since understanding the composition, distribution, and diversity of herbaceous vegetation is basic to the know the dynamics of the forest ecosystem, the present study was conducted with the broader objective to provide the baseline information on composition, structure and diversity of herbaceous layer in different forest communities of a dry tropical forest in north western Himalayas.

2. Materials and Methods

2.1 Vegetation sampling and data analysis

A reconnaissance survey was undertaken to define vegetation type and community association and traverses along roads, drainage, hills and ridges were made and three forest types were identified on the basis of forest classification by Champion and Seth (1968). A total of seven hundred fifty sample points were laid separately for northern dry mixed deciduous (370), Himalayan sub-tropical scrub (280) and Himalayan sub-tropical pine forest (100)
respectively for quantitative sampling. Stratified random sampling with a sample intensity of 0.01 per cent of the total area was adopted for covering the ground flora in all forest types. The analysis was carried out by laying the quadrats of 1 m² each and a single summary statistic or importance value was calculated by summing the relative values for species following Ganesh et al. (1996). The equation used is Species Importance Value (SIV%) = Relative Frequency + Relative Density + Relative Dominance.

2.2 Species richness and diversity

Total species richness was simply taken as a count of number of species present in the respective forest type. Species richness (number of species per unit area) was calculated as Margalef’s Index (1958) using formula Da = S-1/ln (N) and Menhinik’s index of richness (Whittaker, 1977) was calculated as Richness Ds = S/lnN, where, S = number of species and N = Total number of individuals (of all species in case of Menhinik’s index). The diversity (H') was determined by using Shannon-Weiner (1963) information index as H' = - Σni/n log2 ni/n; where ni was the SIV value of a species and n was the sum total SIV values of all species in that forest type. Simpson’s diversity index (1949) was calculated as Ds = 1-Cd, Where Cd = Simpson’s concentration of dominance = (Σni/n²). Indices used to calculate species evenness ‘r’ included Peilou’s Index (1975) as E_r = H'/ln (s) and Sheldon’s Index (1969) E_s = eH'/s, where H’ is Shannon-Wiener’s Index and ‘s’ is the number of species.

2.3 Study Area

The present study area extends northwards of Pathankote-Jammu national highway covering the southern areas of Kathua, Samba and Jammu districts respectively with an approximate geographical coverage of 3350 sq km with predominance of typical sub-tropical vegetation ranging from 300 m asl to 990 m asl (Fig.1) Beset with small dry hillocks, gorges and ravines, the major part of this zone is under forests and offers but limited facility to agriculture. The soils are shallow and infested with gravel and stones. The Jammu Siwaliks has a markedly periodic climate, characterized by dry and increasingly hot season from March to June, a warm humid monsoon season from July to September and a dry and cold weather from October to December. The normal annual rainfall of Jammu is 1113 mm, 72% of it is received during monsoon months with an average number of rainy days per year being 54. June is recorded as hottest month with average maximum of 47°C while January being the coldest month (6.8°C). The foggy winters and scorching summers bear a marked climatic perturbation.

3. Results

3.1 Vegetation structure and composition

The forests of Kandi Siwaliks were divided into three types in accordance with the classification made in revised survey of forest types of India by Champion and Seth (1968).

3.1.1 Northern dry mixed deciduous forest (SB/C2)

Occupying an area of 804.46 km² accounting to 27.3% of total geographical area, this forest type is restricted to Jammu foothills of low to moderate elevations (Fig.1). The herbaceous layer is structurally and numerically most prominent during monsoon season. Most commonly found species include Anagalis arvensis L., Fumaria indica Pugsley, Oxalis corniculata L., Stellaria media Vill., Gnaphalium purpureum L., Eclipta prostrata L., Youngia japonica DC, Salvia plebia R. Br., Malvastrum coronellianum Garcke, Erigeron bonariensis L., Bidens bitemnata Merr. and Sherff., Achyranthes aspera L., Sonchus oleraceus L., Euphorbia hirta, Geranium rotundifolium L., Carex fedia Nees., Cynodon dactylon Pers. etc.

Most of understorey is dominated by scattered or gregarious chunks of weed flora. The commonly found species include Argemone mexicana L., Cassia occidentalis L., Solanum nigrum L., Xanthium strumarium L., Euphorbia helioscopia L.; Datura innoxia Mill., Chenopodium murale L., Malva parviflora L. etc. The most notorious among the herbaceous weeds in this forest are Parthenium hysterophorus and Cannabis sativa L.

3.1.2 Himalayan subtropical scrub (9/C1/DSI)

296.80 km², amounting to 10.1% of the total geographic area under study, recorded the dominance of scrubby vegetation. Restricted to dry hillocks and gentle slopes of low elevation, the fairly dense vegetation cover comprised an admixture of shrubs and rather small sized deciduous trees, mostly of thorny type. The perennial grasses are represented chiefly by Apluda mutica L., Chrysopogon fulvor Coiv., Cymbopogon stracheyi Raizada, Heteropogon contortus P. Beauv., Dicanthium annulatum Stapf. and Saccharum benghalense Retz., the latter occurring in tall dense clumps in riparian localities.


3.1.3 Himalayan subtropical pine forest (9/C1a)

This forest type occupied an area of 99.85 km², thus forming 3.4% of the total area under study. It comprised of 25-30 m high pure crop of Pinus roxburghii in all the higher ridges and on the steeper rocky slopes at an altitude of 900 m asl, with broad-leaved species and shrubs towards moderate and lower elevations (Fig.1). The herbaceous flora included Rumex hattatus Don, Cymbopogon stracheyi Raizada & Jain., Allium rubellum M. Bieb., Allium angiospermum L., Arenaria serpyllifolia L., Atylosa crassa Prain., Borreria stricta K., Schum. Capsella bursa-pastoris Medik., Carthamus oxyccantha M. Bieb., Commelina benghalensis L., Fumaria indica Pugsley, Gentiana aprica Dcne, Lindebergia indica Vatke and Reinwaratia indica Dumbott.
3.2 Floristic structure species richness and diversity

A total of 266 species belonging to 201 genera and 64 families have been recorded in the ground stratum of different forest communities. Most of the herbs are annuals and biennials restricted to forest floors or open blanks within and along the forest fringes. Among the angiosperm families, Fabaceae topped the list with 21 genera and 35 species followed by Asteraceae (24/28), Poaceae (19/21), and Lamiaceae (10/15) respectively. As many as 25 families showed monotypic representation in the area as represented by a single genus and single species.

The community analysis was performed using stratified random sampling involving 0.01 % of the total area for each community wherein 750 quadrats of 1 m² each were laid for various phytosociological parameters. Maximum species richness i.e 135 was recorded for subtropical dry deciduous forest followed by 62 in Himalayan subtropical scrub and 59 in Himalayan subtropical Pine forest respectively (Table-1). Further, the species diversity was also found maximum in subtropical dry deciduous forest with highest values recorded for Margalef’s Index (34.89), Menhinick’s Index (1.62), Simpson’s Index (0.97) and Shannon-Wiener’s Index (3.66) followed by Himalayan subtropical scrub [Margalef’s Index (17.68), Menhinick’s Index (1.16), Simpson’s Index (0.97) and Shannon-Wiener’s Index (3.55)] and Himalayan subtropical Pine forest [Margalef’s Index (18.01), Menhinick’s Index (1.43), Simpson’s Index (0.96) and Shannon-Wiener’s Index (3.40)] respectively (Table-1).

Table 1: Community Characteristics of herbaceous layer in different forest ecosystems

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Subtropical dry deciduous forest</th>
<th>Himalayan subtropical scrub</th>
<th>Himalayan subtropical Pine forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species richness</td>
<td>135</td>
<td>62</td>
<td>59</td>
</tr>
<tr>
<td>Total number of individuals</td>
<td>6936</td>
<td>2865</td>
<td>1689</td>
</tr>
<tr>
<td>Margalef’s Index (Da)</td>
<td>34.89</td>
<td>17.68</td>
<td>18.01</td>
</tr>
<tr>
<td>Menhinick’s Index (Db)</td>
<td>1.62</td>
<td>1.16</td>
<td>1.43</td>
</tr>
</tbody>
</table>

The Peilou’s evenness Index varied from 0.75 to 0.86 with maximum values recorded as 0.86 for Himalayan subtropical scrub followed by Himalayan subtropical pine forest (0.83) and subtropical dry deciduous forest (0.75) respectively. The Sheldon’s evenness index ranged from 0.28 to 0.56 with highest value (0.56) noticed in Himalayan subtropical scrub followed by Himalayan subtropical Pine forest (0.50) and subtropical dry deciduous forest (0.28) respectively.

3.3 Vegetation Analysis

Vegetation analysis revealed that highest Species Importance Value (Value, percentage) amongst the herbs in different forest communities. In northern dry mixed deciduous forest, Cynodon dactylon Pers. is found the most dominant species (IVI = 12.75, 4.25%) with relative frequency of 7.00%, relative density of 5.70% and relative dominance of 0.05%, respectively. The most frequently occurring species is again Cynodon dactylon Pers. with frequency value of 48.60%. Dicanthium annulatum Stapf. possessed highest density i.e, 107.29, whereas Torenia cordifolia Roxb. was most abundant herb of the region with a value of 16.50. While in Himalayan sub-tropical scrub, among the herbaceous layer Ageratum conyzoides L. was observed most dominant with IVI value of 18.03 (6.01%) in which relative frequency contributes to 6.49% followed by relative density of 7.66% and relative dominance of 3.88%. Ageratum conyzoides L. was found highly frequent with frequency value of 25.71% and highest density i.e. 78.93 among its associates. Heteropogon contortus Beauv. had the highest abundance value of 7.06. The herbaceous layer in Himalayan Subtropical Pine Forest was dominated by Cynodon dactylon Pers. with highest IVI value of 23.07 (7.69%) of which the major share is contributed by relative density value of 10.82% followed by relative frequency of 12.17% and relative abundance of 0.08%, respectively. Cynodon dactylon Pers. also possessed the highest frequency...
and density values of 88% and 185, respectively, whereas *Arenaria serpyllifolia* L. was found abundant among its associates with abundance value of 4.66 (Table - 2).

### 4. Discussion

Though a number of studies have been undertaken on composition, structure and diversity of vegetation in different regions of the state, hardly a few studies pertaining to herbaceous stratum are available. As a result our understanding of various aspects of herbaceous species distribution is far from adequate in this part of Himalayas. The edaphic conditions, topography, weather and seasonal pattern coupled with unregulated man-made disturbances have greatly influenced the pattern and distribution of ground layer in Kandi Siwaliks. Several factors as lower altitude, habitat heterogeneity, resource availability, disturbance levels, moderate fragmentation together with stochastic factors like random climatic variability, fluctuations to resources and dispersal limitation may influence the vegetation composition (Connell, 1989; Whitmore, 1998; Dalling et al., 2002; Fajardo & Alaback, 2005 and Shaheen et al., 2011).

The recorded diversity values (H’) of 3.40 to 3.66 lie more or less within the reported range of 0.83 to 4.0 for Himalayas (Singh et al., 1981 & 1984 and Gupta & Kumar, 2014). Present study revealed the changing patterns of herbaceous vegetation composition, diversity and structure in different forest communities. Northern dry mixed deciduous forests occupying 27.3% of the study area exhibited maximum species richness and diversity. Similar trends were obtained in middle and higher elevations in a sub-tropical forest in Arunachal Pradesh by Rana & Gairola (2010).

Maximum species richness of 135 was found in Northern dry deciduous forest. Similar trends were also noted in case of diversity values to the tune of H’ = 3.66 for Subtropical dry deciduous forest, 3.55 for Himalayan subtropical scrub and 3.40 in case of Himalayan subtropical Pine forest. The values of the present study are in consonance to the values reported for different subtropical forest types by many workers viz., Singh et al. (1984 & 1985), Jha and Singh (1990), Parthasarthy et al. (1992), Visalakshi, (1995), Pandey and Shukla (1999), Gautam et al. (2008), Sagar et al. (2008), Krishnamurthy et al. (2010), Rana and Gairola (2010), Tynsong & Tiwari (2011), Sagar et al. (2012), Gairola and Soni (2013), Gunaga et al. (2013) and Mandal & Joshi (2014). The concentration of dominance (Simpson’s index) in the present study sites were within the reported range (0.10-1) for tropical dry forests by other workers (Negi et al., 2002; Kukreti & Negi, 2004; Gautam et al., 2008; Gupta & Kumar, 2014 and Mandal & Joshi, 2014).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Species</th>
<th>Northern dry mixed deciduous forest</th>
<th>Himalayan subtropical dry scrub</th>
<th>Himalayan subtropical Pine forest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Density (Trees Ha⁻¹)</td>
<td>Basal Area (m²)</td>
<td>SIV (%)</td>
</tr>
<tr>
<td>1</td>
<td>Cynodon dactylon Pers.</td>
<td>105.13</td>
<td>0.00028</td>
<td>12.75</td>
</tr>
<tr>
<td>2</td>
<td>Oxalis corniculata L.</td>
<td>104.05</td>
<td>0.0005</td>
<td>8.05</td>
</tr>
<tr>
<td>3</td>
<td>Crotalaria prostrata Rottl.</td>
<td>19.72</td>
<td>0.0003</td>
<td>10.27</td>
</tr>
<tr>
<td>4</td>
<td>Dichanthium annulatum Stapf.</td>
<td>107.29</td>
<td>0.0013</td>
<td>10.99</td>
</tr>
<tr>
<td>5</td>
<td>Poa annua L.</td>
<td>93.24</td>
<td>0.0040</td>
<td>9.34</td>
</tr>
<tr>
<td>6</td>
<td>Malvastrum coromandelianum Earcke</td>
<td>56.48</td>
<td>0.0028</td>
<td>7.25</td>
</tr>
<tr>
<td>7</td>
<td>Parthenium hysterophorus L.</td>
<td>52.70</td>
<td>0.0017</td>
<td>6.81</td>
</tr>
<tr>
<td>8</td>
<td>Agretum conyoides L.</td>
<td>35.40</td>
<td>0.0073</td>
<td>6.50</td>
</tr>
<tr>
<td>9</td>
<td>Anagallis arvensis L.</td>
<td>49.45</td>
<td>0.0011</td>
<td>6.39</td>
</tr>
<tr>
<td>10</td>
<td>Tridax procumbens L.</td>
<td>52.16</td>
<td>0.0006</td>
<td>6.18</td>
</tr>
<tr>
<td>11</td>
<td>Cyperus rotundus L.</td>
<td>79.72</td>
<td>0.0002</td>
<td>6.04</td>
</tr>
<tr>
<td>12</td>
<td>Amanthus viridis L.</td>
<td>29.45</td>
<td>0.0049</td>
<td>4.89</td>
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<tr>
<td>13</td>
<td>Apluda mutica L.</td>
<td>24.59</td>
<td>0.007</td>
<td>4.68</td>
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<tr>
<td>14</td>
<td>Ipomea carnea Jack.</td>
<td>20.27</td>
<td>0.012</td>
<td>4.47</td>
</tr>
<tr>
<td>15</td>
<td>Cardiopterum halicacabum</td>
<td>22.24</td>
<td>0.012</td>
<td>4.45</td>
</tr>
<tr>
<td>16</td>
<td>Saussurea heteromalla Hand-Maz.</td>
<td>25.13</td>
<td>0.0054</td>
<td>4.22</td>
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<tr>
<td>17</td>
<td>Aspidotypos wallichii Hook.</td>
<td>10.0</td>
<td>0.014</td>
<td>4.18</td>
</tr>
<tr>
<td>18</td>
<td>Solanum erianthum Don.</td>
<td>0.81</td>
<td>0.0191</td>
<td>4.08</td>
</tr>
<tr>
<td>19</td>
<td>Verbascum thapsus L.</td>
<td>8.64</td>
<td>0.014</td>
<td>3.87</td>
</tr>
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<td>20</td>
<td>Gomphrena celosioides Mart.</td>
<td>13.51</td>
<td>0.011</td>
<td>3.74</td>
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<td>21</td>
<td>Heteropogon contortus Beauv.</td>
<td>29.45</td>
<td>0.0021</td>
<td>3.69</td>
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<td>Sida alba L.</td>
<td>22.43</td>
<td>0.0062</td>
<td>3.57</td>
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<tr>
<td>23</td>
<td>Commelina benghalensis L.</td>
<td>27.83</td>
<td>0.0002</td>
<td>3.54</td>
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<td>24</td>
<td>Cannabis sativa L.</td>
<td>42.79</td>
<td>0.0023</td>
<td>3.53</td>
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<td>25</td>
<td>Rosa brumonii Lindl.</td>
<td>2.43</td>
<td>0.0153</td>
<td>3.42</td>
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<td>26</td>
<td>Euphorbia hirta L.</td>
<td>22.43</td>
<td>0.0025</td>
<td>3.35</td>
</tr>
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<td>27</td>
<td>Cryptolepis buchananii Roem &amp; Sch.</td>
<td>8.91</td>
<td>0.01</td>
<td>3.24</td>
</tr>
<tr>
<td>28</td>
<td>Boerhavia diffusa L.</td>
<td>24.05</td>
<td>0.0013</td>
<td>3.23</td>
</tr>
<tr>
<td>29</td>
<td>Solanum surattense Burm.f</td>
<td>9.45</td>
<td>0.009</td>
<td>3.19</td>
</tr>
<tr>
<td>30</td>
<td>Triandetia rhomboidea Jacq.</td>
<td>13.78</td>
<td>0.0054</td>
<td>3.14</td>
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<tr>
<td>31</td>
<td>Carthamus oxycahth M.Bieb.</td>
<td>6.21</td>
<td>0.0128</td>
<td>3.10</td>
</tr>
</tbody>
</table>
The Peilou’s evenness Index varied from 0.67 to 0.84 whereas, the Sheldon’s evenness Index ranged from 0.29 to 0.62. Similar results have been obtained in the studies conducted in other parts of Himalayas (Behera et al., 2002; Feroz et al., 2008; Tynsong & Tiwari, 2011 and Gupta & Kumar, 2014). In several studies it has been observed that the species diversity in highest in the herb layer among all forest strata and it bears a marked influence on the establishment of higher strata. Slobodkin and Sanders (1969) opined that species richness of any community is a function of severity, variability and predictability of the environment in which it develops. Therefore, diversity tends to increase as the environment becomes more favourable and more predictable (Putman, 1994). The study therefore, concludes that northern dry mixed deciduous forests revealed maximum herb species richness and diversity which is attributed to congenial environmental factors, moderate disturbance and edge effect along the forest fringes.

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References


