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FLORISTIC DIVERSITY AND VEGETATION STRUCTURE OF THE REMNANT SUBTROPICAL BROAD LEAVED FORESTS FROM KABAL VALLEY, SWAT, PAKISTAN

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Abstract

Under the prevailing anthropogenic and deteriorating environmental conditions, subtropical broad leaved forests in Pakistan are vanishing at a rapid pace. Muslim communities living in rural areas pay great respect and sanctity to the graveyards and avoid interference with the natural vegetation in these sites. The relics of the natural climax plant communities can be seen in the Muslim graveyards of almost every village of Kabal valley, Swat. Little attention has been given to the significance of cultural norms and religious beliefs in conserving phytodiversity. The present endeavor was undertaken to quantify the existing phytodiversity from the studied area during 2010 to 2014. Species and environmental data from 40 *relevés* measuring 10 x 10 m size laid in different Muslim graveyards was stored in TURBOVEG and exported to JUICE for analysis through Two Way Hierarchical Cluster Analysis and Canonical Correspondence Analysis (CCA). The vegetation comprised of an association dominated by *Olea ferruginea* and *Celtis eriocarpa* with five distinct communities based on floristic components and environmental variables. Soil moisture, pH, phosphorus, organic matter content and altitude were the main determining factors in establishing these plant communities. The vegetation was stratified with the highest tree layer (17.48±2.94m), shrub layer (1.85±0.28m) and herb layer (65.25±17.79cm). The canopy covered the area about 84.38±11.83%, of which tree layer shared 69.25±16.15%, shrub layer 37.63±11.43% and herb layer56.50±11.72%. In all, 229 vascular plant species were recorded from the sampled area. Mean species richness was 28.83±6.69, followed by Shannon index (2.59±0.32), Simpson index (0.85±0.06) and evenness index (0.78±0.07). The significance of indigenous peoples' beliefs and taboos in biodiversity conservation has been discussed in the paper.

Key words: Subtropical vegetation, Muslim graveyards, Kabal valley, Swat, Phytodiversity, Conservation.

Introduction

The forest area of Pakistan is very limited, covering only 4.8 percent of total land area, which is far below the optimal standard of 25%, forest cover for a country. However, meager forests of Pakistan are rich in biodiversity and present a unique blend of tree, shrub and herb species, living across various ecological zones including subtropical forests. Subtropical forests are found in the lower reaches of Himalaya, Hindukush and Sulaiman Ranges between 600-1700 m above sea level (Champion *et al*., 1965). These forests are subdivided into subtropical broad-leaved forest and subtropical pine forests. Broad leaved forests grow in the lower most range between 600-1000 m, and consists of drought tolerant species like *Olea ferruginea*, *Celtis eriocarpa* and *Acacia modesta*. These forests cover fairly large area of about 1,191,000 ha (Hussain & Ilahi, 1991). In spite of their significant contribution in national economy, the forest resources of Pakistan are under severe threat of deforestation due to various reasons and are declining at an alarming rate of 1.5% annually (Khan & Khan, 2009). Subtropical forests being easily accessible are almost vanishing in various parts of Pakistan (Hussain *et al*., 1992) and their remnants are seen in conserved form in the Muslim graveyards of the country (Stewart, 1972t; Chaghtai *et al.*, 1983; Ahmad *et al*., 2009; Ali *et al.*, 2017).

In every religion, there are some sacred places for which care is taken, sanctity given and kept out from external disturbances. The Muslim graveyards are one of such places. The soil of graveyards is fertile due to the decomposition of human bodies. The places are undisturbed as a result; plant can grow at their will. The management and growing types of plants depends upon the socio-economic pattern of the area (Rahman *et al*., 2007). Sacred groves in the graveyards are forest patches conserved by the local people intertwined with their socio-cultural and religious practices. These groves harbor rich biodiversity, represent the climax vegetation and play a significant role in the conservation of biodiversity. Indigenous cultural and ritual practices of the local people in sacred groves serve as a tool for conserving biodiversity (Anthwal *et al*., 2006).

The role of sacred groves and Muslim graveyards in the conservation of biodiversity has long been recognized (Chaghtai *et al*., 1983; Hussain *et al*., 1993; Khan *et al*., 1997; Ahmad *et al*., 2009). Rich floristic and vegetation diversity has been reported from the graveyards and cemeteries in various parts of the world (Uslu *et al*., 2009; Frosch & Diel, 2011; Shah & Rozina, 2013; Rahman, 2013; Hadi *et al*., 2014, Molnar *et al*., 2017).

Almost every village in Kabal valley of district Swat has a patch of the original remnant subtropical broad leaved forest represented in the Muslim graveyards, but little scientific attention has been given to the conserved areas. The present study is designed to document the existing floristic diversity and to quantify the ecological status of this vegetation type highlighting the underlying environmental variables and identifying the significance of cultural beliefs in conservation of biodiversity under climate change regime.

Materials and Methods

Study area: Kabal valley is part of Tehsil Kabal located in the North West of District Swat at about 15Km from Saidu Sharif, Khyber Pakhtunkhwa, Pakistan. It lies between 34°44′ to 34°57′North latitude and72°08′ to 72°20′ East longitude in Swat district. The Muslim graveyards are located between 861 to 1620meters from the mean sea level. The soils of the valley are alluvial and fertile (Hussain & Ilahi, 1991) supporting a variety of crops, vegetables and fruit orchards. Natural vegetation of the area is sub-tropical broad leaved forests (Champion *et al*., 1965).

Sampling: Stratified random sampling was used to collect data from the Muslim graveyard vegetation during 2010 to 2014. Species minimal area/number curve rule (Hussain, 1989) was used to determine the plot (*relevé*) size and number (Fig. 1). A total of 40*relevés* measuring 10 X 10 meters were studied. Plant specimens were collected and preserved on standard herbarium sheets. In each *relevé*, cover-abundance values were recorded according to the modified method of Braun-Blanquet (Barkman *et al.*, 1964). Height of herbs and shrubs was measured directly by using a measuring tape, while height of trees was determined according to Brower *et al*. (1998). One kilogram soil sample was collected from each *relevé*. Geographic coordinates, altitude, exposure, and slope gradient were recorded using Global Positioning System (GPS).

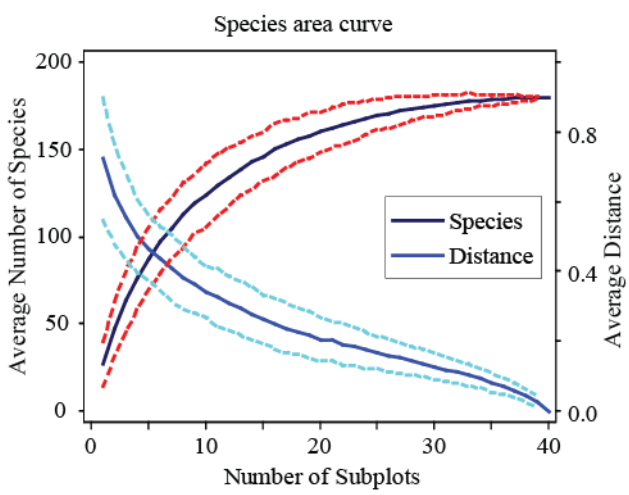

Fig. 1. Species minimal area curve.

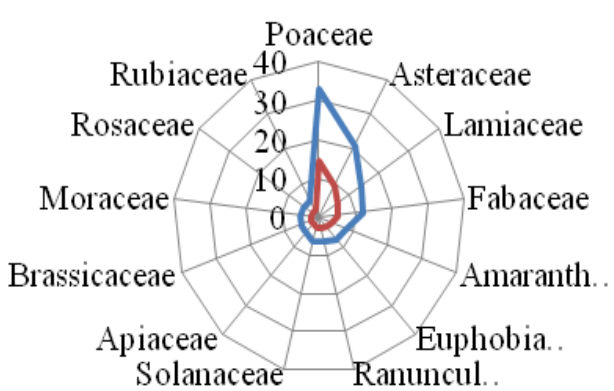

Fig. 2. Number and percentage of largest families.

Table 1. Floristic composition.

Group	Families	Genera	Species
Pteridophytes	2	4	6
Gymnosperms	1	1	1
Monocotyledons	11	37	45
Dicotyledons	56	139	177
Total	70	181	229

Data storage and analysis: The soil texture was determined by the hydrometer method as described by Koehler *et al.* (1984). The pH was determined in 1:5 soil water suspension using the pH meter (Mclean, 1982). $CaCO_3$ was determined byacid neutralization method (Black, 1965). The soil organic matter was determined by using standardized solution of$FeSO_4$ and $K_2Cr_2O_7$ as given by Nelson & Sommers (1982). AB-DTPA or Mehlic No.3 extractable P and K was determined in samples on the basis of pH of soil samples. Plant specimens were identified according to Flora of Pakistan (Nasir & Ali, 1970-1989; Ali & Nasir, 1989-1991; Ali & Qaiser, 1993-2017). Species richness, Simpson index, Shannon-Wiener diversity index and Evenness index were calculated according to Singh *et al.* (2008). Data from 40*relevés* was stored in the database software TURBOVEG, V. 2.101, (Hennekens & Schaminee, 2001) and exported as standard XML files to JUICE, V. 7.0.99 (Tichý, 2002). The data was classified using Two Way Hierarchical Cluster Analysis in PC-ORD, V. 6 (McCune & Mefford, 1999) through JUICE platform to create realistic species-*relevé* associations. Threshold levels of fidelity, frequency and cover were set as 30-60, 30-60 and10-50 respectively for identifying diagnostic, constant and dominant species of each group in the synoptic table at $p \leq 0.05$. The plant communities were named after two or three species having highest fidelity/constancy values. Canonical Correspondence Analysis (CCA) was performed in CANOCO (V. 4.5) for windows (Ter Braak & Smilauer, 2002) to observe the relationship between species, *relevés* and environmental variables.

Results

Floristic enumeration: Overall, 229 species of vascular plants belonging to 70 families and 181 genera were recorded from the sampled area. Among them, 6 species of 4 genera and 2 families belonged to Pteridophytes, one species of Gymnosperm, 45 species distributed in 37 genera and 11 families belonged to monocotyledons; while 177 species of 139 genera and 56 families belonged to dicotyledons (Table 1). Poaceae (32 spp.), Asteraceae (21 spp.), Lamiaceae (14 spp.), Fabaceae (12 spp.), Amaranthaceae (8 spp.), Euphorbiaceae (7 spp.), Ranunculaceae, Solanaceae (6 spp. each), Apiaceae, Brassicaceae, Moraceae, Rosaceae and Rubiaceae (5 spp. each) were the largest families (Fig. 2), while rests of the families were represented by less than 4 species. *Amaranthus* (5 spp.), *Euphorbia*, *Galium* (4 spp. each), *Artemisia*, *Quercus*, Poa, *Veronica*, *Solanum* and *Celtis* (3 spp. each) were the largest genera (Table 2).

Table 2. Synoptic table of plant communities from Muslim graveyards of Kabal valley, Swat, Pakistan.

Number	1	2	3	4	5
Abbreviated community name	PCL*	DMJ	FMV	AZ	BV
No of *relevés*	7	14	8	3	8
No of species	94	132	85	45	122
Geographic position of communities					
Longitude° East	72.16-72.34	72.22-72.28	72.26-72.34	72.25-72.26	72.26-72.28
Latitude° North	34.83-34.94	34.81-34.87	34.76-34.84	34.73-34.74	34.82-34.86
Altitude (Meters) M.S.L.	1087-1628	1000-1201	871-1064	842-861	963-1101
Physiognomic features of communities					
Total cover %	77.9±11.5	82.1±14.9	86.2±10.2	90.0±0.0	90.0±6.5
Tree cover %	62.7±11.3	65.0±20.9	71.2±16.4	73.3±11.5	78.5±5.8
Shrub cover %	27.1±13.8	35.7±7.6	43.7±9.2	50.0±0.0	39.4±12.0
Herb cover %	40.0±14.1	60.4±8.9	56.2±5.8	58.3±2.9	63.7±6.9
Unidentified Mosses cover %	2.0±1.5	2.7±1.7	1.1±0.8	0.7±0.6	3.2±1.6
Unidentified lichens Cover %	1.0±0.8	1.4±0.5	1.0±0.8	1.7±0.6	1.7±0.4
Average height highest trees (Meters)	19.3±3.8	15.4±2.1	16.7±2.0	20.7±1.1	19.0±1.8
Average height lowest trees (Meters)	8.7±0.9	8.9±1.9	8.5±1.6	7.0±0.0	10.0±1.5
Average height Highest shrubs (Meters)	1.6±0.2	1.8±0.4	2.0±0.0	2.0±0.0	2.0±0.0
Average height lowest shrubs (Meters)	0.6±0.1	0.6±0.2	0.5±0.0	0.5±0.0	0.5±0.0
Average height highest herbs (centimeters)	55.7±16.0	65.4±18.2	64.4±17.6	73.3±20.8	71.2±18.3
Average height lowest herbs (centimeters)	5.4±2.1	4.6±1.2	5.9±2.6	10.0±0.0	6.9±2.6
Edaphic features of communities					
Clay %	8.5±5.0	12.2±3.1	13.7±2.8	18.9±0.9	10.5±1.3
Silt %	51.9±10.7	40.1±5.9	51.0±12.3	51.5±0.5	38.8±6.4
Sand %	39.6±12.6	46.3±6.2	35.2±12.2	29.6±1.0	49.4±7.7
Moisture %	30.6±2.3	35.4±3.5	31.7±4.3	22.0±1.0	34.6±2.9
pH	6.7±0.9	7.2±0.4	7.2±0.2	7.9±0.1	7.1±0.3
$CaCO_3$ %	6.2±1.2	8.1±6.1	6.7±1.0	15.2±1.6	4.2±1.4
Organic Matter %	3.4±1.1	1.9±0.8	2.9±1.2	1.5±0.2	1.9±0.6
Nitrogen %	0.2±0.0	0.1±0.0	0.1±0.0	0.07±0.0	0.1±0.0
Phosphorus (ppm)	8.8±10.1	18.0±10.5	14.0±11.7	2.7±2.3	20.5±9.9
Potassium (ppm)	252.0±39.1	399.6±112.0	339.4±206.2	118.3±37.5	410.9±89.6
Constant species of Association					
1. *Olea ferruginea*	100---	100---	100---	100---	100---
2. *Celtis eriocarpa*	43---	71---	75---	100---	100---
3. *Cynodon dactylon*	57---	64---	75---	67---	25---
Characteristic species of communities (Frequency^{Fidelity})					
4. *Pinus roxburghii*	**100** ^{100}	-	-	-	-
5. *Cotoneaster racemiflorus*	**71**---	71---	50---	-	25---
6. *Leucas lanata*	**43** $^{61.8}$	-	-	-	-
7. *Daphne mucronata*	-	**100** $^{81.1}$	25 ---	67 ---	-
8. *Maytenus royleanus*	-	**100** $^{81.1}$	-	-	50 ---
9. *Justicia adhatoda*	-	**71** $^{47.1}$	50 ---	-	25 ---
10. *Ficus palmata*	-	43 ---	**100** $^{68.1}$	-	-
11. *Melia azedarach*	-	14 ---	**100** $^{68.1}$	-	50 ---
12. *Acacia modesta*	-	-	75 $^{62.9}$	**100** $^{52.8}$	-
13. *Ziziphus nummularia*	-	-	-	**100** ^{100}	-
14. *Bosea amherstiana*	-	43---	50 ---	-	**100** $^{55.3}$
15. *Vitex negundo*	29---	57---	**100**---	100---	**100**---
Other species					
16. *Girardinia palmata*	29 $^{49.8}$	-	-	-	-
17. *Cotoneaster nummularia*	29 $^{49.8}$	-	-	-	-
18. *Andrachne cordifolia*	29 $^{49.8}$	-	-	-	-

Table 2. (Cont'd.).

Number	1	2	3	4	5
19. *Adiantum capillus-veneris*	29 49.8	-	-	-	-
20. *Ajuga parviflora*	29 49.8	-	-	-	-
21. *Adiantum incisum*	29 49.8	-	-	-	-
22. *Berberis lycium*	29 49.8	-	-	-	-
23. *Pellaea nitidula*	29 49.8	-	-	-	-
24. *Diospyros lotus*	29 49.8	-	-	-	-
25. *Ficus sarmentosa*	29 49.8	-	-	-	-
26. *Desmostachya bipinnata*	29 49.8	-	-	-	-
27. *Quercus dilatata*	29 49.8	-	-	-	-
28. *Impatiens brachycentra*	29 49.8	-	-	-	-
29. *Jasminum officinale*	29 49.8	-	-	-	-
30. *Rumex hastatus*	57 42.8	29 ---	-	-	-
31. *Pistacia chinensis* subsp.*integerrima*	43 42.3	14 ---	-	-	-
32. *Dichanthium annulatum*	29 ---	64 54.9	12 ---	-	-
33. *Lespedeza juncea*	-	29 45.4	-	-	-
34. *Origanum vulgare*	-	21 38.8	-	-	-
35. *Brachiaria reptans*	-	21 38.8	-	-	-
36. *Sedum hispanicum*	-	21 38.8	-	-	-
37. *Quercus baloot*	14 ---	29 35.7	-	-	-
38. *Artemisia capillaris*	14 ---	29 35.7	-	-	-
39. *Jasminum humile*	14 ---	29 35.7	-	-	-
40. *Morus nigra*	-	-	75 57.7	-	25 ---
41. *Verbena officinalis*	-	-	50 49.0	-	-
42. *Dicliptera bupleuroides*	-	57 ---	100 45.2	-	62 ---
43. *Rubus fruticosus*	-	14 ---	50 37.5	67 ---	-
44. *Astragalus candolleanus*	14 ---	-	-	100 100	-
45. *Asparagus adscendens*	29 ---	7 ---	-	100 85.4	-
46. *Ajuga bracteosa*	29 ---	-	-	67 80.6	-
47. *Datura stramonium*	-	-	-	67 80.6	-
48. *Teucrium stocksianum*	-	-	-	67 80.6	-
49. *Cymbopogon jwarancusa*	-	-	-	67 80.6	-
50. *Salvia moocroftiana*	-	-	25---	100 75.3	-
51. *Otostegia limbata*	-	14---	-	100 75.3	-
52. *Euphorbia prostrata*	-	-	12---	67 64.0	-
53. *Conyza bonariensis*	-	7---	-	67 53.8	12 ---
54. *Plantago lanceolata*	-	-	50 ---	100 52.8	25 ---
55. *Cynoglossum lanceolatum*	-	-	38 ---	100 49.3	12 ---
56. *Lepidium apetalum*	-	-	12 ---	67 46.6	25 ---
57. *Sorghum halepense*	14---	-	12 ---	67 46.6	12 ---
58. *Ailanthus altissima*	-	14---	50 ---	100 46.2	25 ---
59. *Acrachne racemosa*	-	-	-	-	38 56.9
60. *Corchorus olitorius*	-	-	-	-	38 56.9
61. *Polygonum aviculare*	29---	-	-	-	50 49.0
62. *Digitaria violascens*	14---	-	-	-	25 45.9
63. *Sonchus oleraceus*	-	-	-	-	25 45.9
64. *Broussonetia papyrifera*	-	-	-	-	25 45.9
65. *Cleome viscosa*	-	-	-	-	25 45.9
66. *Asplenium adiantum-nigrum*	-	-	-	-	25 45.9
67. *Galinsoga parviflora*	-	-	-	-	25 45.9
68. *Calendula arvensis*	-	-	-	-	25 45.9
69. *Echinochloa colona*	-	-	-	-	25 45.9
70. *Brachiaria ramosa*	-	-	12---	-	38 45.8
71. *Physalis divaricata*	-	7---	-	-	38 45.8

Table 2. (Cont'd.).

Number	1	2	3	4	5
72. *Iris germanica*	-	7---	12---	-	38 37.8
73. *Amaranthus retroflexus*	-	29---	-	-	50 37.5
74. *Malvastrum coromendelianum*	-	14---	75 41.9	-	75 41.9
75. *Morus alba*	-	-	50 37.5	-	50 37.5
76. *Bromus pectinatus*	-	14---	12 ---	-	-
77. *Nepeta govaniana*	14---	-	-	-	-
78. *Geranium collinum*	-	7---	-	-	12 ---
79. *Barleria cristata*	29---	14---	-	-	-
80. *Vicia monantha*	14---	21---	-	33 ---	-
81. *Crepis multicaulis*	14---	-	-	-	-
82. *Chenopodium ambrosioides*	14---	-	25 ---	-	25 ---
83. *Clematis graveolens*	-	-	-	-	-
84. *Aegopodium alpestre*	14---	-	-	-	-
85. *Arisaema flavum*	14---	-	-	-	-
86. *Piptatherum munroi*	14---	-	-	-	-
87. *Bothriochloa bladhii*	-	7---	-	-	-
88. *Pseudomertensia parvifolia*	14---	-	-	-	-
89. *Viola canescens*	14---	-	-	-	-
90. *Solanum villosum*	-	14---	-	-	12 ---
91. *Stachys parviflora*	-	7---	-	-	-
92. *Punica granatum*	14---	14---	-	-	-
93. *Indigofera linifolia*	-	14---	-	-	-
94. *Lathyrus hirsutus*	-	-	12 ---	-	-
95. *Euphorbia hirta*	-	7---	-	-	-
96. *Eryngium coeruleum*	-	7---	-	-	-
97. *Torilis japonica*	-	-	-	33---	-
98. *Urtica dioica*	14---	7---	-	-	-
99. *Micromeria biflora*	-	29 ---	-	67---	-
100. *Melilotus indica*	-	7---	12 ---	-	-
101. *Indigofera heterantha v. gerardiana*	-	14 ---	-	-	-
102. *Ipomoea eriocarpa*	-	-	-	-	12 ---
103. *Ixiolirion tataricum*	-	7 ---	-	-	-
104. *Coronopus didymus*	14---	-	-	-	-
105. *Oenothera rosea*	-	7 ---	-	-	12 ---
106. *Hypericum perforatum*	14 ---	-	-	-	-
107. *Spiraea canescens*	14---	-	-	-	-
108. *Adonis aestivalis*	-	-	12 ---	-	-
109. *Gagea pakistanica*	14---	14---	-	-	-
110. *Withania somnifera*	29---	14---	-	-	-
111. *Solanum pseudo-capsicum*	-	-	-	-	12 ---
112. *Dodonaea viscosa*	29---	14 ---	-	67 ---	-
113. *Quercus incana*	14---	-	-	-	-
114. *Boerhavia procumbens*	-	-	12 ---	-	-
115. *Rosularia adenotricha*	-	7 ---	-	-	-
116. *Heteropogon contortus*	14---	-	-	-	-
117. *Arnebia decumbens*	-	7 ---	12 ---	-	-
118. *Periploca aphylla*	-	14 ---	-	-	-
119. *Sageretia thea*	-	14 ---	-	-	-
120. *Neslia apiculata*	-	7 ---	12 ---	-	-
121. *Cornus macrophylla*	-	14 ---	-	-	-
122. *Ranunculus muricatus*	-	7 ---	-	-	-
123. *Pennisetum orientale*	14---	7 ---	-	-	-
124. *Convolvulus arvensis*	-	-	12 ---	-	-

Table 2. (Cont'd.).

Number	1	2	3	4	5
125. *Carpesium abrotanoides*	-	-	12 ---	-	25 ---
126. *Lamium amplexicaule*	14---	7 ---		-	-
127. *Galium acutum*	-	-	12 ---	-	-
128. *Bromus oxyodon*	-	7 ---	-	-	-
129. *Amaranthus hybridus*	14---	7 ---	-	-	-
130. *Trifolium repens*	-	7 ---	-	-	-
131. *Filago hurdwarica*	-	-	-	-	-
132. *Heracleum canescens*	14---	-	-	-	-
133. *Poa infirma*	14---	7---	-	-	-
134. *Galium aparine*	-	36---	12 ---	33 ---	38---
135. *Brachypodium distachyon*	-	14---	-	-	25---
136. *Narcissus tazetta*	14---	36---	38---	-	50---
137. *Ceratocephala falcata*	14---	-	-	-	-
138. *Veronica persica*	14---	29---	12---	-	38 ---
139. *Solanum nigrum*	14---	21---	-	67 ---	38---
140. *Chrozophora tinctoria*	-	7---	-	-	-
141. *Arenaria serpyllifolia*	-	7---	-	-	-
142. *Anagallis arvensis*	-	14---	-	-	25---
143. *Stellaria media*	29---	29---	38---	33---	38---
144. *Celtis tetrandra*	29---	29---	25---	-	-
145. *Isodon rugosus*	14---	14---	-	-	-
146. *Geranium rotundifolium*	-	21---	12---	33---	38---
147. *Salvia plebeia*	-	7---	-	-	25---
148. *Galium elegans*	-	7---	-	-	-
149. *Cannabis sativa*	14---	7---	38---	67---	38---
150. *Fallopia dumetorum*	14	-	-	-	-
151. *Clematis grata*	29---	-	-	-	25---
152. *Veronica hederifolia*	14---	7---	-	-	25---
153. *Fumaria indica*	-	-	38---	100 ---	38---
154. *Malva neglecta*	-	-	25---	-	12---
155. *Carpesium cernuum*	-	7---	25---	-	25---
156. *Oxalis corniculata*	43---	50---	50---	-	62---
157. *Conyza canadensis*	14---	-	25---	33---	38---
158. *Setaria viridis*	14---	29---	25---	-	50---
159. *Artemisia vulgaris*	-	-	12---	-	25---
160. *Phyllanthus fraternus*	-	7---	12---	67---	25---
161. *Anchusa arvensis s. orientalis*	29 ---	14 ---	-	-	25 ---
162. *Ziziphus jujuba*	-	29---	-	-	25---
163. *Colchicum luteum*	14 ---	29---	38---	-	25---
164. *Poa annua*	14 ---	29---	12---	33 ---	50---
165. *Lolium temulentum*	-	7---	-	33 ---	25---
166. *Veronica polita*	-	7---	-	-	25---
167. *Sigesbeckia orientalis*	-	-	12---	-	12---
168. *Celtis caucasica*	-	43---	25---	-	25---
169. *Achyranthes aspera*	-	64---	50---	100---	62---
170. *Lathyrus aphaca*	-	-	-	33---	12---
171. *Piptatherum gracile*	-	29---	12---	33---	50---
172. *Rumex dentatus*	29---	7---	25---	-	12---
173. *Rubia cordifolia*	-	7---	12---	-	12---
174. *Medicago polymorpha*	14---	36---	38---	33---	38---
175. *Chenopodium album*	-	29---	38---	-	50---
176. *Vicia sativa*	-	7---	25---	-	38---
177. *Bidens biternata*	14---	21---	25---	-	38---

Table 2. (Cont'd.).

Number	1	2	3	4	5
178. *Apluda mutica*	14---	21---	12---	-	38---
179. *Scandix pecten-veneris*	14---	29---	38---	67---	25---
180. *Artemisia scoparia*	-	7---	12---	-	25---
181. *Tulipa clusiana*	-	36---	12---	33---	50---
182. *Alliaria petiolata*	-	29---	50---	33---	50---
183. *Eleusine indica*	-	7---	12---	-	25---
184. *Ceterach dalhousiae*	29---	43---	-	-	25---
185. *Taraxacum officinale*	29---	29 ---	-	-	38---
186. *Scilla griffithii*	29---	29 ---	50---	-	50---
187. *Pelargonium zonale*	14---	29 ---	25---	-	25---
188. *Euphorbia helioscopia*	-	7---	-	-	25---
189. *Galium divaricatum*	-	-	-	-	12---
190. *Cerastium glomeratum*	-	14---	-	33 ---	12---
191. *Poa bulbosa*	14 ---	14---	25 ---	-	12---
192. *Digera muricata*	-	7---	-	-	12 ---
193. *Onopordum acanthium*	-	-	25 ---	-	12---
194. *Sclerochloa dura*	-	7---	-	-	12---
195. *Eragrostis cilianensis*	-	-	-	-	12---
196. *Ranunculus arvensis*	14 ---	-	12 ---	-	12---
197. *Amaranthus spinosus*	-	14---	-	-	12---
198. *Dactyloctenium aegyptium*	-	7---	-	-	12---
199. *Arthraxon prionodes*	14 ---	29---	-	-	12---
200. *Allium ampeloprasum* var. *porrum*	-	21 ---	25 ---	-	-
201. *Zanthoxylum armatum*	14---	14 ---	-	-	-
202. *Amaranthus graecizans*	-	14 ---	-	-	-
203. *Viola betonicifolia*	-	7 ---	-	-	-
204. *Myrsine africana*	14---	-	-	-	-
205. *Papaver pavoninum*	-	-	12---	-	-
206. *Nanorrhinum vamosissimum*	14---	-	-	-	-
207. *Moraea sisyrinchium*	-	21 ---	25---	-	-
208. *Amaranthus viridis*	29---	21 ---	38---	-	25---
209. *Commelina benghalensis*	14---	7 ---	38---	-	25---
210. *Duchesnea indica*	14 ---	-	-	-	12---
211. *Xanthium strumarium*	-	7 ---	25 ---	-	25---
212. *Brachypodium sylvaticum*	-	-	-	-	12---
213. *Mirabilis jalapa*	-	-	-	-	12---
214. *Cichorium intybus*	-	7 ---	-	-	12---
215. *Thlaspi arvense*	-	-	25 ---	-	25---
216. *Melilotus alba*	-	-	-	-	12---
217. *Digitaria sanguinalis*	-	-	-	-	12---
218. *Euphorbia peplus*	-	-	-	-	12---
219. *Papaver hybridum*	-	-	-	-	12---
220. *Portulaca oleracea*	-	-	-	-	12---
221. *Notholirion thomsonianum*	-	-	-	-	12---
222. *Cyperus rotundus*	-	7---	12 ---	-	12---
223. *Sinapis alba*	-	-	-	-	12---
224. *Eclipta prostrata*	-	-	-	-	12---
225. *Asplenium trichomanes*	29---	43---	-	-	25---
226. *Clinopodium vulgare*	-	-	-	-	12---
227. *Tagetes minuta*	14---	-	-	-	12---
228. *Setaria pumila*	-	-	12 ---	-	12---
229. *Avena fatua*	-	14---	-	-	12---

*1. PCL: *Plectranthus-Cotoneaster-Leucas* community, 2. DMJ: *Daphne-Maytenus-Justicia* community, 3. FMV: *Ficus-Melia-Vitex* community, 4. AZ: *Acacia-Ziziphus* community, 5. BV: *Bosea-Vitex* community

Vegetation classification: Two Way Hierarchical Cluster Analysis (taking Euclidean distance as distance measure and Ward's method as group linkage parameter) showed that the vegetation comprised Olea-Celtis-Cynodon association with five communities (Table 2; Fig. 3).

Olea-Celtis-Cynodon association: Synoptic table showing constancy and fidelity values of species which are significant at $p \leq 0.05$ after the Fischer test as shown in Table 2. *Olea ferruginea* was the dominant species in the community with constancy of 100%, followed by *Celtis eriocarpa* (43 to 100% constancy) and *Cynodon dactylon* (25 to 75% constancy) represented in all graveyards. The average height of highest tree layer in the association was 17.5±2.9 meters, and the lowest one was 8.8±1.7 meters. The height of highest shrub layer was 1.8±0.3 meters with the lowest one of 0.6±0.1 meters; while, in the case of herbs, highest layer was 0.7±0.2 meters with the lowest ones was 0.06±0.02 meters. The soil of the association was loam in nature with the composition of 12.1±4.0% clay, 46.0±10.0% silt and 42.3±10.7% sand. The average pH of soils was 7.1±0.5with 32.6±4.8% moisture with $CaCO_3$ content of 7.3±4.5%, Potassium 343.0± 144.9ppm, Phosphorus 14.9±11.1ppm and Nitrogen 0.12±0.06%. The organic matter of the soils was recorded as 2.3±1.1% (Table 2). The overall diversity indices for the association depicted Shannon-Wiener index as 2.59, Simpson index as 0.85 and evenness index as 0.78 (Table 4). Depending upon the floristic composition and microhabitat differences, following five sub-variant plant communities were recognized.

***Pinus-Cotoneaster-Leucas* (PCL) community:** This community is based on 7 *relevés* that contained 94 species. The community occurs at higher elevation between 1087-1628m from above mean sea level. Besides, *Olea ferruginea* (100%), *Celtis eriocarpa* (43%) and *Cynodon dactylon* (57%), *Pinus roxburghii* (100%), *Cotoneaster racemiflorus* (71%) and *Leucas lanata* (43%) were the constant species in this community. Other important species with fidelity values were *Pistacia chinensis* subsp. *integerrima*(42.3), *Quercus dilatata*, *Diospyros lotus*, *Berberis lycium*, *Cotoneaster nummularia*, *Jasminum officinale*, *Andrachne cordifolia*, *Girardinia palmata*, *Adiantum capillus-veneris*, *Adiantum incisum*, *Ajuga parviflora*, *Desmostachya bipinnata*, *Impatiens brachycentra*, *Pellaea nitidula* (49.8 each) and *Rumex hastatus*(42.8). Shannon-Wiener index was 2.37, Simpson index was 0.82 and evenness index was 0.80. The soil of this community was silt loam with pH 6.7±0.9 and 30.6% moisture. The average $CaCO_3$was 6.2±1.2% with3.4±1.1% organic matter, 0.2±0.0% Nitrogen, 8.8±10.1ppm Phosphorus and 252.9±39.1ppm Potassium. Total vegetation cover was lowest i.e.77.9±11.5% with 62.7±11.3% tree layer, 27.1±13.8% shrub layer, 40.0±14.1% herb layer, 2.0±1.5% moss layer and 1.0±0.8% lichen layer (Fig. 6). The average height of highest tree layer was 19.3±3.8m with the ones 8.7±0.9m.The highest shrub layer was 1.6±0.2m while the lowest one 0.6±0.1m. In the case of highest herb layer, it was 55.7±16.0cm with the lowest at that of 5.4±2.1cm (Fig. 7).

***Daphne-Maytenus-Justicia* (DMJ) community:** This community contained 132 plant species recorded from 14 *relevés*. The community is situated on middle elevations between 1000 to1201m. The constant species with percentage frequency for this community were *Daphne mucronata* (100%) *Maytenus royleanus* (100%) and *Justicia adhatoda* (71%). Other associates were *Cotoneaster racemiflorus* (71), *Achyranthes aspera*, *Cynodon dactylon*, *Dichanthium annulatum* (64 each), *Dicliptera bupleuroides*, *Vitex negundo* (57each), *Oxalis corniculata* (50), *Celtis caucasica*, *Ficus palmata*, *Bosea amherstiana*, *Asplenium trichomanes*, *Ceterach dalhousiae* (43 each), *Galium aparine*, *Medicago polymorpha*, *Narcissus tazetta* and *Tulipa clusiana* (36 each). Shannon-Wiener index was 2.55, Simpson index was 0.84 and evenness index was recorded as 0.83. The community is found on loam soil with good moisture content of 35.4±3.5% and a pH of 7.2±0.4. The soil contained 8.1±6.1% $CaCO_3$, 1.9±0.8% organic matter, 0.1±0.0% nitrogen, 18.0±10.5ppm phosphorus and 399.6±112.0ppm potassium. Total vegetation cover was 82.1±14.9% with contribution of tree layer 65.0±20.9%, shrub layer 35.7±7.5%, herb layer 60.4±8.9%, moss layer 2.7±1.7% and lichen layer 1.4±0.5%. Height of highest tree layer was lowest compared to other communities i.e. 15.4±2.1m, lowest tree layer was 8.8±1.9m, highest shrub layer was 1.8±0.4m, lowest shrub layer was 0.6±0.2m, highest herb layer was 65.4±18.2cm and lowest herb layer was at 4.6±1.2cm.

Table 4. Diversity indices of communities and association.

Communities	No. of *Relevés*	No. of species	Diversity indices		Evenness
			Shannon-Wiener	Simpson	Pielou
PCL*	7	94	2.37	0.82	0.80
DMJ	14	132	2.55	0.84	0.83
FMV	8	85	2.76	0.89	0.86
AZ	3	45	2.71	0.88	0.83
BV	8	122	2.65	0.84	0.83
Over all	40	229	2.59	0.85	0.78

*See Table 2 for names of communities

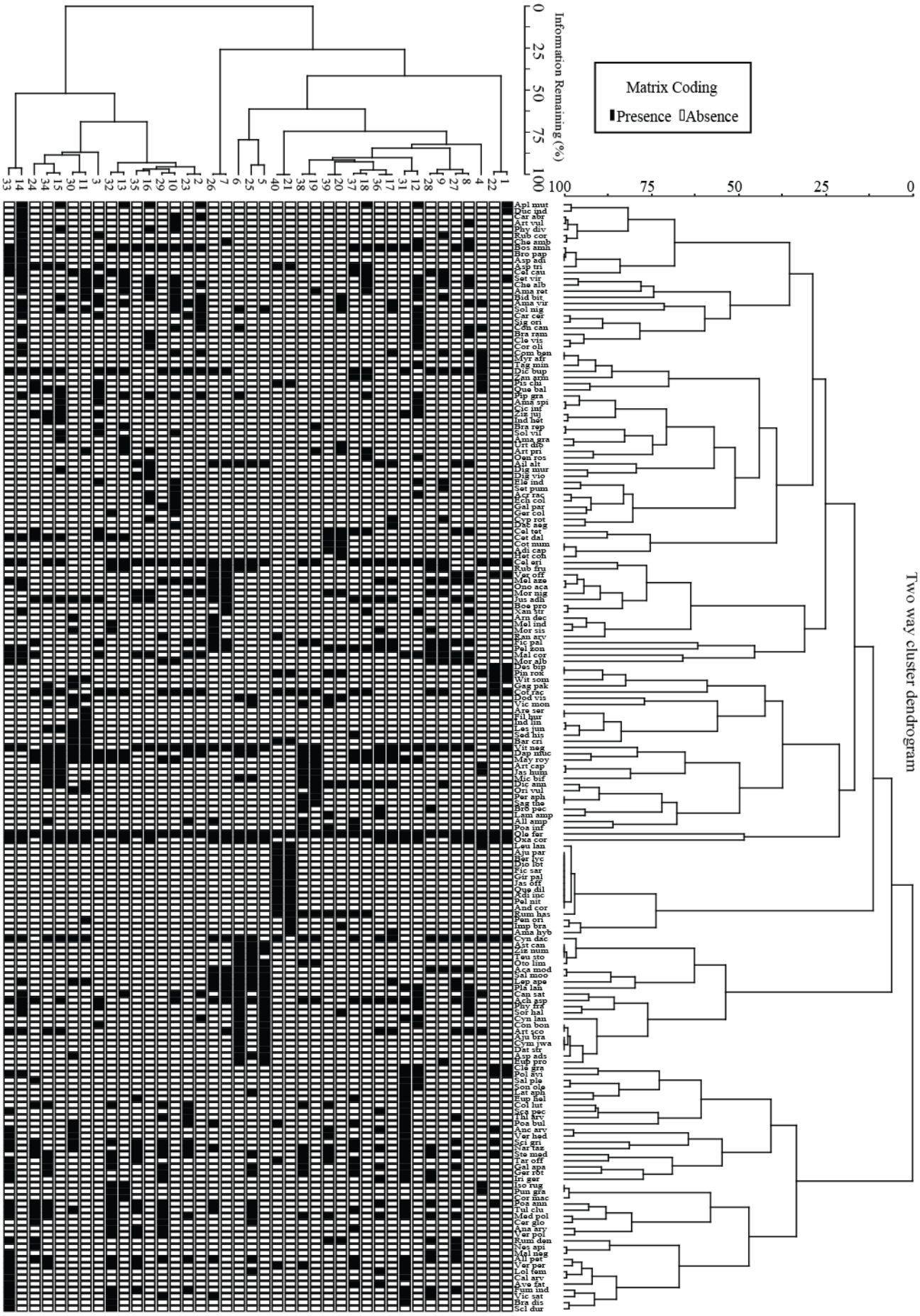

Fig. 3. Two way hierarchical cluster dendrogram of species and samples.

***Ficus-Melia-Vitex* (FMV) community:** This community type contained 85 plant species recorded in 8 *relevés*. The community occupied altitudinal range between 871 to1064m. The community occurred on silt loam soil with 31.7±4.3% moisture and slightly alkaline pH (i.e. 7.2±0.2). $CaCO_3$ content of the soil was 6.7±1.0%, organic matter 2.9±1.2%, nitrogen 0.1±0.0%, phosphorus 14.0±11.7ppm and potassium 339.4±206.2ppm. Diversity indices were highest for this community type. Shannon-Wiener index was 2.76, followed by Simpson index (0.89) and evenness index (0.86). Characteristic species with constancy values were *Ficus palmata* (100%), *Melia azedarach* (100%) and *Vitex negundo* (100%). Other common species include *Dicliptera bupleuroides* (100), *Acacia modesta, Morus nigra, Malvastrum coromendelianum* (75 each), *Ailanthus altissima, Morus alba, Bosea amherstiana, Cotoneaster racemiflorus, Justicia adhatoda, Rubus fruticosus, Achyranthes aspera, Alliaria petiolata, Oxalis corniculata, Pelargonium zonale, Plantago lanceolata,Verbena officinalis* (50 each), *Artemisia scoparia,Amaranthus viridis, Cannabis sativa, Chenopodium album, Commelina benghalensis, Fumaria indica, Lepidium apetalum, Medicago polymorpha, Narcissus tazetta, Poa annua* and *Stellaria media* (38 each). Total cover was 86.2±10.2%, tree layer was 71.2±16.4%, shrub layer 43.7±9.2%, herb layer 56.2±5.8%, moss layer 1.1±0.8% and lichen 1.0±0.8%. In this stratified community, highest tree layer was 16.7±2.0m with the 8.5±1.6m lowest tree layer, highest shrub layer 2.0±0.0m with0.5±0.0m lowest shrub layer and highest herb layer was 64.4±17.6cm with 5.9±2.6cms the lowest ones.

***Acacia-Ziziphus* (AZ) community:** Based on the species data from 3 *relevés*, this community comprised of 45 species. The community in present at lower altitudes between 842 to 861m. The soils were silt loam with 22.0±1.0% moisture, which is comparatively drier in nature. The soil was alkaline with pH 7.9±0.1 containing 15.2±1.6% $CaCO_3$, 1.5±0.2% organic matter, 0.07±0.0% nitrogen, 2.7±2.3ppm phosphorus and 118.3±37.5% potassium. Shannon-Wiener diversity index was calculated as 2.71, Simpson index as0.88 and evenness index as0.83. Total vegetation cover was 90.0%, tree layer covered 73.3±11.5%, shrub layer covered 50.0%, herb layer covered 58.3±2.9%, unidentified mosses covered 0.7±0.6%, while unidentified lichens covered 1.7±0.6%. This community was dominated by *Acacia modesta* (100%) and *Ziziphus nummularia* (100%). Other associates in this community include *Daphne mucronata, Dodonaea viscosa, Rubus fruticosus, Artemisia scoparia, Ajuga bracteosa*; *Cannabis sativa, Conyza bonariensis, Cymbopogon jwarancusa, Cynodon dactylon, Cynoglossum lanceolatum, Datura stramonium, Euphorbia prostrata, Micromeria biflora, Phyllanthus fraternus, Solanum nigrum, Sorghum halepense, Teucrium stocksianum* (67 each), *Alliaria petiolata, Cerastium glomeratum, Conyza canadensis, Galium aparine, Geranium rotundifolium, Lathyrus aphaca, Lolium temulentum, Medicago polymorpha, Piptatherum gracile, Poa annua, Stellaria media, Torilis japonica, Tulipa clusiana* and *Vicia monantha* (33 each). The community was clearly stratified with highest tree layer at 20.7±1.1m with the lowest (7.0±0.0m), highest shrub layer at 2.0±0,0m with the lowest at 0.5±0.0m, highest herb layer at 73.3±20.8cms with the lowest as10.0±0.0cms. Average tree height was highest in this community.

***Bosea-Vitex* (BV) community:** This community was represented in 8 *relevés* that contained 122 plant species. Altitudinal ranges of this community were 963 to1101m. The soils were loamy with slightly alkaline pH (7.1±0.3) containing 34.6±2.9% moisture. $CaCO_3$was 4.2±1.4% with 1.9±0.6% organic matter, 0.1±0.0% nitrogen, 20.5±9.9ppm phosphorus and 410.9±89.6ppm potassium. Potassium content of soil was highest in this community. For this community, Shannon-Wiener index was determined as 2.65, Simpson index as 0.84 and evenness index as 0.83. *Bosea amherstiana* (100) and *Vitex negundo* (100) characterised this community. Other important species were *Malvastrum coromendelianum* (75), *Achyranthes aspera, Dicliptera bupleuroides, Oxalis corniculata* (62 each), *Melia azedarach, Morus alba, Maytenus royleanus, Alliaria petiolata, Amaranthus retroflexus, Chenopodium album, Narcissus tazetta, Piptatherum gracile, Poa annua, Polygonum aviculare, Scilla griffithii, Setaria viridis, Tulipa clusiana* (50 each), *Acrachne racemosa, Apluda mutica, Bidens biternata, Brachiaria ramosa, Cannabis sativa, Conyza canadensis, Corchorus olitorius, Fumaria indica, Galium aparine, Geranium rotundifolium, Iris germanica, Medicago polymorpha, Physalis divaricata, Solanum nigrum, Stellaria media, Taraxacum officinale, Veronica persica* and *Vicia sativa* (38 each). Total vegetation cover was 90.0±6.5%, tree layer covered 78.5±5.8%, shrub layer covered 39.4±12.0%, herb layer covered 63.3±6.9%, mosses covered 3.2±1.6%; while lichens covered 1.7±0.4%. Height of highest tree layer was 19.0±1.8m with the lowest as 10.0±1.5m, highest shrub layer was 2.0±0.0m with the lowest as 0.5±0.0m and the highest herb layer was 71.2±18.3cms with the lowest as 6.9±2.6cms.

Vegetation ordination: The corelation of environmental variables distributed along the vegetation in the natural plant communities of Kabal valley analysed through canonical correspondence analysis is shown in Table 3 and Figs. 4 and 5. Environmental data is responsible for 62.5% variation in the data set with 499 runs of permutation test (p=0.001). Explained fitted commulative variation along axis 1 is 24.76and along axis 2 is 40.75. Along axis 1, organic matter, nitrogen content of soil and altitude were positively corelated revealing strong factors, while pH and clay content of soil were strongly negatively corelated. Along axis 2, slope gradient and silt content of the soil has a strong influence on species and sample distribution. Influence produced by potassium, phosphorous, moisture and $CaCO_3$ was weak. Species like *Desmostachya bipinnata, Pinus roxbughii, Duchesnia indica* and *Clematis grata*were favoured by slope gradient and silt content. *Diospheros lotus, Ficus sarmentosa, Quercus dilatata, Adiantum incisum* and *Berberis lycium*were positively affected by organic matter, nitrogen and altitude along axis 1.

Table 3. Canonical correspondence analysis.

Statistic	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	0.6711	0.4336	0.3855	0.2217
Explained variation (cumulative)	15.46	25.45	34.33	39.44
Pseudo-canonical correlation	0.9911	0.9879	0.9689	0.934
Explained fitted variation (cumulative)	24.76	40.75	54.98	63.15
Permutation Test Results:				
On All Axes	pseudo-F=2.7, P=0.001			
Total variation:	4.34030			
Explanatory variables account for:	62.5%			

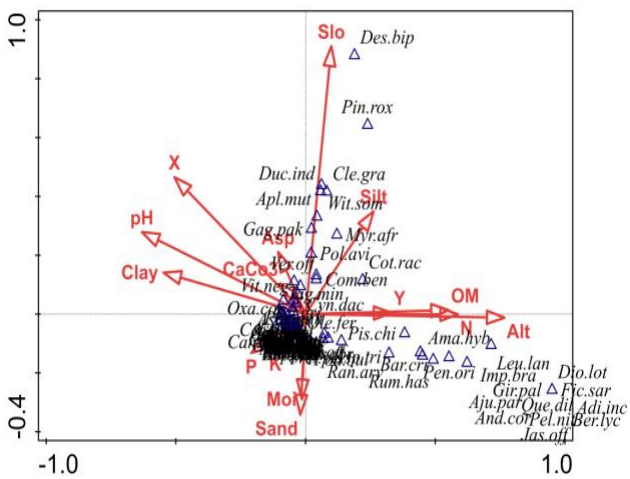

Fig. 4. CCA biplot of species and environmental variables.

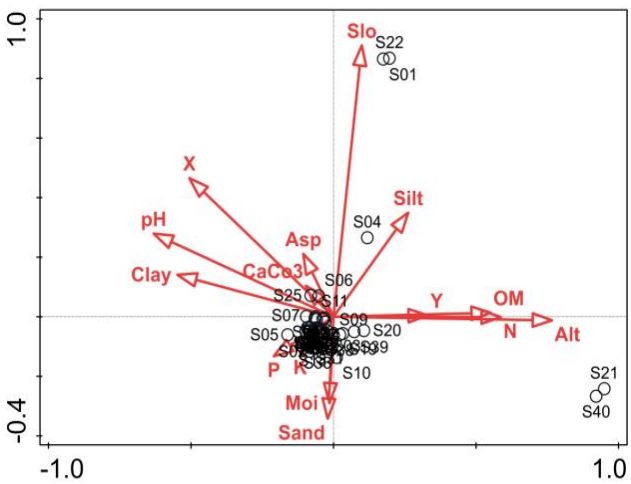

Fig. 5. CCA biplot of samples and environmental data.

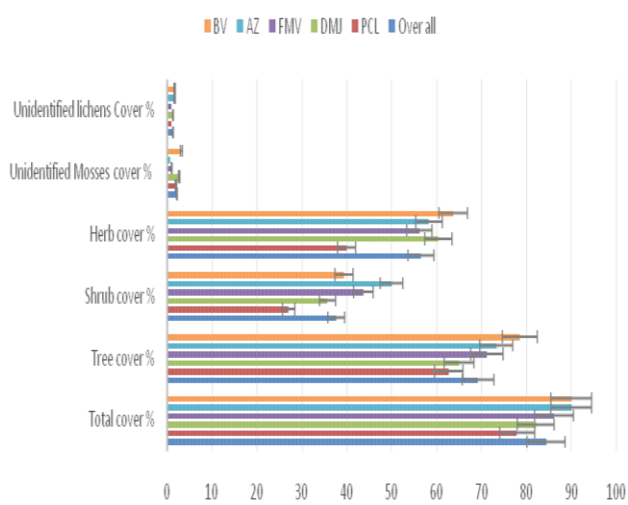

Fig. 6. Percentage coverage of different vegetation layers.

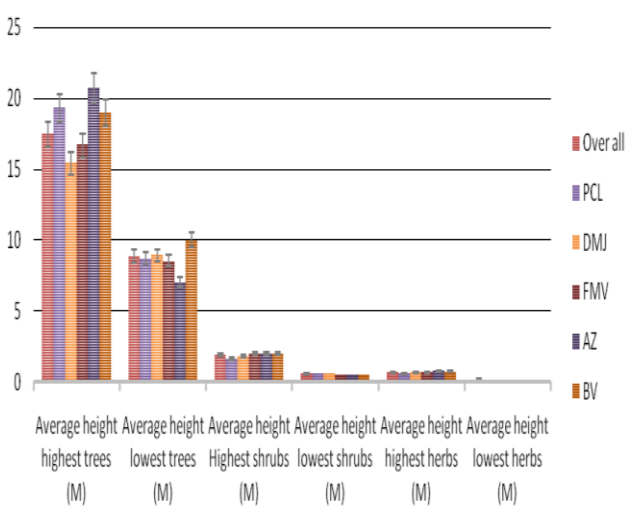

Fig. 7. Average height of different vegetation layers.

Discussion

The subtropical forests of Pakistan are easily accessible and almost vanishing (Hussain *et al*., 1992) due to excessive human intervention in the form of clearing forests for cultivation, buildings construction and over exploitation for daily needs. The dearth of fully protected areas is so serious that scientists feel contended with studying comparatively less disturbed areas to get an insight into the natural vegetation of an area (Chaghtai *et al*., 1883). Muslim graveyards were considered to be the most protected places by Champion *et al.* (1965), Stewart (1972) , Chaghtai *et al.* (1983), Hussain *et al*. (1993) and Ahmad *et al*. (2009), thus regarded as ideal for studying natural vegetation of an area. The people of Kabal valley are religious and pay a great respect to the saints and dead ones. In almost every village, a piece of land is specified as graveyard for burial of their dead ones. As a mark of respect, the people refrain from cutting and chopping trees and bushes and do not let their cattle to graze in the graveyards (Chaghtai *et al*., 1983). Due to least intervention, relics of the natural sub-tropical broad leaved

forests are represented in these graveyards. The overall vegetation belonged to an association dominated by *Olea ferruginea*, *Celtis eriocarpa* and *Cynodon dactylon*. *Olea ferruginea* has been reported as dominant in graveyards of Dir district (Ahmad *et al*., 2009), Malakand (Khan *et al*., 2015; Ali *et al*., 2017), Swabi district (Hussain *et al*., 1993) and Kohat district (Chaghtai *et al*., 1983). *Celtis* remained dominant in Dir (Ahmad *et al*., 2009), while *Cynodon dactylon* remained a dominant herb layer species in Swabi (Hussain *et al*., 1993) and Kohat (Chaghtai *et al*., 1983) districts. Though not in a dominant status,*Olea ferruginea* and *Cynodon dactylon* are reported from the areas outside graveyards (Hussain *et al*., 1997; Ilyas *et al*., 2012, 2015), but species like *Bosea amherstiana*, *Vitex negundo*, *Piptatherum gracile* and *Colchicum luteum* are now confined only to these protected sites. This indicates that developing various strategies for biodiversity conservation is important for today's critically degraded environment, and there is a growing recognition that the effective conservation of biodiversity will depend on the long-term participation and understanding of local communities (Hongmao *et al*., 2002). By limiting human activity at sacred sites, many traditional societies serendipitously protected biodiversity there as well. New research shows that religion can still be a powerful force for conservation today (Pretty *et al*., 2009).

As shown in Table 4, the recorded average diversity of communities ($H' = 2.5 \pm 0.32$) is comparatively higher compared with investigations carried in other areas (Dad, 2016). It indicates that lowering biotic interference has a positive effect on biodiversity indices. A high biotic disturbance has been also reported to disturb the natural balance of vegetation communities and prevent them from attaining maturity (Saxena & Singh, 1982). The vegetation of all the communities was stratified with distinct tree, shrub and herb layers. Differences in dominant species were due to changes in edaphic and other environmental factors (Hussain *et al*., 1993; Ahmad *et al*., 2016; Khan *et al.,* 2016).

A high species environment correlation and high cumulative percentage of variance reflected that the measured environmental variables used in CCA explained a major part of gradient variation. An analysis of these variables reflected that these operate at different levels to influence the vegetation structure. As shown by CCA ordination (Figs. 4 & 5), altitude and organic matter content particularly influential, while steepness of slope and other edaphic factors like soil pH and moisture were also important. Previous studies have also shown that along an altitudinal gradient, many ecological, biological and historical factors affect species distribution (Colwell & Lees, 2000; Ilyas *et al.,* 2015; Dad, 2016; Khan *et al*., 2016; Ali *et al*., 2017). In our study, with few exceptions, plant species with differing altitudinal locations were perfectly associated along this gradient. Along this gradient, topography represented by steep slope appears to be responsible particularly for the distribution of *Pinus-Cotoneaster-Leucas* community. Previous studies have also reported slope steepness (Zhang, 2002) and soil moisture (Ahmad *et al.,* 2016) as important influencing factors for the species distribution.

The phenomenon of conservation of sacred groves is as old as human civilization in which a group of plant or individual plants are protected by the local communities by giving them sacred status on the basis of religious faith (Bhagwat *et al*., 2011; Saini *et al*., 2011). The idea that indigenous people and other small-scale societies were exemplary conservationists, gained widespread currency in academic circles (Smith &Wishnie, 2000). The indigenous conservationism has often been attributed to a spiritual respect for and a practical understanding of the natural world (Martinez, 1996; Negi, 2010). Evidence offered in support of this characterization includes culturally expressed conservation ethics and the relatively higher richness of biodiversity found within graveyards (Gadgil *et al*., 1993; Alcorn, 1996; Bernbaum, 2006; Negi, 2005, 2010). In traditional societies, sustainable natural resource management is driven by the beliefs and behaviors of human communities, and local cultures are strengthened by their intimate connections to the natural environment that sustains them (Rist *et al.,* 2003).

Under the prevailing climate regime compounded by severe over exploitation of biological resources, plant biodiversity is under threat. There is emerging recognition that the diversity of life comprises both biological and cultural diversity (Pretty *et al.,* 2009). Community conserved areas including sacred groves and patches of vegetation on Muslim graveyards constitute the oldest form of protected areas. The maintenance of cultural diversity into the future, and knowledge, innovations and outlooks increase the capacity of human systems to change (Hongmao *et al*., 2002; Pretty *et al.,* 2009). Keeping the significance of religion, faith and cultural norms, we strongly recommend that future policy programs should address both cultural and biological diversity in a two-pronged strategy for conserving biodiversity.

Conclusion

Despite of the high anthropogenic pressure in the adjoining areas, patches of remnant sub-tropical forests are preserved in Muslim graveyards. A major plant association along with five communities is recognized in the area controlled by edaphic and topographic factors. Local communities coupled with cultural norms, religious beliefs and taboos should be used for conserving phytodiversity of the area.

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