Pak. J. Bot., 52(2): 601-612, 2020. DOI: http://dx.doi.org/10.30848/PJB2020-2(17)

DIVERSITY AND ABUNDANCE OF CLIMBERS IN RELATION TO THEIR HOSTS AND ELEVATION IN THE MONSOON FORESTS OF MURREE IN THE HIMALAYAS

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Abstract

Climbers play diverse roles in the biology of forests. Climber species due to its fragile nature are sustible to any change in the forests. Knowledge about climber species in the forests is relatively inadequate and this is the first effort to report the climber plant species in Pakistan. Ecological methods were used to find out climbers abundance, distribution and their relationship with trees/ shrubs in five 1-ha plot range of 735 m to 1754 m elevation at sea level at five localities viz., Baroha, Ghoragali, Numbal, Patriata and Salgaran in the Murree Forests in Western Himalaya, Pakistan during the year of 2016-2017. An overall 3400 climbing plants belonging to 23 species, 19 genera and 13 families were identified and described. Apocynaceae (22%) was the most leading family followed by Ranunculaceae (13%) Rosaceae (13%) and Menispermaceae (9%). Based on our findings the climber species are classified into four classes based on their habit/ form as well. The dominant class was represented by twining climbing mode (43%) followed by woody (30.4%) and hook mode (22%) while tendrils (4.3%) were rare. The abundance and distribution of climber plants were affected by parameters like biotic factors (collection pressure, grazing pressure and No. of hosts) and abiotic factors (topographic and edaphic). Canonical Corresponding Analysis (CCA) indicated that grazing and collection pressures along with elevation were the most important factors influencing the distribution and abundances of climbers. Documentation of the climbers is imperative in the context of increasing forest disturbances, deforestation and fragmentation of forest habitat. Current study will lead towards many other detail studies on climbers in near future.

Key words: Climbers; Diversity; Abundance; Climbing mode; Ordination; Monsoon Forests; Himalaya.

Introduction

Plants having distinct structure to climb on hosts are termed as climbers. Climbers are mostly fixed in the soil but need support for their weak stem. They compete strongly with large trees and shrubs for light, space as well as nutrients (Richards, 1952). Climber plants play significant ecological role in nutrients cycling, forests dynamics and hence establish an essential tropic level within an ecosystem very few studies have been done on climbers. Kokou *et al*., (2002) divided the climbers in to three categories namely climbing vines, climbing shrubs and woody climbing plants (lianas). Climbing vines are generally herbaceous type in sprawling growth habit like runners. Vines are not able to reach the mature forest canopy due to weak nature. Climbing shrubs climb without clingy tendrils or roots. Cracks in the bark of fibrous barked trees support these shrub climbers to climb. Lianas are mostly woody and may reach to the crown of forest trees (Jongkind & Hawthorne, 2005). Specific structure, dynamics and functions of vegetation and ecosystem is influenced by Lianas (Burns & Dawson, 2005), the occurrence and abundance of which is more important in moist tropical forest (Hegarty, 1991).

A considerable number of vascular plant families comprise climbing species. Vitaceae and Hippocrateaceae families' are almost climbers; their axes have condensed groups of subsidiary tissue which are extremely light demanding (Hegarty, 1991; Schnitzer & Carson, 2001). There is another group of climbers called Lianas beside the soft tissues. They possess a considerable amount of supporting tissues allowing them to climb over the large trees. Woody climbers (Lianas) are intact structural parasites (Stevens, 1987); defending on other plants for support. Differences in climbing approaches, dispersal and phenological approaches help in distribution gaps and allow effective resource dividing between the climber species (Oldeman, 1990). Four major characteristics i.e., high growth rates, roots lateral growth, propagation through seed and production of branches play vital role in the colonization of climbers in forest and boundaries of forest clearing. In the diversity of tropical forest 25 % of woody plants total diversity is contributed by Lianas (Schnitzer & Carson, 2001) and yet are frequently unnoticed in many forest records and in forest ecological practices (Phillips *et al*., 2005). The overall low care to lianas is most possibly owing to problems in restricting individuals whole lower minimum size of populations and general absence of taxonomic studies that possibly led to in the elimination of liana in many records. The climbers will be the first to reduce in the silviculturally managed forests therefore, they are the most threatened group of plants, and need to be documented both qualitatively and quantitatively.

Climbers show great variety in their mechanism of climbing (Bongers *et al*., 2005; Jongkind & Hawthorne, 2005). These include root climbers, branch twiner, stem twiner, scramblers, tendril climber and hook/thorn climbers. The most common in the forest edges are the tendril climbers, where the common support is through smaller thread like structures called tendrils, than in forest insides (Putz & Holbrook, 1991). On the other hand stem and branch twiners are more consistently spread in later staged successional forests (Dewalt *et al*., 2000).

Climbing or veining has impact on a magnificent economy of the nature. It permits plant to reach full disclosure to sunlight, nutrients and water with least expenditure in vegetation support. They add sustainability to cover shutting after fall of tree and help to equalize the micro-climate beneath. Forest plant diversity specifically added by Lianas give valuable niche and contacts amongst tree covers which allow arboreal animal to cross the tree tops. At the time of shortage of fruits and flowers many climber species also contribute important share of the diet for numerous (Sarvalingam *et al*., 2015).

Since the era of consumers Darwin and his colleagues up to present climbing species have charmed plant scientists for centuries. The importance of lianas and vines for the world's ecosystems is under deep discussion, mainly for tropical and sub-tropical ecosystems. Climber studies are lacking with regarding in Pakistan but available in Indian forests, like the forests of Anamalais, Western Ghats (Eastern Ghats, Kalrayan hills) (Kadavul & Parthasarathy, 1999; Muthuramkumar & Parthasarathy, 2000; Srinivas & Parthasarathy, 2000).

It has been reported that the structure of host tree is important in the determination of climber association (Putz, 1980, 1984b; Muthuramkumar & Parthasarathy, 2001). Some of the host trees lack sites for attachment of climber species for eaxmple smooth barked trees will evade climber plant infestation (Putz, 1980; Putz, 1984b). Climber distribution is influenced by type and forest locality as well (Grubb, 1987; Balfour & Bond, 1993). Climbers play a major role in renewal forests ecosystem and biodiversity, carbon sequestration, entire-forest transpiration and controlling soil erosion (Klinge & Rodriguez, 1973; Putz, 1983). A climber also reduces the surrounding tree damage and further reduces 50% of the post-harvest canopy gaps (Appanah & Putz, 1984).

The distribution and abundance of climbers (lianas) are also apparently determined by biotic elements such as the architecture of hosts than by climate or soil factor (Balfour & Bond, 1993). For instance, previous study concluded that tall palms had less climber species rising into their crowns than shorter palms (Rich *et al*., 1987). Gardette (1998) reported that the major factors that contributed to a high species-richness or great abundance of climbers were the presence of many supports of different height classes and the proximity of climber parents. Dipterocarp species with clear long trunks and branches at about 25 meters from the ground were free from lianas. However, the presence of non-dipterocarp species in the surrounding areas as supporting forms may enhance the success of lianas to reach the canopy of dipterocarp species. If this commercial dipterocarp trees are harvested for timber production, it is anticipated that the forest floor will receive direct sunlight which will further enhance the growth of lianas.

Majority of the previous studies focused heavily on trees and shrubs and little consideration has been given to climber plants in spite of the various roles they play in ecosystems (Bongers *et al*., 2005) especially in Pakistan. Present study was therefore conducted with specific objectives to investigate the species composition, taxonomic diversity, climbing mechanism and abundance of climbers associated hosts (trees and shrubs) at different altitudes.

Materials and Methods

Study area: The current study was conducted in Murree (33°52′26.34″ N latitude and 73°23′42.21″ E longitude) forests. Murree is a famous hill station, situated in the northeast of Islamabad along the Islamabad-Kohala highway, 30 km. It is located in a sub-division of District Rawalpindi, Punjab province of Pakistan with an area of 37977 ha. It is situated on the southern grades of the Western Himalaya foothills, as they go up northeastwards. Its altitude ranges from 520 m–2,380 m. Murree is located in two ecological zones, i.e., "1) Blue pine or Kail zone" (Moist Temperate Coniferous Forests) and "2) Chir zone" (Subtropical Forests), casing a slight area of outer Himalayas (Fig. 1). Tree species in Murree forests mainly composed of *Pinus roxburghii* (Pine Chir), *Pinus wallichiana* (Blue Pine), *Aesculus indica* (Chestnut), *Quercus incana* W. Bartram, and Indian Olive (*Olea europaea* subsp. cuspidata.).

Sampling of Climbers: Five plots of 1 hectare (each 100 ×100 m^2) were established at five localities i.e., Baroha, Salgaran, Numbal, Ghoragali and Patriata between 735 m and 1754 meter above sea level (masl) in the Murree Forests, Western Himalayas Pakistan during the year of 2016-2017. Quadrats along transects were established on various slops of Murree forest at aforementioned stations. Quadrats size for trees, climbers and shrubs was kept 10 m × 10 m (Salzer & Willoughby, 2004; Hussain *et al*., 2019). Fifty (50) quadrats were placed in these total 5 localities by using Global Positioning System (GPS) (Khan *et al*., 2013a) as presented in the map (Fig. 2). Plants including climbers in each quadrat were counted, identified and the diameter at breast height (DBH≥1 cm) was taken for tree species (Muoghalu & Okeesan, 2005; Noreen *et al.,* 2019). Climbing mechanisms of climbers were also noted for each species (Putz, 1984).

Environmental variables i.e., collection pressure, elevation, grazing pressure, number of hosts, soil pH, electrical conductivity and habit were also recorded. Study areas were selected on the basis of elevation gradient (varying degree of altitude) and disturbance like forest clearing, human interference was observed. The selection of sites in increasing order of disturbance was based on the assessment of the intensity of anthropogenic (Low=1, High=2) and grazing pressures (Low=1, moderate=2 and High =3) in the forest area (Kumar & Ram, 2005). The plants were collected from each quadrat, labeled with tags, and pressed in the presser. Plants were poisoned by using 3 percent solution of Ethyl Alcohol and Mercuric Chloride. Plant specimens mounted on herbarium sheets of standard size (17.5 × 11.5 inch). All plant specimens were identified and confirmed with the help of available literature of the Flora of Pakistan (Nasir & Ali, 1971; Ali & Qaiser, 1995) and deposited in the Plant Ecology and Conservation Lab. at Department of Plant Sciences, Quaid-i-Azam University Islamabad.

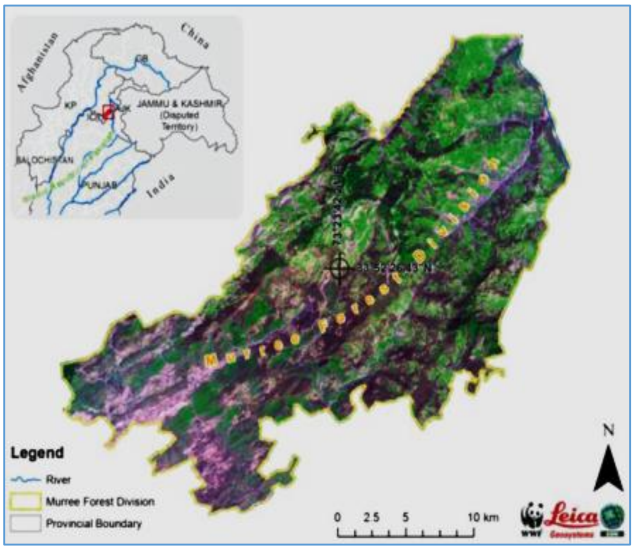

Fig. 1. Murree Forest Division – SPOT 5 Satellite Sensor bird's eye view.

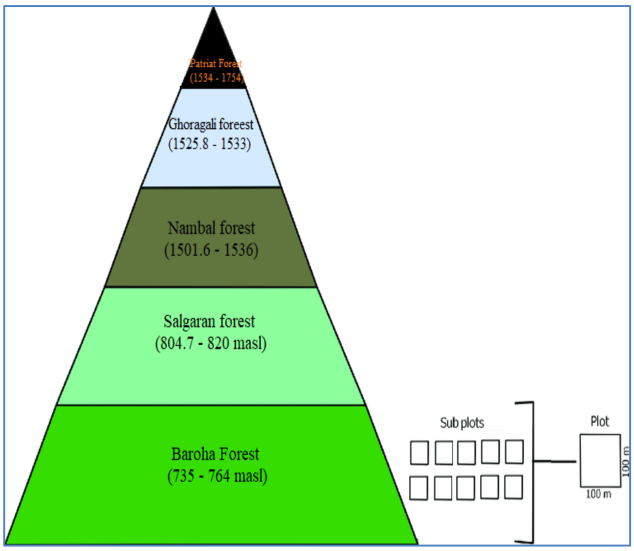

Fig. 2. Sampling design showing different elevations of 5 localities.

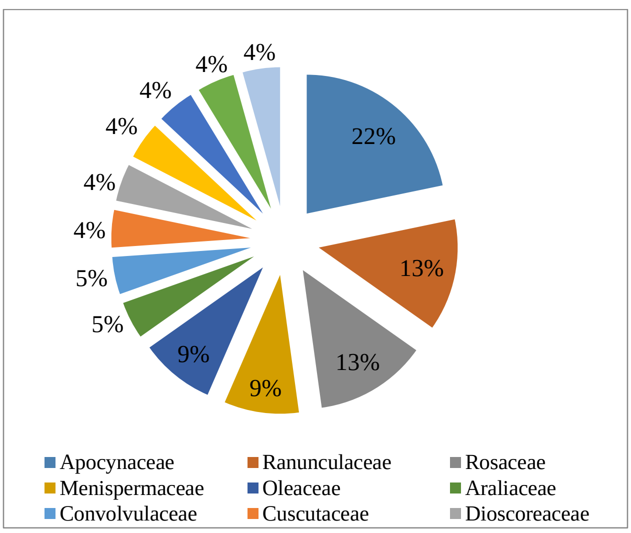

Fig. 3. Family wise distribution of climber plants.

Soil samples: Fifty soil samples for analyses were gathered up to 45 cm depth from all quadrats in five localities by soil sampling tube (Ahmad *et al*., 2016). The soil samples were cleaned from large particles. Electrical Conductivity (E.C) and pH of the soil was measured in Plant Ecology & Conservation Lab., Department of Plant Science, Quaid-i-Azam University, Islamabad-Pakistan via E.C and pH meter respectively (Koehler *et al*., 1984; Khan *et al*., 2016; Iqbal *et al*., 2018).

Analyses of data: The data was analyzed to assess the relationship between climber plant species with host and environmental variables. Species were classified according to climbing mode/ mechanism based on annotations in the field and consistent references (Putz, 1984). Data of 5 stations and 50 quadrats were put in MS EXCEL sheet. The quadrats data of climber species were organized as per software requisite (Lepš & Šmilauer, 2003). Cluster Analysis (CA) was performed through PCORD software (Bano *et al.*, 2018). The effect of environmental factors and host plant species was examined in CANOCO (4.5 software version) to indicate the climber species distribution and composition (Ahmad *et al*., 2019; Anwar *et al*., 2019; Khan *et al*., 2020).

Results

Floristic Composition: A total of 3400 climber individuals belonging to 23 species, 19 generas and 13 families on 4788 host individuals including trees and shrubs belonging to 20 species, 18 genera and 16 families were documented from Murree forests, Western Himalaya Pakistan (Table 1). The number and density of species within five localities varied (Table 2). The dominant family was Apocynaceae (22%) followed by Ranunculaceae (13%), Rosaceae (13%), Menispermaceae (9%), Oleaceae (9%), Convolvulaceae (5%), Araliaceae (5%), Dioscoreaceae, Leguminosae, Rubiaceae, Smilacaceae and Vitaceae with 4 % (Fig. 3).

The climber plants were classified into abundant (0.21 – 0.06 RA), moderately occurred (0.04 – 0.02 RA) and rare (0.01 RA) based on occurrence and relative species abundance (RA). The most abundant species was *Hedera nepalensis* accounting for 21% of total climber individuals with 0.21 relative abundance. The second most abundant climber was *Clematis grata* (16%), followed by *Jasminum humile* (12.65%), *Rosa macrophylla* (7.94%) and *Cuscuta reflexa* (6.47%). The rare climber species are *Rosa multiflora*, *Rubia cordifolia*, *Tylophora hirsuta* and *Tinospora malabarica* in terms of occurrence (Fig. 4).

There were 20 associated hosts (shrubs and trees) observed in the study areas. These hosts species are distributed over 18 generas and 16 families (Table 1).

Climber host relationship: Density of associated hosts (tree and shrub) was ranged from 711 to 1188 plants / hectare whereas climber density ranged from 460 to 950 plants / ha. The mean DBH with standard error of climbers varied from 7.3 $\pm$ 0.5 to 12.3 $\pm$ 0.4 cm in the studied plots. The highest number (950 individuals with 28%) of climber was supported by associated hosts in Patriata at highest elevation while lowest numbers (460 individuals with 13.5%) of climbers were supported by hosts in Baroha at lowest elevation. Density association analysis between climbers and hosts indicated that they were contrary to one another i.e. highest density (1188) of associated hosts only supported least density (460) of climber individuals at Baroha (Table 2).

Table 1. Associated climbers, host shrub and tree species.

S. No.	Plant species	Family	Habit
1.	*Aesculus indica* (Wall. ex Cambess.) Hook.	Hippocastinaceae	Tree
2.	*Arundo donax* L.	Poaceae	Shrub
3.	*Berberis lycium* Royle	Oleaceae	Shrub
4.	*Buxus wallichiana* Baill.	Buxaceae	Shrub
5.	*Carissa opaca* Stapf ex Haines	Apocynaceae	Shrub
6.	*Cedrus Deodara* (Roxb. ex D.Don) G.Don	Pinaceae	Tree
7.	*Dodonaea viscosa* (L.) Jacq.	Sapindaceae	Shrub
8.	*Justicia adhatoda* L.	Acanthaceae	Shrub
9.	*Lantana camara* L.	Verbenaceae	Shrub
10.	*Mallotus philippensis* (Lam.) Müll.Arg.	Euphorbiaceae	Shrub/ small tree
11.	*Maytenus royleanus* (Wall. ex Lawson)	Celastraceae	Shrub
12.	*Myrsine africana* L.	Myrsinaceae	Shrub
13.	*Olea ferruginea* Wall. ex Aitch.	Oleaceae	Shrub
14.	*Pinus roxburghii* Sarg.	Pinaceae	Tree
15.	*Pinus wallachiana* A.B.Jacks.	Pinaceae	Tree
16.	*Punica granatum* L.	Lythraceae	Shrub/ small tree
17.	*Quercus dilatata* Royle.	Fagaceae	Tree
18.	*Quercus incana* W. Bartram	Fagaceae	Tree
19.	*Salix spp.,*	Salicaceae	Tree
20.	*Viburnum grandiflorum* Wall. ex DC.	Caprifoliaceae	Shrub

Table 2. Climber and host species richness in terms of numbers of individuals in five localities of study area along its elevation gradient.

Parameters/Hectare	Baroha (735-764)	Salgaran (804.7-820)	Numbal (1501.6-1536)	Ghora gali (1525.8-1533)	Patriata (1534-1754) masl
Species number					
Tree/ shrub	15	13	16	17	20
Climbers	10	12	11	13	18
Family number					
Tree/ shrub	15	14	16	15	16
Climbers	10	12	11	13	13
Density					
Trees & shrub	1188	1065	972	852	711
Climbers	460	560	610	820	950
Basal area					
Hosts	25.5	32.4	35.5	37.2	37.7
Climbers	7.3 ± 0.5	8.5 ± 0.7	9.3 ± 0.4	10.4± 0.5	12.3 ± 0.4
Climbing mode					
Twiner	40	70	160	250	290
Woody	330	350	300	430	460
Hook	60	90	150	140	130
Tendril	30	50	0	0	0

Table 3. Different climbers and their recorded climbing modes.

S. No.	Plant species	Family	Climbing mode	Rel. Abundance
1.	*Hedera nepalensis* K.Koch	Araliaceae	Woody climber	0.21
2.	*Ipomoea purpurea* (L.) Roth	Twiner climber	Twiner climber	0.01
3.	*Jasminum humile* L.	Oleaceae	Woody climber	0.13
4.	*Rosa macrophylla*	Rosaceae	Hook climber	0.08
5.	*Cuscuta reflexa* Roxb.	Cuscutaceae	Twiner climber	0.06
6.	*Caesalpinia decapetala* (Roth) Alston	Leguminosae	Hook climber	0.04
7.	*Cissampelos pareira* L.	Menispermaceae	Twiner climber	0.04
8.	*Smilax aspera* L.	Smilacaceae	Hook climber	0.03
9.	*Cissus carnosa* Lam.	Vitaceae	Tendril climber	0.02
10.	*Clematis connata* DC.	Ranunculaceae	Woody climber	0.02
11.	*Rosa brunonii* Lindl.	Rosaceae	Hook climber	0.02
12.	*Dioscorea deltoidea* Wall. ex Griseb.	Dioscoriaceae	Twiner climber	0.03
13.	*Pergularia daemia* (Forssk.) Chiov.	Apocynaceae	Twiner climber	0.02
14.	*Jasminum officinale* L.	Oleaceae	Woody climber	0.02
15.	*Clematis gouriana* Roxb. ex DC.	Ranuculaceae	Twiner climber	0.01
16.	*Cryptolepis buchananii* Roem. & Schult.	Apocynaceae	Twiner climber	0.01
17.	*Ceropegia macrantha* Wight	Apocynaceae	Twiner climber	0.01
18.	*Clematis grata* Wall.	Ranuculaceae	Woody climber	0.16
19.	*Cynanchum auriculatum* Royle ex Wight	Apocynaceae	Twiner climber	0.01
20.	*Rosa multiflora* Thunb.	Rosaceae	Hook climber	0.01
21.	*Rubia cordifolia* L.	Rubiaceae	Twiner climber	0.01
22.	*Tinospora malabarica* (Lam.) Hook. f.	Menispermaceae	Woody climber	0.01
23.	*Tylophora hirsute* Wight	Apocynaceae	Twiner climber	0.01

Climbing mechanism: Climbing modes differ greatly among the five localities. The changes in the amount of climbing modes among plots correspond with the alteration in richness of climber species along varying altitude. The twiner and woody climbers increased along elevation (Table 2). The climbers or climbing plants are separated into 4 groups based on their climbing mechanism / modes. The majority of climbing plants exhibited the twining mode 11 (48%) characterized the leading group followed by woody mode 6 (26%). Hook mode was exhibited by 5 (22%) climber plants while only 1 plant used tendrils ascending the host plant (Table 3). There were greater proportions of twiners and woody climbers in all plots in general.

Multivariate analyses: The Cluster and Two-way Cluster analyses (TWCA) using PCORD separated the plant species into two main climber associations which could be obviously witnessed in the dendrograms.

Association of climbers: Cluster analysis using PCORD version 5 broadly divided the 23 climber species and 50 quadrats into two associations based on compositional differences of the species. Association 1st was establish at an elevation range of 735-820 masl in the sub-tropical region while association 2nd was established the elevation ranges of 1501.6 to 1754 masl. in the moist-temperate region (Fig. 5).

Two-way cluster analysis: Two-way Cluster Analysis elucidated the absence and presence of the climber species at each quadrat in the study area along with the establishment of the peculiar associations. 1, 0 data of plant species was used to construct dendrogram. The white dots show the absence while black show the presence of climber species in the dendrogram. Fifty sampling quadrats of five localities were categorized into two groups; Association 1st was found by Baroha and Salgaran (735-820 m.a.s.l.) in the sub-tropical region while association 2nd was established by Nambal, Ghoragali and Patriata (1501.6 to 1754 m.a.s.l.) in the sub-temperate region (Fig. 6).

Assessment of the important environmental gradient: The environmental variables and Climber species data's were placed altogether in CANOCO (version 4.5). Seven environmental elements including biotic features (Anthropogenic, grazing pressure and No. of hosts) and abiotic factors (topographic and edaphic) display significant impact with ($p \leq 0.002$) on climber species composition, distribution pattern, and abundance (Table 4).

CCA bi-plot: The impact of analyzed environmental variables were anthropogenic (collection) pressure, elevation, grazing pressure, number of hosts, soil pH, electrical conductivity, and habit. Each triangle characterized climber species and the distance between them indicating the similarity and differences index. The CCA illustrates the distribution of climber species with environmental variables accordingly. The first quadrants CCA (bi-plot diagram) revealed the climber plants under the influence higher grazing pressure and of number of associated hosts (trees and shrubs). Whereas going through 2nd quadrant plants were clustered mostly under the effect of electrical conductivity. In quadrant maximum of the climbers were under the impact of elevation gradient. While in 4th quadrant assembled plants are under higher anthropogenic pressure, habit form and higher pH (Fig. 7).

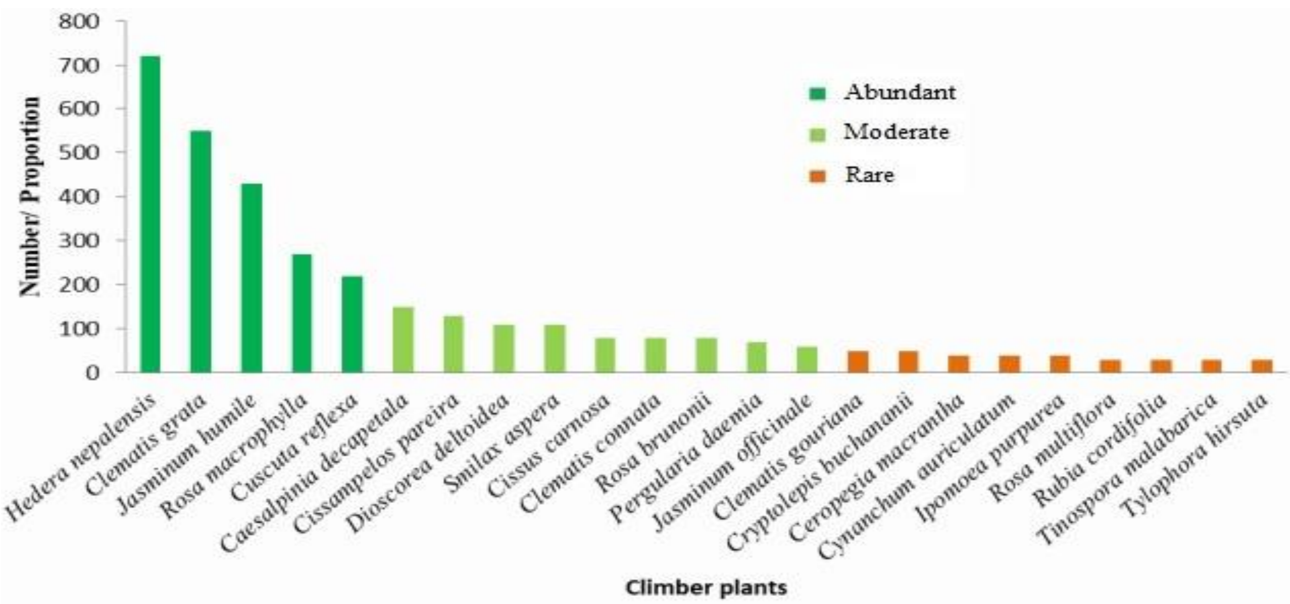

Fig. 4. Abundant, moderate and rare climber species in the study area.

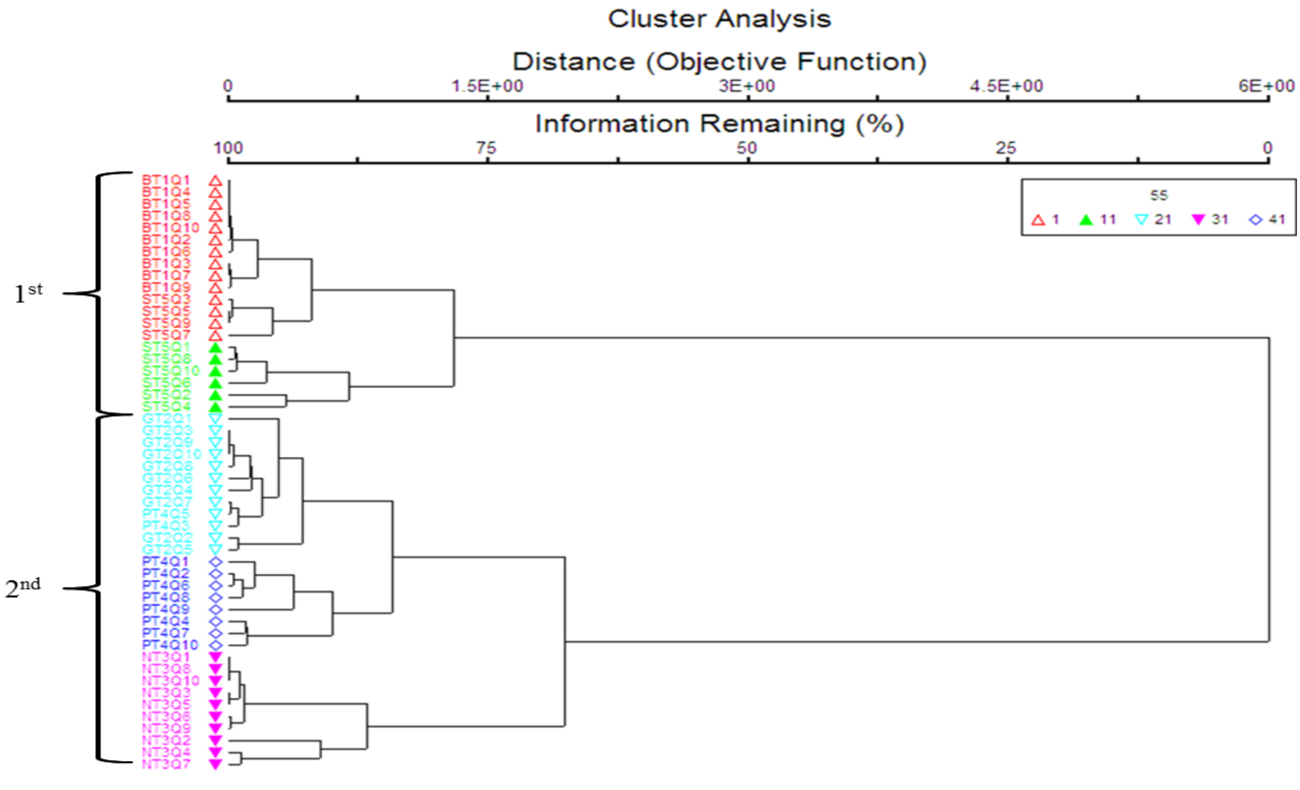

Fig. 5. Cluster dendrogram classifying climber plant species into two associations i.e., sub-tropical and temperate association.

Table 4. Summary table of CCA results of 23 climber species in relations to the environmental variables.

Axes	1	2	3	4	Total inertia
Eigen values	0.466	0.042	0.035	0.019	1.169
Species- environment correlations	0.976	0.636	0.627	0.555	
Cumulative % variance of species data	39.8	43.4	46.4	48.0	
Cumulative % variance of Spp-environment relation	80.4	87.6	93.6	96.8	

**** Summary of Monte Carlo test ****

Test of significance of 1st canonical axis		Test of significance of entire canonical axis	
Eigen value	0.466	Trace	0.579
F- ratio	7.792	F-ratio	5.887
P- value	0.002	P-value	0.002

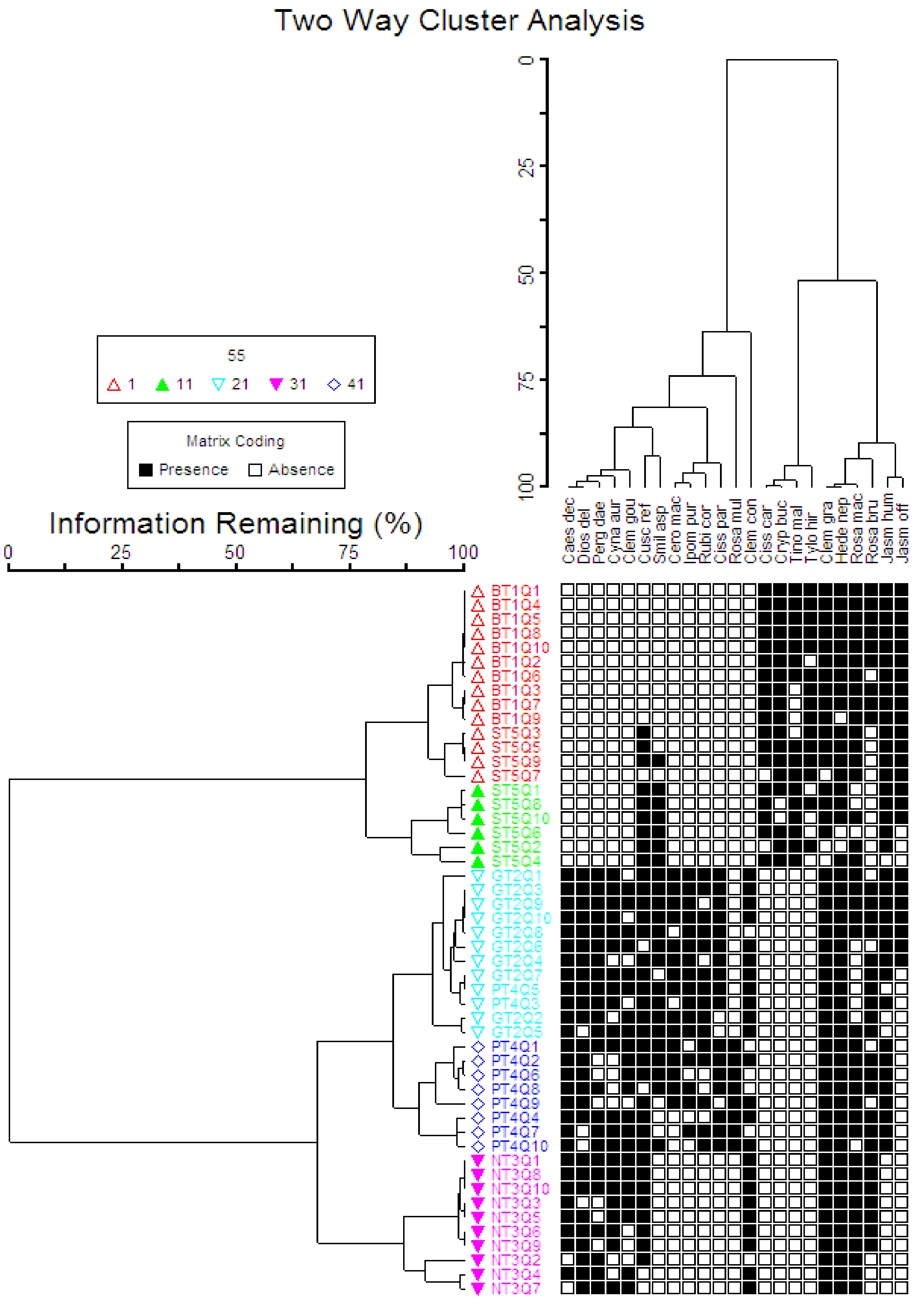

Fig. 6. TWCA showing distribution of climber plants in the sampled sites of the area.

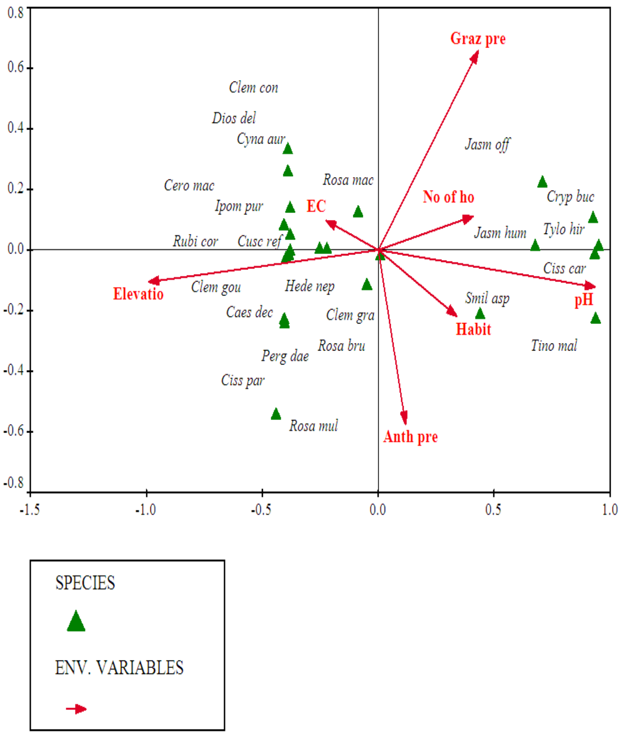

Fig. 7. CCA Plot of climbers under the influence of measured environmental factors.

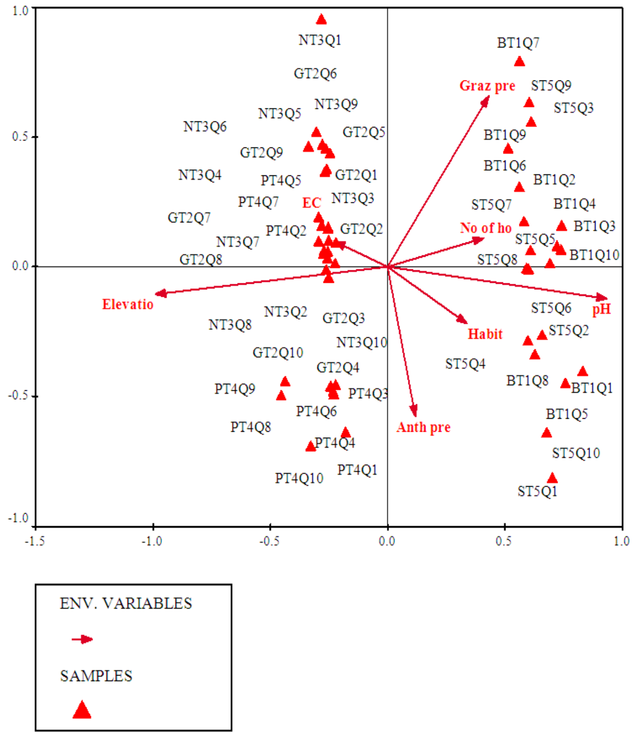

Fig. 8. CCA bi-plot displays the distribution of stations in relation to the recorded environmental variables.

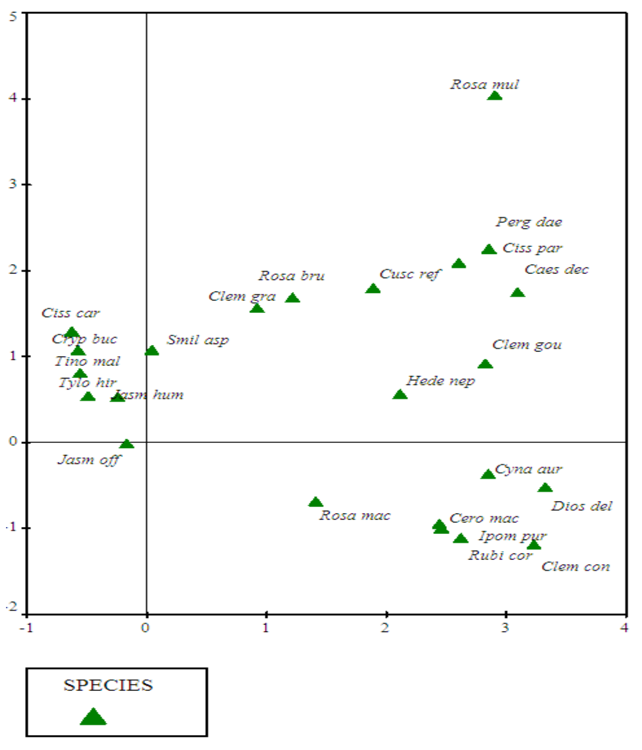

Fig. 9. DCA biplot portraying the distribution of climber species and habitat type among 5 sites in the Muree forests.

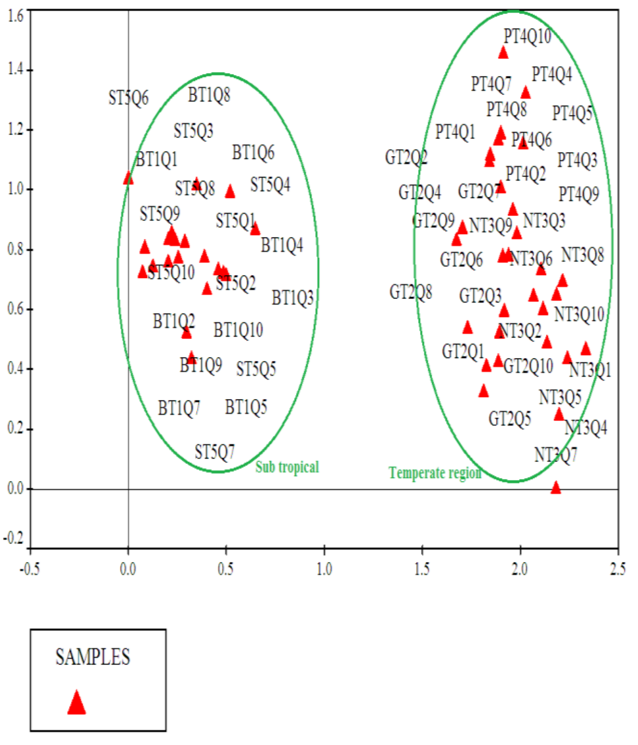

Fig. 10. DCA diagram showing distribution of samples and habitat type for 50 samples.

Table 5. Summary of all the four axes of DCA for 23 climber species.

Axes	1	2	3	4	Total inertia
Eigen-values	0.492	0.078	0.048	0.032	1.169
Length of gradients	2.333	1.453	1.325	1.331	
Cumulative % variance of species data	42.0	48.7	52.8	55.5	

The variance explained by the first CCA axis was 39.8 whereas the same for the second axis was 43.4. The third and fourth axes of CCA elucidate 46.4 - 48 of the accumulative variance in climbers data demonstrating that, elevation and anthropogenic pressure had the maximum correlation with 3 and 4^{th} which may strongly effect the climber species distribution pattern. Conferring to CCA results, several species were common to all elevations; few unique species emerged at specific elevations. Climber richness increased with increase elevation. The CCA ordination bi-plot established on sample and environmental factors represents the samples of first and second axis were correlated with both grazing and EC and negatively correlated with respect to each other (Fig. 8).

Indirect gradient analysis through DCA: DCA diagram (Fig. 9) shows the distribution of climber species in 50 samples. In DCA ordination for 23 climber species, the maximum gradient length recorded for axis 1 was 2.333 with eigenvalue 0.492. The gradient length for axis 2 was 1.453 with eigen-value 0.078. The total inertia in climber plants data was 1.169 (Table 5).

In study area two vegetation regions/ zones i.e. Sub-tropical and temperate forests associations were demarcated. DCA diagram shows the distribution of samples and habitat type for 50 samples. DCA ordination analysis showed maximum samples occurred in temperate region as compared to sub-tropical region (Fig. 10).

Discussion

In the present study 23 climber species and their 20 associated hosts (shrubs and trees) were recorded in five plots of 1 ha size at different localities of the Murree Forests in the foot hills of western Himalaya Pakistan. Similar and different data on the diversity, abundance and richness of climber species were also documented from other forests in the world, for example; Villagra *et al.*, (2013) recorded 72 climber species abundance between Nascentes-de-Paranapiacaba Municipal Natural Park (NPMNP) and Alto da Serra-de-Paranapiacaba Biological Reserve (ASPRB) in the Atlantic Forest, Brazil which varied significantly because of the succession and current disturbance in the ASPRB forest. Ghollasimood *et al.*, (2012) reported 4901 climber individuals belonging to 45 climber species in 37 genera of 20 families, in Perak coastal hill forest, Malaysia. Forty nine climbers comprising of (35 lianas and 14 vines) species spread over 41 genera and 28 families in the Nigerian secondary forests were reported by Muoghalu & Okeesan, (2005), 53 climber species at Lambir, Malaysia (Putz & Chai, 1987), 69 climber plants in the low lands forest of Ecuador (Gentry, 1991) with a variety of 35 to 50 hemi-epiphytes and lianas per 0.1 ha for five plots and 12 to 65 liana climbers per 0.1 ha in terra-firme in Yasunni, Ecuador (Nable-Nielsen, 2001) in neotropical forest of America. The climber species richness in our study areas is conversely lower than that (89 lianas) reported in lowland rain forests of Panamanian (Delwalt *et al*., 2000). Utmost care must be taken to the survival of climber plants in the Murree areas through sustainable conservation measures where the study of climber confirms their scarcity in the area. Conservation of climber has also becomes imperative as this group of plants not only provide valuable services for the humankind but also play key role in the forest regeneration as by keeping many pollinators throughout the year via different seasons phonological behaviours as compared to other flowering species.

Climber species density and richness increased along altitude in the study area. This is in resemblance with the study conducted in the Nigerian forests (Muoghalu & Okeesan, 2005). However, unlike to the described changes in abundance of climber species along elevation gradient in South African Knysna forest, where higher climber densities at lower altitude than those at higher elevations (Balfour & Bond, 1993). These alterations affirmed the qualitative findings and quantitative suggestion of White (1978), Proctor *et al*., (1983) and Putz (1984a) who reported greater climber abundance being linked with soil nutrient gradient. This also follows to the affirmation that climber species composition is a function of geographical variations (Delwalt *et al*., 2000; Grubb, 1987).

Climber relationship with hosts (Trees and shrubs) size seems to be a vital aspect in shaping the occurrence of climbers on associated hosts. The most important and influential relationship between the girth size of hosts was recorded 35 – 37.7 inches DBH and those of climbers on them that show the influene of thickness of hosts in climbers variation. The highest numbers i.e., 950 individuals (28% of climbers) supported by associated hosts were reported from Patriata the highest elevation site. There is a consistent association between hosts (tree and shrub) species and the climber species in these forests. Few host trees hosted larger frequency of climbers, for example *Pinus roxburghii* and few others that confirm few tree species are more favourable for the climbers. These results are in resemblance with the outcomes of tropical forest of Malaysia (Putz & Chai, 1987); also in harmony with the findings of Campbell and Newbery (1993) in lowland of Sabah forest, Borneo and climber association with host tree as reported by Muthuramkumar & Parthasarathy (2001).

The modes through which the climbing plants climb the host plants play a vital role in their diversity, distribution and abundance (Nabe-Nielsen 2001). Four major modes of climbing mechanism system were documented in the current study. Of these twisting climbing mode around the hosts were the most prominent, 43% of the climber species in the research areas are modified to this climbing mode. Many authors like (Gentry 1991; DeWalt *et al*., 2000; Nabe-Nielsen, 2001; Parthasarathy *et al*., 2004; Jongkind & Hawthorne, 2005; Kuzee & Bongers, 2005) have recorded more or less similar findings in various forests around the globe. The twinning mode of climbers in the forest is also specified by Nabe-Nielsen (2001) and Senbeta *et al*., (2005) with small to medium-sized diameter.

Climbing mechanism used by lianas to climb to the forest canopies was characterized by twiners, hook climbers, tendril climbers, root climbers, horns and slender stranglers. However, a few lianas use the combination of climbing modes to reach the forest canopy such as twiner-tendril climbers, twiner-hook climbers or twiner-thorn climbers as represented in the families Apocynaceae, Leguminosae, Rosaceae, Capparaceae, Menispermaceae, Oleaceae, Convolvulaceae, Araliaceae, Dioscoriaceae, Leguminosae, Rubiaceae, Smilacaceae and Vitaceae respectively. However, previous studies reported that the climbing mode in liana was confined only to one climbing technique (Putz, 1984a; Gollasimood *et al*., 2012; Kumar *et al*., 2013; Addo-Fordjour *et al*., 2014; Ghosh, 2014;). Overall the top five most abundant families were Apocynaceae, Leguminosae, Rosaceae, Capparaceae and Menispermaceae. Other studies reported that Annonaceae, Arecaceae, Leguminosae, Sterculiaceae and Connaraceae were among the maximum abundant climber families (Putz & Chai, 1987; Gentry, 1991; Appanah *et al*., 1993; Kammesheidt *et al*., 2009; Di-Negeri *et al*., 2012; Ghollasimood *et al*., 2012).

In the current study the density and richness of climber species increased with elevation in the study area. This is in divergence to specified clear variances in richness of climber species along elevational gradient in Knysna forest, in the lower altitudes of South Africa having higher density of climber with respect to those at higher elevations (Balfour & Bond, 1993). These variations declared to a large extent the qualitative suggestion and the quantitative findings of Proctor *et al*., (1983) and Putz (1984a) and also can be related to the gradient of soil nutrients with richer climber abundance in moist temperate sort of rich organic contents soil. Of these plots none is enough high to be categorized as Afromontane forest which White (1978) proposed would have less lianas than in lowland Guineo Congolian forests. Our findings may be reflection of the particular microenvironment demands of maximum of the infrequent climber species. It also follows to the declaration that climber species composition is function of geographic location as well as geological histories (Grubb, 1987; Putz & Chai, 1987; Delwalt *et al*., 2000).

It was found that the altitudinal gradient and number of associated hosts influence the number, taxonomy and distribution of climbers as well as climber host relationships in the study area. In this regard, it is revealed that climber species were found to be more concentrated between altitudes 1501m to 1754 m a.s.l. Furthermore, it was found that climbers also favor growth adjacent to high EC, low grazing and anthropogenic pressure areas. This finding was dissimilar to other studies where lianas were found in abundance at lower altitude (Proctor *et al*., 1983; Appanah & Putz, 1984; Putz & Chai, 1987; Campbell & Newberry, 1993; DeWalt *et al*., 2006; Wai, 2009; Ghollasimood *et al*., 2012;). Therefore it was generally indicated that different locality, habitat and variation in the altitudinal gradient are possible factors that limit the distribution and abundance of lianas as suggested by previous published studies (Hegarty, 1991; Givnish, 1998; Bhattarai & Vataas, 2003; Schnitzer, 2005).

Conclusions

Floristic composition and pattern distribution of climbers is related to the elevation and other macroclimatic variables. Associated host species, grazing, anthropogenic pressure and altitude were the most significant factors that influence the abundance and distribution of climbers. The current study shows that Murree Forests have a great floristic diversity and density of climbers, which add significantly to the whole faunal and floral diversity of these forests. The significance of climber plants can attract researchers to study various aspects which could possibly be utilized in forest management plans. This type of baseline inventory is a much needed for the area as well as research in order to understand the role of these dependent life forms in forest functions, ecosystem services and forests conservation in a better way.

Acknowledgments

We are thankful to Quaid-i-Azam University, Islamabad Pakistan for providing the Vice Chancellor Fellowship and Turkish Scientific and Technological Research Council of Turkey for support from TÜBİTAK- Grant No: B.14.2.TBT.0.06.01.02-216-10539 during this study.

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(Received for publication 17 August 2018)