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Phytodiversity of Herbaceous Vegetation in Disturbed and Undisturbed Forest Ecosystems of Pahalgam Valley, Kashmir Himalaya, India

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SAS, HM and AAW designed the study, managed the literature searches, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NA and AH coordinated data collection, managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The study investigated the comparative assessment of seasonal herbaceous diversity at disturbed and undisturbed forest sites at Pahalgam and Betab valley of Kashmir. The results revealed that Shannon's diversity attained maximum value (2.238) at site I to a minimum value (0.421) at site IV during summer season. Average values of diversity (H') ranged between 1.883, site I to 0.431, site IV. Dominance index depicted inverse relationship to diversity index (H′) at different sites during different seasons. Equability values varied between (0.890) in autumn season at site II to (0.296) in winter season at site I. Average equability values varied between 0.828, site II to 0.625, site IV. Richness index showed high trend during summer season (2.83, site I) and low at site IV (0.184) in autumn season. Average variation in richness index varied between 0.516, site IV to 1.900, site I. The abundance to frequency ratio (A/F) indicated most of species performed contagious pattern of species distribution (50%-100%, site I; 62%-100%, site II; 28%-100%, site III and 100%, site IV) followed by random (11-31%, site I; 37%, site II; 33%-57% and regular (18%-30%, site I, 25% site II and 14% site III). The study revealed that biotic interference and seasonal influences have affected the species diversity and efforts are required to conserve species diversity in the selected forest sites of the study area.

Keywords: Phytodiversity, Pahalgam valley, Kashmir, forest, seasons, species.

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1. INTRODUCTION

The global biodiversity crisis has given rise to a growing concern at the prospect of a rapidly accelerating loss of species population, domesticated varieties, medicinal herbs and natural habitats. Currently, biodiversity is declining at an unprecedented rate in response to human-induced changes [1,2]. The species diversity is one of the most important indices which are used for the evaluation of ecosystems at different scales [3]. About 12.9% of Earth's land surface is only protected [4] and with a growing human population, it is highly unlikely that protected areas will ever cover more than a small fraction of Earth's land surface. This is particularly the case in the temperate zone [5]. It is estimated that about 8% of the known plant species are presently on the brink of extinction [6]. Plant diversity is a fundamental component of ecosystem diversity, contributing to both habitat structure and ecosystem function [7]. Natural and human disturbances are both considered as major drivers of species diversity in plant communities. In general, frequency and magnitude of disturbance are key factors for changes in species diversity [8,9,10,11]. The relationship between disturbance and species diversity also depends on the spatial scale [12, 13,14]. Under extensive disturbance species diversity normally declines, but moderate disturbance can enhance or reduce it depending on the spatial scale and types of species [15,16,14]. Hence, understanding the relationship between disturbance and species diversity is fundamental during the setting of conservation policy. The destruction of vegetation has been continuing at an alarming pace world over due to a variety of causes [17,18]. In India, habitat destruction, over exploitation, pollution and species introduction are identified as a major cause of diversity loss [19]. In most developing countries, including India even protected forests experience extensive anthropogenic disturbance [20]. The degree of anthropogenic disturbance may differ in different parts of a conservation area [21]. These anthropogenic impacts cause loss of biodiversity especially in regions which are under development process [22].

India has 2.5% of the world's land area and 1.8% of the global forest area which supports 15.6% of the world's human population and 14% of the livestock population. This large population depends on forest resources directly or indirectly for various purposes. Increasing population and human activities tends to alter the energy demand and carbon budget [23]. However, in India the forest cover is 21.02% of the geographical area and much of it is under anthropogenic stress [24]. Species diversity is an important concept and one of the major attributes of a natural community. Floristic inventory and diversity studies help us to understand the species composition and diversity status of forests and offer vital information for forest conservation [25]. Studies have shown that composition and structure of forest are influenced by a number of factors [26]. Prominent among these factors are disturbances which are thought to be key aspects and the cause of local species variation within forests based on their intensity, scale and frequency [27,28]. An increasing interest in the development and management of natural forests has given rise to the need to understand the community structure and ecosystem stability [29].

Forests play a key role in regulating climate, conserving biodiversity and providing livelihood to the people [30]. They are the primary source to rejuvenate productivity of land through recycling of nutrients, which make physicochemical conditions of the soils favourable for plant growth [31]. Understanding species diversity and plant distribution patterns is important for assessing the complexity and sustainability of forest ecosystems. There are large anthropogenic demands on forest resources in different regions of India because more than 200 million people dependent on forests for livelihoods. [32] have given an overview of forest biodiversity and its conservation in India and stressed the need for people's participation in biodiversity conservation and rehabilitation. Due to increasing human population, the biotic pressure on native forest is inevitable. The uncontrolled lopping and felling of trees for fuel wood, leaf fodder, burning of ground vegetation, livestock grazing and harvesting of ground vegetation for forage are some of the factors responsible for exploitation of forests [31]. Soil is an essential component that has sustained life on this planet, favoring the growth of plants that have survived human competition. The chemical and physical properties of soils are controlled largely by clay and humus as they act center of activity around which reactions and nutrient exchange occurs [33]. The vegetation in turn influences the physical and chemical properties of soil to a great extent. It improves the soil structure, infiltration rate and water holding capacity. Much depends on intensity of canopy removal (amount of basal area removed or gap size) and degree of ground disturbance.

The valley of Kashmir provides home to a large number of plant and animal species [34-37]. Kashmir Himalaya due to its rich repository of vegetation has attracted naturalists and botanists for more than two centuries [38]. Numerous studies dealing with diverse aspects of vegetation from different areas of this region have been carried out from time to time [39, 38]. The herbaceous layer plays an important role in ecosystem function, contributing organic matter, aiding in decomposition, and conserving nutrients [40-45]. Species diversity is driven by disturbance, forest cover type, and site history [46-50]. However, the herbaceous layer composition is changing continuously in space and time due to multitude of factors such as anthropogenic disturbances, livestock grazing, fire and rainfall which differs in intensity and duration [51]. In this context, the present study was conducted to assess the seasonal variation and effects of biotic disturbance on phytodiversity of herbaceous vegetation in disturbed and undisturbed forest ecosystems of Pahalgam valley.

2. MATERIALS AND METHODS

2.1 Study Area and Sites

Pahalgam is located between 34° 01' N latitude and 75° 11' E longitudes at an elevation of 2,740 meters in Anantnag district of Jammu and Kashmir and is nearly 96 kilometers away from the summer capital, Srinagar, Kashmir. The present study was conducted on seasonal basis at four different ecosystems of Pahalgam Valley further sub-divided into protected and degraded forest sites. Site I (Pahalgam protected forest) and Site II (Pahalgam degraded forest) located near Baisaran Pahalgam at an altitudinal range of 2,900 m masl. Site III (Betab Valley protected forest) and Site IV (Betab Valley degraded forest) located about 6-7 kilometers away from Pahalgam town at an altitudinal range of 2,450 m masl. Disturbed forest site is due to livestock grazing, influence of tourist activities and fuel fodder collection by local population whereas undisturbed forests are free from such activities.

2.2 Soil Attributes

Soil pH at site I & II (5.66-6.74), site III & IV (6.11-6.46) were acid to nearly neutral range. Organic carbon at site I &II (1.86-0.23%), site III &IV (0.75-2.48%). Total nitrogen varied between 1.60-0.210% at site I &II and 0.172-2.39% at site II & IV. Average soil moisture content at site I &II (15-26%), at site III & IV (20-38%).

2.3 Vegetation Analysis

The dominant vegetation of the study area consists of conifers with principal species of *cedrus deodera*, *Pinus griffithii* and *Abies pindrow*. Major shrubs include *Indigofera heteranthus* and *Vibruum spp*. Ground flora consists mainly of *Rumex patientia* and *Primula spp*. To study the community composition and other phytosociological characteristics of the herbaceous vegetation at the four selected sites, field surveys were conducted in three seasons Summer (June to August), Autumn (September to November) and Winter(December to February). Phytosociological attributes of plant species were studied by randomly laying 25 quadrats of 1×1 m^2 size at each site [52,53]. Specimen of each plant species encountered at each site during the study period was collected and herbarium was prepared in the P.G. Department of Environmental Sciences, S.P. College, Srinagar, Kashmir.

2.4 Data Analysis

The vegetation data recorded was quantitatively analysed for density, frequency and abundance following [54]. The relative values of these indices were determined as per [55].These values were summed up to get importance value index (IVI) of individual species [56]. The ratio of abundance to frequency (A/F) for different species was determined for eliciting the distribution pattern. This ratio has been indicated as regular (<0.025), random (0.025 to 0.05) and contagious distribution (>0.05) by following [57]. Plant diversity in the four study sites were evaluated using the following indices.

2.5 Measurement of Diversity

The diversity index was calculated by using the [58].

$$\text{Diversity index} = H = -\sum Pi \ln Pi$$

where Pi = S / N
S = number of individuals of one species
N = total number of all individuals in the sample
In = logarithm to base e

Simpson Index [59]:

$$D = \Sigma \, pi^2$$

2.6 Measurement of Species Richness

Margalef's index was used as a simple measure of species richness [60].

Margalef's index = (S – 1) / In N

S = total number of species
N = total number of individuals in the sample
In = natural logarithm

2.7 Measurement of Evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used [61].

e = H / In S
H = Shannon–Wiener diversity index
S = total number of species in the sample

3. RESULTS

3.1 Vegetation Attributes

Total number of herbaceous species ranged from 7 to 16 at site I, 4 to 8 at site II, 6 to 9 at site III, while at site IV species number (2) remained constant during entire period of study. Species recorded at four sites are presented in Table 1. The seasonal break-up of total species recorded at four sites showed maximum species occurrence during summer (site I=20, site II=10; site III=13). However, site IV showed equal number of species occurrence (02) during three seasons. Overall a decreasing trend in species occurrence was observed at most of the sites from summer to winter season (Fig. 1).

Plant species recorded at four study sites with high dominants based on importance value (IV) during different seasons are presented in 'Figs. 2-5'. The dominant species at site I and II were *Capsella bursa-pastoris* (44.16 $_{autumn}$, site I; 78.22 $_{autumn}$, site II), *Cynodon dactylon* (72.48 $_{winter}$ site I; 95.56 $_{autumn}$, site II), *Erigeron Canadensis* (13.28 $_{autumn}$, site I ; 20.78 $_{summer}$, site II), *Oxalis corniculata* (13.18 $_{summer}$, site I; 47.45 $_{autumn}$, site II), *Plantago lanceolata* (17.68 $_{autumn}$, site I; 59.80$_{winter}$, site II), *Rumex hastatus* (27.91,site I$_{winter}$; 37.91,$_{autumn\ site}$ II), *Taraxacum officinale* (32.40$_{autumn}$, site I; 20.93$_{summer}$, site II), *Trifolium pratense* (22.12 $_{autumn}$, site I; 32.47$_{summer}$, site II). However, *Convolvulus arvensis* (27.91$_{winter}$), *Fragaria nubicola* (106.89 $_{winter}$), *Poa annua* (37.54 $_{winter}$), *Stipa sibirica* (24.05 $_{winter}$), *Trifolium repens* (31.13$_{winter}$) at site I. Species with low dominance at this site include *Dioscorea deltoidea, Geranium wallichii, Malva neglecta, Mentha longifolia, Potentilla sp. Viola indica* and *Urtica dioica.* However, *Bellis perennis* (116.59$_{winter}$) was dominant at site II (Figs. 2 and 3). *Cynodon dactylon* (93.44 $_{autumn,}$ site III; 233.97$_{winter,}$ site IV) and *Taraxacum officinale* (29.47$_{summer,}$ site III; 78.19$_{autumn,}$ site IV) were commonly dominated species at site III and IV respectively**.** *Bellis perennis* (129.43, $_{winter}$), *Fragaria nubicola* (29.76$_{winter}$), *Plantago lanceolata* (32.10$_{autumn}$), *Poa annua* (72.55$_{autumn}$), *Ranunculus arvensis* (28.75$_{summer}$), *Rorippa sylvestris* (69.51$_{winter}$), *Rumex hastatus* (19.56$_{summer}$), and *Trifolium pratense* (37.23$_{autumn}$) were dominant only at site III. Least dominant species at site III are *Podophyllum hexahydrum***,** *Potentilla sp.* and *Urtica diodica* (Figs. 4 and 5).

Different diversity indices investigated during the entire study period are depicted in (Figs. 6-9). Diversity index (H´) showed a range 1.442 (winter) to 2.238 (summer) at site I, 1.143 (winter) to 1.717 (summer) at site II, 1.214 (winter) to 1.590 (summer) at site III and 0.421 (summer) to 0.441 (winter) at site IV. Dominance Index varied between 0.118 (summer) to 0.804 (winter) at site I and 0.213 (summer) to 0.355 (winter) at site II, 0.217 (summer) to 0.399 (winter) at site III and 0.736 (autumn) to 0.788 (winter) at site IV. Dominance showed an inverse trend with diversity index (H´) at site I, site II and site III. However, no such trend in dominance index was observed at site IV. Pielou's evenness index at site I recorded maximum increase during autumn season (0.860) and minimum in winter season (0.296). At site II evenness ranged between 0.858 (summer) to 0.890 in autumn seasons. However, at site III evenness index varied between 0.677 (winter) to 0.793 (autumn) and 0.610 (summer) to 6.40 (winter) at site IV. Richness index at four sites varied between 2.83 (summer) at site I to 0.184 site IV (autumn) season. It varied between 2.83 to 1.032 at site I; 1.341 to 0.62 at site II; 1.580 to 0.890 at site III from summer and winter seasons. However, at site IV it varied between 1.180 summer to 0.184 autumn.

3.2 Distribution Pattern

The abundance to frequency ratio (A/F) indicated most of the species performed contagious distribution followed by random and regular pattern of distribution at different sites during different seasons (Figs. 10-13). However, A/F values of species recorded are presented in Figs. 14 to 17. The A/F ratio depicted 50% $_{(summer)}$ to 83.33% $_{(winter)}$ species at site I and 62.5% $_{(summer)}$ to 100% $_{(autumn)}$ species at site II performed contagious pattern of distribution. 28.58% $_{(autumn)}$ to 100% $_{(winter)}$ species fall under contagious distribution at site III whereas site IV showed 100% species as contagious distribution during estimated seasons. Randomly distributed species varied between 16.66% $_{(winter)}$ to 37.50% during summer season at site I. At site II, 37.50% species recorded random distribution during summer season. No species fall under random distribution category during autumn and winter seasons. At site III, 33.33% $_{(summer)}$ to 57.142% $_{(autumn)}$ were randomly distributed and no species was recorded under this category during winter season. However at site IV occurrence of species was negligible under random distribution during the three study seasons. Regular distribution of species at site I ranged from 12.50% $_{(summer)}$ to 30% $_{(autumn)}$ season and no species was reported during winter season under this category. Site II reported 25% species under regular category in winter season with absence of species under this category in summer and autumn seasons. However at site III in autumn season (14.28%) species presented regular distribution with absence of species during summer and winter season under this category at site IV.

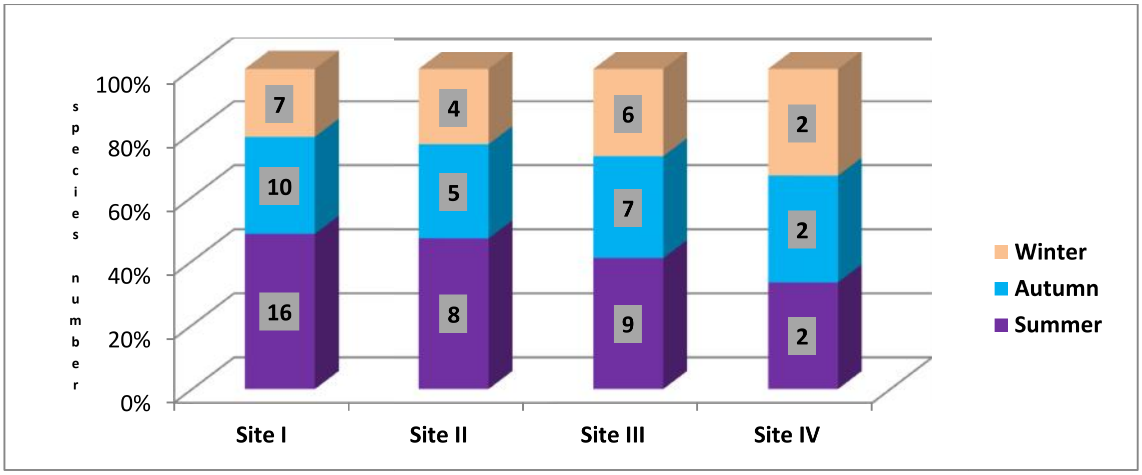

Fig. 1. Species recorded at four sites during different seasons

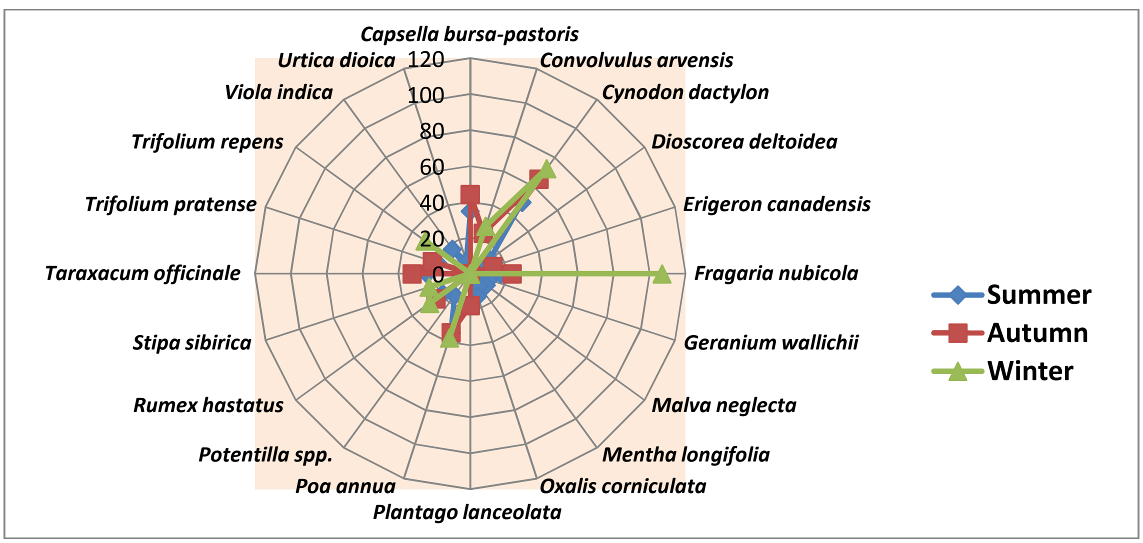

Fig. 2. Twenty species recorded at site I during different seasons

Table 1. List of plant species recorded in the four study sites

Name of the plant Species (Site I)	Family	Name of plant species (Site II)	Family	Name of the plant species (Site III)	Family	Name of the plant species (Site IV)	Family
Capsella bursa-pastoris	Brassicaceae	*Bellis perennis*	Asteraceae	*Bellis perennis*	Asteraceae	*Cynodon dactylon*	Poaceae
Convolvulus arvensis	Convolvulaceae	*Capsella bursa-pastoris*	Brassicaceae	*Cynodon dactylon*	Poaceae	*Taraxacum officinale*	Asteraceae
Cynodon dactylon	Poaceae	*Cynodon dactylon*	Poaceae	*Frageria nubicola*	Rosaceae	----	----
Dioscorea deltoides	Dioscoreaceae	*Erigeron canadensis*	Asteraceae	*Plantago lanceolata*	Plantaginaceae	----	----
Erigeron canadensis	Asteraceae	*Oxalis corniculata*	Oxalidaceae	*Poa annua*	Poaceae	----	----
Frageria nubicola	Rosaceae	*Plantago lanceolata*	Plantaginaceae	*Podophyllum hexahydrum*	Podophyllaceae	-----	----
				Potentilla sp.	Rosaceae		
Geranium wallichii	Geraniaceae	*Rumex hastatus*	Polygonaceae	*Ranunculus arvesnsis*	Ranunculaeae	------	------ -------
Malva neglecta	*Malvaceae*	----	-----	*Rorippa sylvestris*	Brassicaewae	------	------
Mentha longifolia	*Lamiaceae*	---- -----	-----	*Rumex hastatus*	Poygonaceae	------	
Oxalis corniculata	Oxalidaceae		------				
Plantago lanceolata	Plantaginaceae	*Taraxacum officinale*	Asteraceae	*Taraxacum officinale*	Asteraceae	----	---
				Trifolium pretense	Fabaceae	----	----
Poa annua	Poaceae	*Trifolium pratense*	Fabaceae				
Potentilla sp.	Rosaceae	----	----	*Urtica dioica*	Urticaceae	----	----
Rumex hastatus	Polygonaceae	----	----	----	----	----	----
Stipa sibirica	Poaceae	----	----	----	----	----	----
Taraxacum officinale	Asteraceae	----	----	----	----	----	----
Trifolium pratense	Fabaceae	----	----	----	----	----	----
Trifolium repens	Fabaceae	----	----	----	----	----	----
Viola indica	Violaceae	----	-----	-----	----	----	----
Urtica dioica	Urticaceae						

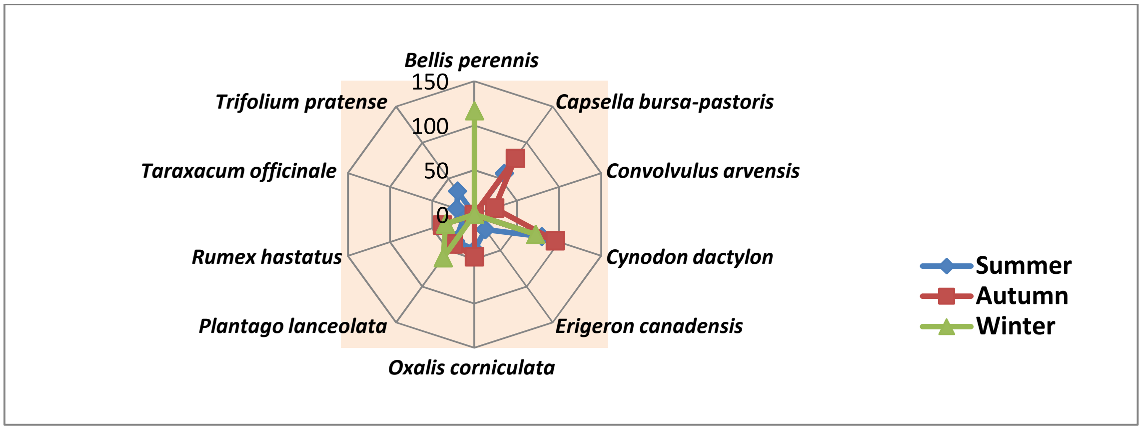

Fig. 3. Ten species recorded at site II during different seasons

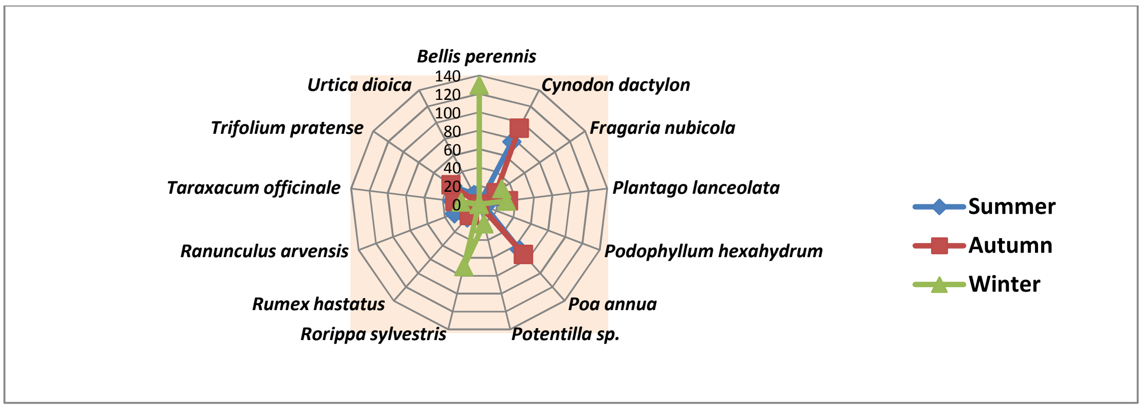

Fig. 4. Thirteen species recorded at site III during different seasons

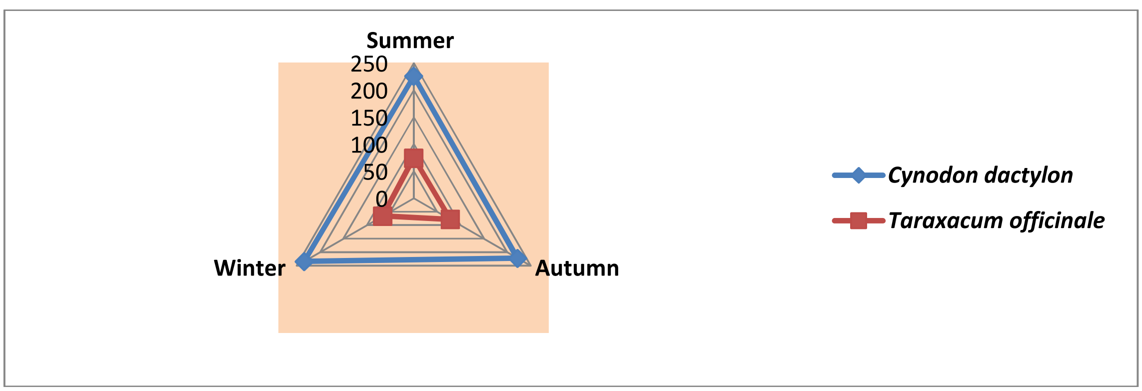

Fig. 5. Two highly dominant species recorded at site IV during different seasons

4. DISCUSSION

Diversity is considered to be an outcome of evaluation of species in a bio-geographic region. It is considered to be synthetic measure of the structure, complexity and stability of a community [62] and is a combination of two factors: the number of species present, referred to as species richness and the distribution of individuals among species, referred to as species evenness or equability. Species diversity therefore, refers to the variation that exists among the different life forms. An important component of any ecosystem is the species it contains. Species also serves as good indicators of the ecological condition of a system [63]. In the present study, the general structure of species at four study sites depicted a decreasing trend in their number from summer to winter season (site I=16 to 07, site II=08 to 04; site III=09 to 06 and site IV=02 each in all seasons). The number of species in a particular forest type varies markedly along the altitudinal range of its growth, which depends on the complex suit of factors that characterize the habitat of individual species. Ecological function of the species involves all kinds of processes, which are inevitably associated with some changes over space; composition and structure are affected at species level. According to [64] plants may facilitate other plants directly, by ameliorating harsh environmental conditions, altering substrate characteristics, or increasing the availability of a resource. The species in a community grow together in a particular environment because they have a similar requirement for existence in terms of environmental factors [65]. An increase in exposed soil coinciding with a reduction in vegetation cover can be perceived as an indicator of ecosystem dysfunction [66]. Lower vegetation cover reduces the efficiency with which resources can be captured and utilized such as water, organic material and nutrients [67,68,69].

The maximum number of species occurrence during two seasons (summer and autumn) could be due to the environmental factors such as light, temperature, soil characteristics and moisture availability due to rains [70,71,72]. At disturbed sites more herbaceous vegetation was reported compared to undisturbed sites mainly because of reduction in competition for space and resources. [73,74] have reported similar results and stated increase in herb species number immediately after disturbance by fire due to reduction in the tree cover which allows more light received by soil to facilitate growth of understory species.

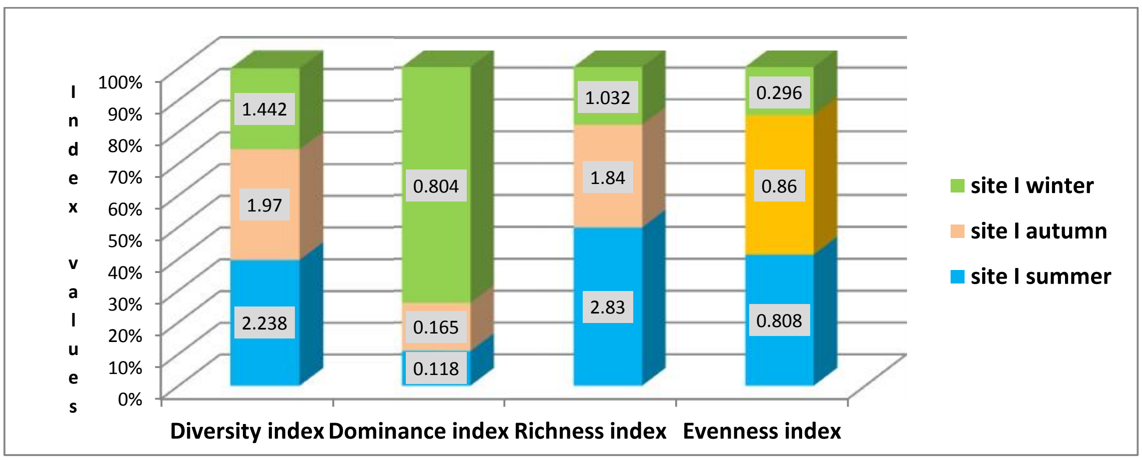

Fig. 6. Diversity estimates of herbaceous vegetation at site I using different diversity Indices

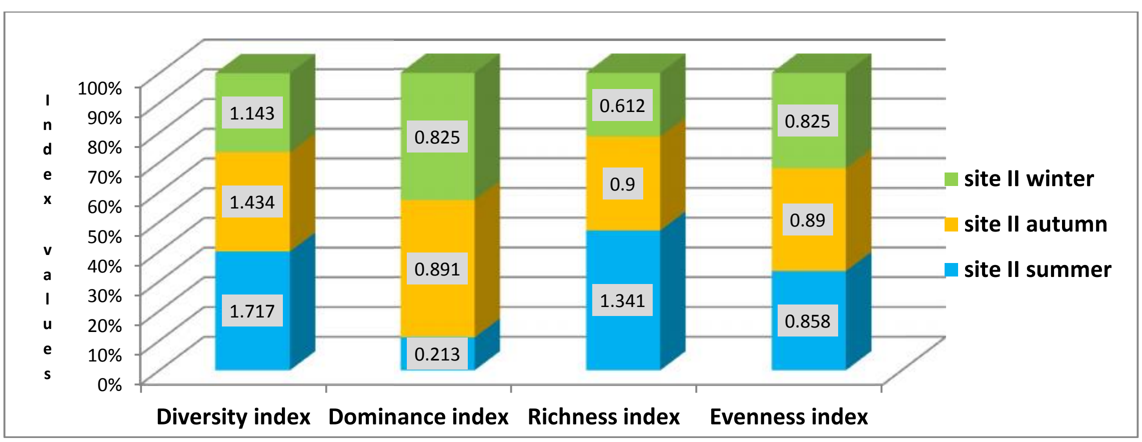

Fig. 7. Diversity estimates of herbaceous vegetation at site II using different diversity Indices

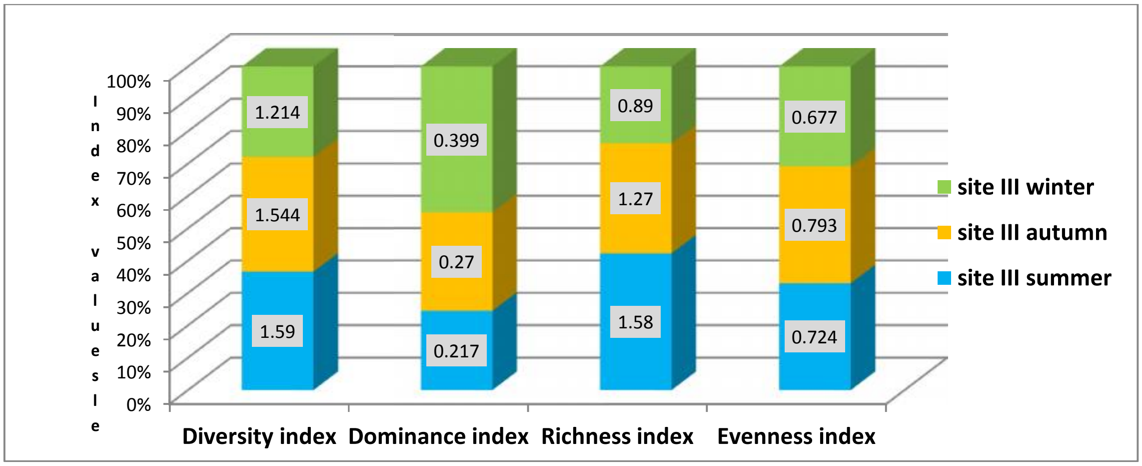

Fig. 8. Diversity estimates of herbaceous vegetation at site III using different diversity Indices

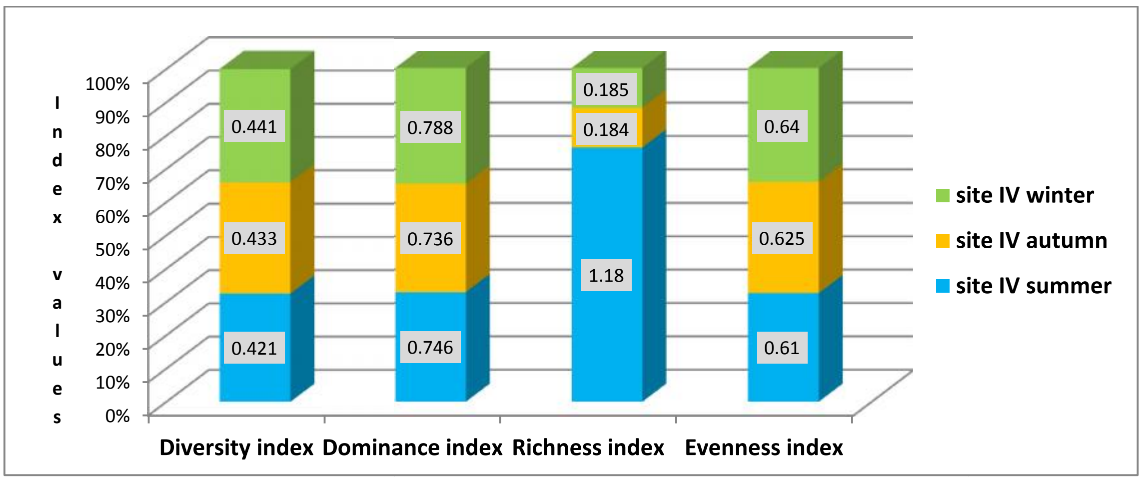

Fig. 9 . Diversity estimates of herbaceous vegetation at site IV using different diversity Indices

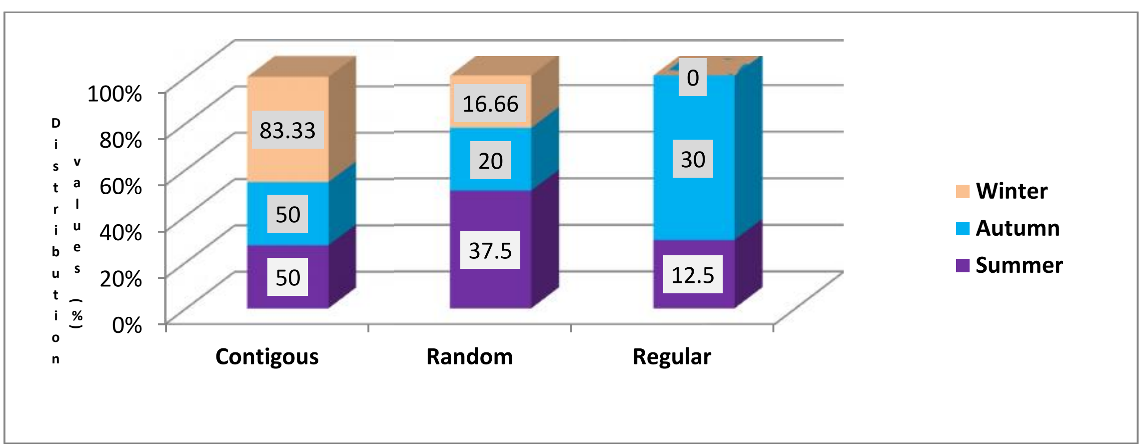

Fig. 10. Distribution pattern (%) of herbaceous vegetation at site I during different seasons

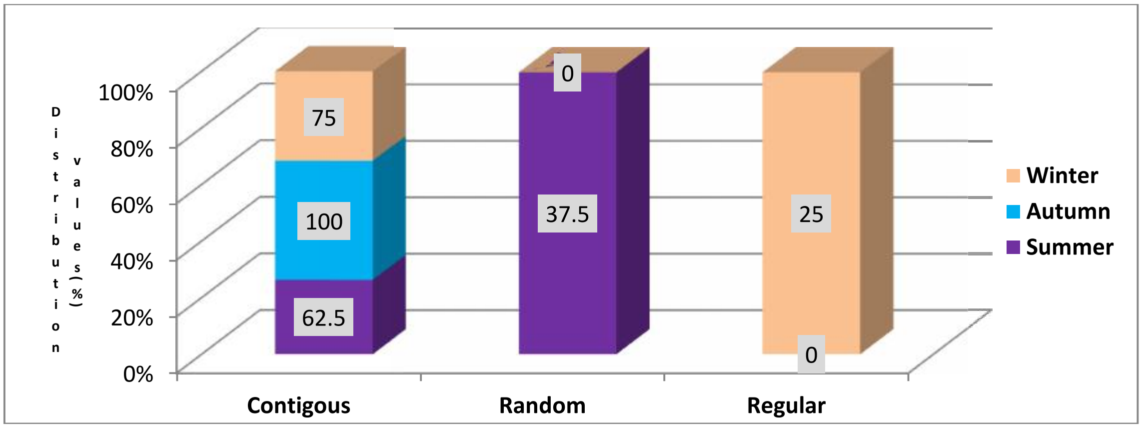

Fig. 11. Distribution pattern (%) of herbaceous vegetation at site II during different seasons

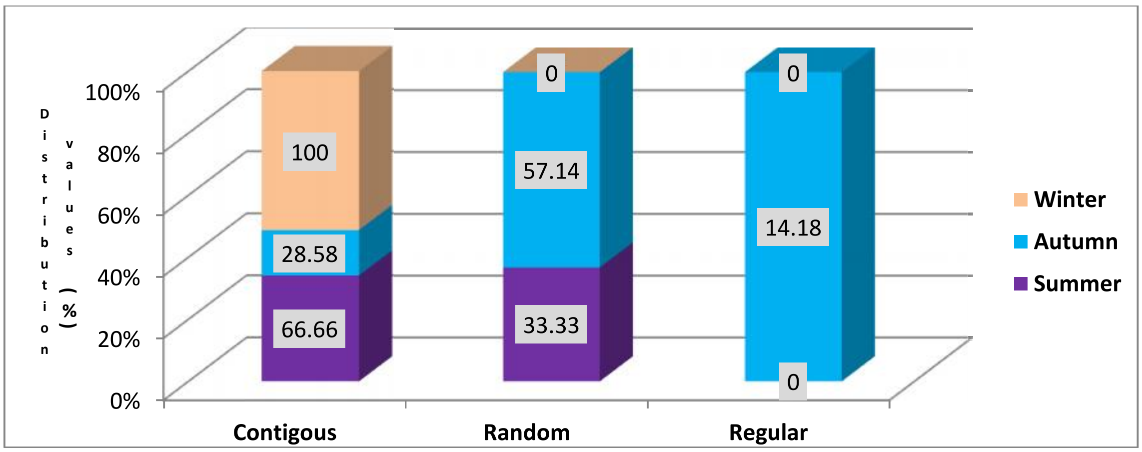

Fig.12. Distribution pattern (%) of herbaceous vegetation at site III during different seasons

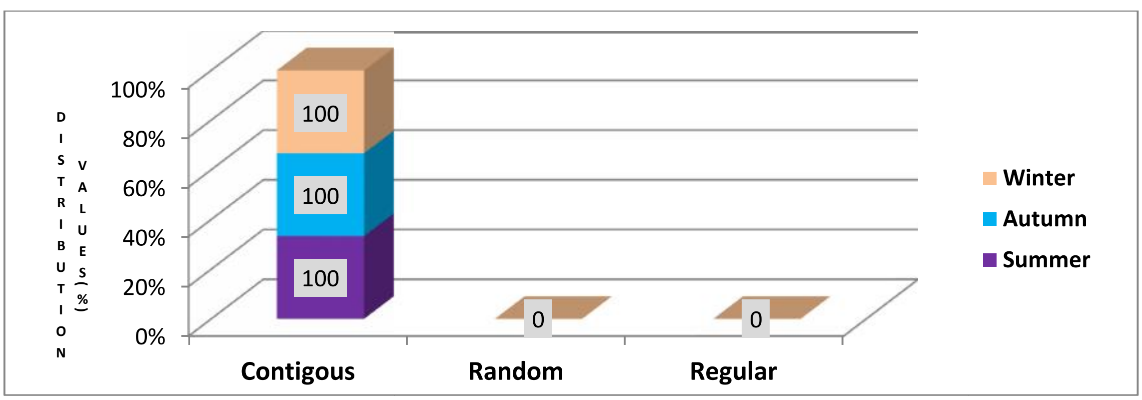

Fig. 13. Distribution pattern (%) of herbaceous vegetation at site IV during different seasons

The species diversity in the present study ranged from 1.442$_{(winter)}$ to 2.238 $_{(summer)}$ at site I, 1.143$_{(winter)}$ to 1.717$_{(summer)}$ at site II, and 1.214$_{(winter)}$ to 1.590$_{(summer)}$ at site III and 0.421$_{(summer)}$ to 0.441$_{(winter)}$ at site IV (Figs. 6 and 7). These results indicate more increase in species diversity at protected sites compared to unprotected ones. In agreement with these results [75] and [76] reported that grazing by domestic livestock is commonly associated with changes in species composition in rangelands throughout the world. [77] also reported diversity higher at protected sites (2.71) compared to unprotected sites (1.69). The higher diversity as observed in summer and autumn season attributed high number species number which is in accordance to the study conducted by [78]. An increasing trend in species diversity was observed during summer season which declined with the commencement of autumn and winter seasons at most of the sites [79]. This character is attributed to the fact that during summer season, new species goes on sprouting depending upon the root/seed stock in the soil and thereby adding to species in total resulting in more diversity. During autumn and winter season the rate of sprouting of root/seed stock is diminished and species number declined owing to adverse climatic conditions [80]. The lower diversity during autumn and winter season recorded at most of the study sites may also be due to lower rate of evolution and diversification of communities [81,82] and severity in the environment [83]. Comparatively, results of Shannon diversity at both sites fall within the range of the other studies [84-86,72]. However, highest species diversity during summer season at site I might be due to the moderate level of grazing or anthropogenic disturbances and invasion of new species [8,87,72]. Many other studies mentioned similar results pertaining to the present study emphasizing moderate level of anthropogenic disturbances promoted species diversity [88,89]. [90] in their study were also of the same view that species diversity increased due to moderate level of disturbances. [77] recorded similar results about species diversity in herb layer vegetation of Bhoramdeo Wildlife Sanctuary, Chattisgarh. However, [91] and [9] considered it as a positive force that might increase species diversity in the community by preventing competitive exclusion by dominant species. Highest trend in species diversity during summer season at most of the sites could be due to various environmental and climatic factors [92]. The results further suggest that underlying site conditions, specifically soil type, and potentially aspect, affect the way understory plant diversity will respond to ground disturbance and light availability. However, ground disturbance is more influential immediately after a disturbance, but lessen in its importance as succession progresses. These effects also are more pronounced on the drier sites [93]. Human disturbances, particularly from the overexploitation of biological resources, generally have negative impacts on species diversity at a global scale [94,95]. However, research shows that less severely disturbed forests (intermediate disturbance) provide optimum environments for enhancement of α-diversity [96,8,97,98,99]. In such forests, openings of the canopy allow sunlight to reach the forest floor. Environmental heterogeneity is increased under such conditions through the development of microhabitats with a number of patches, gaps, and edges. Concomitantly, physical properties of the environment (light, temperature, soil moisture, and nutrient resources) are also improved which can provide suitable habitats for new species to colonize. Disturbance-mediated resource heterogeneity has been considered as the major driver of high understory species diversity in mature forests [100].

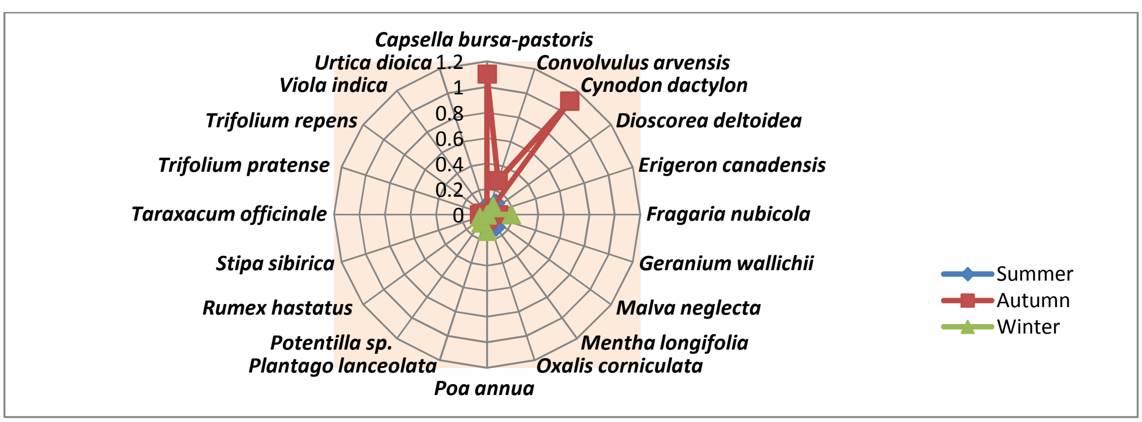

Fig. 14. A/F values of species recorded at site I

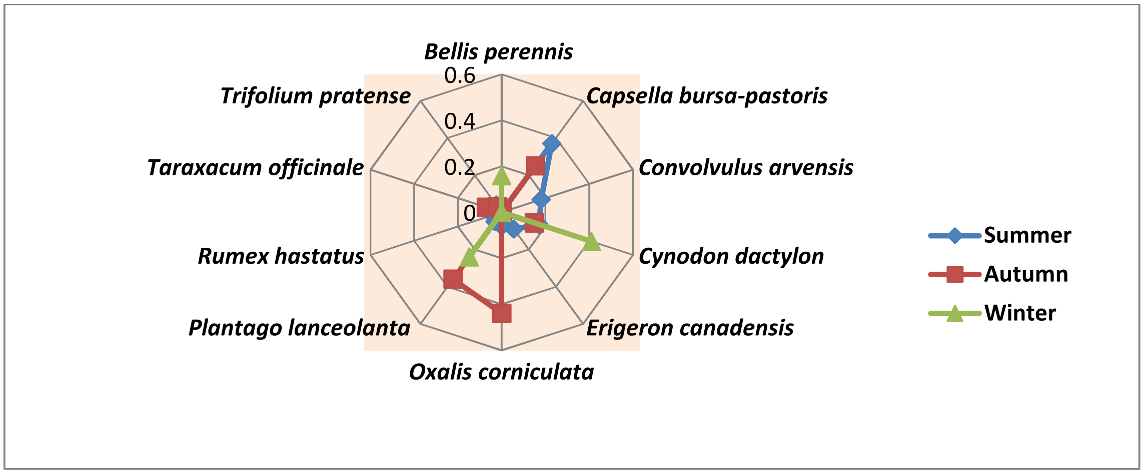

Fig. 15. A/F values of species recorded at site II

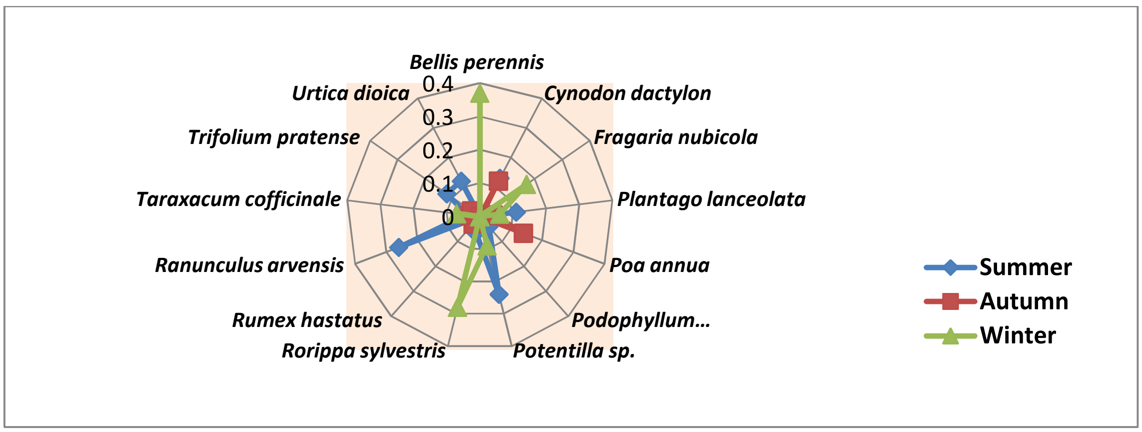

Fig.16. A/F values of species recorded at site III

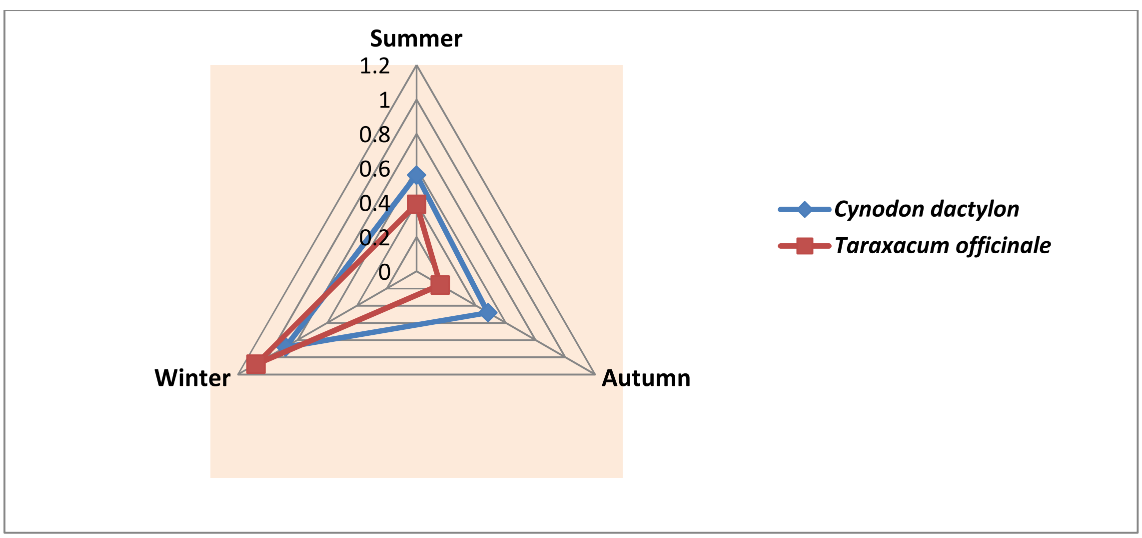

Fig. 17. A/F values of species recorded at site IV

Concentration of dominance ranged from 0.118 $_{(summer)}$ to 0.804$_{(winter)}$ at site I; 0.213$_{(summer)}$ to 0.355 $_{(winter)}$ at site II; 0.217$_{(summer)}$ to 0.399$_{(winter)}$ at site III and 0.746$_{(summer)}$ to 0.788$_{(winter)}$ at site IV. Compatible results of inverse relationship between diversity and dominance were also reported by many other studies [101,72,51]. The average Pielou's indices at the four study sites were around 0.654 (site I); 0.828(site II); 0.731 (site III) and 0.625 (site IV) indicating low dominance and more or regular distribution of plant species in the study sites. These results indicate that sites have influence on species evenness. Disturbance has more influence on species evenness and diversity than richness, but these effects are also site specific [93]. Species richness showed average value of 1.900 (site I); 0.951(site II); 1.246 (site III) and 0.516 (site IV). Our results support the idea that following a disturbance habitat heterogeneity and niche differentiation may be as or more important than overall site productivity in influencing species richness [102] at least at small spatial scales. Species richness was at lower side during autumn and winter season which could be due to dry environmental conditions and also due to slow growth rate, to a maximum in summer season which could be due to favorable climatic conditions [79,91]. Richness index observed higher values at site I (2.83$_{summer}$, site II=1.341$_{summer,}$ 1.580$_{summer}$site III and 1.180 at site IV) and lowest during winter season at three sites (site I=1.032; site II=0.612 and site III=0.89 and 0.184 in autumn season at site IV). Concerning the species richness, a high number of species results with in higher community stability or rather resilience [103]. This wide diversity takes the advantage of heterogeneity and increases their diversity. The level of heterogeneity created, obliviously would depend on the height and architecture of the woody species [104].

High importance value (IV) of a species indicated its dominance and ecological success, its good power of regeneration and greater ecological amplitude. It does vary with the season. The reason why certain species grow together in a particular environment is usually because they have similar requirements for existence in terms of environmental factors such as light, temperature, water, soil nutrients and drainage etc. They may also share the ability to tolerate the activities of animals and humans such as grazing, burning, cutting or trampling [105]. In accordance to our results for site I to site IV, *Bellis perennis*, *Capsella bursa-pastoris*, *Cynodon dactylon*, *Fragaria nubicola*, *Taraxacum officinale* and *Trifolium pratense* showed maximum importance value (IV) during autumn and winter season indicating its dominance due to environmental suitability and ability of the species against grazing activities and other disturbances during different seasons. However, their dominance at a particular site and season could be due to the availability of optimum conditions for their growth. Favourable observations in support of results were achieved by other studies based on seasonal changes in the IVI value of species that makes them dominant during different seasons [106,92]. The growing dominance of non-palatable and other species in the selected sites is probably an indication of adaption against herbivory and adverse climatic conditions. [107] while working in pasturelands of Garhwal Himalaya reported same trend in their results as concurred in the present study. At site I and site II maximum IVI was shared by *Bellis perennis, Capsella bursa-pastoris, Cynodon dactylon, Fragaria nubicola, Oxalis corniculata, Plantago lanceolata, Poa annua, Stipa sibirica, Taraxacum officinale* and *Trifolium pratense* during most of the seasons whereas at site III and IV *Bellis perennis, Cynodon dactylon, Plantago lanceolata, Poa annua, Taraxacum campylodes* and *Trifolium pratense* occupied maximum species during different seasons. Their dominance during a particular season can be well correlated with the other studies [106,79]. Moreover, high importance value by any individual species indicated that most of the available resources are being utilized by that species and left over are being trapped by another species as the competitors and the associates. This could be the reason why high importance value of species was always reported highest by few species during autumn and winter than rest of the seasons. Other reason for their dominance during autumn and winter season could be as the rate of sprouting of root/seed stock is diminished and the species number declined owing to adverse climatic conditions.

It is generally argued that each individual species depends on some other species for its continued existence and on the species co-evolved in the ecosystem on which they depend [108]. The loss of natural associations may be the probable reason for supporting low number of species [109]. It is to be mentioned that distribution of niche space or availability of resource was equally distributed among all species that showed maximum dominance during autumn season at site I, summer, autumn season at site II and site III. However, at site I only 2 to 3 species occupied more niche space than other species during a particular season while as at site III and IV only 1 to 2 species occupied maximum niche. In accordance to these observations it can be mentioned that the nature of plant community at a place is determined by the species that grow and develop in such environment [110]. Difference in the species composition from site to site is mostly due to micro-environmental changes [111].

The distribution pattern depends both on physico-chemical natures of the environment as well as on the biological peculiarities of the organisms themselves. Abundance and frequency ratio (A/F) ratio was used to assess the distribution pattern of species which revealed that most of the species in the present study were contagiously distributed (50%-100%, site I; 62%-100%, site II; 28%-100%, site III and 100%, site IV) followed by random (11-31%, site I; 37%, site II; 33%-57%) and regular (18%-30%, site I, 25% site II and 14% site III) during study seasons. Dominance of contagious distribution may be due to the fact that majority of species reproduce vegetatively in addition to their sexuality. In natural conditions contagious distribution is most common type of distribution and is performed due to small but significant variation in environmental conditions while random distribution is found only in very uniform environment [112]. Contagious distribution of species followed by random and regular were also reported in the study conducted by [77,92,80,113,114,115,116] which compatibly supports the results obtained in the present study. Furthermore, observations indicated that contagious distribution in vegetation (as recorded in all the three sites) was due to multitude factors and the vegetative reproduction may not be the only reason [115,117,72].

5. CONCLUSION

From the present study, it can be concluded that seasons have great influence on the diversity of ground flora. The seasonal break-up of species recorded at four sites showed maximum species occurrence during summer season (site I=20, site II=10; site III=13; site IV=2). Overall a decreased trend was observed in species occurrence from summer to winter season.The disturbed sites supports more herbaceous vegetation as compared to undisturbed sites because of reduction in competition for space and resources. The earlier studies conducted by [73] and [74] have also reported that herb species increase in number immediately after fire because of a general reduction in the tree cover which brings more light to the soil and for growing understorey. The sites/areas facing biotic disturbances supports more herbaceous vegetation as compared to undisturbed one due to the lower competition for various resources [118,119]. Species diversity increased during summer season and thereafter declined due to autumn and winter occurrence based on dry environmental conditions, slow growth rate and other climatic factors ($1.442_{(winter)}$ to $2.238_{(summer)}$ at site I, $1.143_{(winter)}$ to $1.717_{(summer)}$ at site II, and $1.214_{(winter)}$ to $1.590_{(summer)}$ at site III and $0.421_{(summer)}$ to $0.441_{(winter)}$ at site IV). Further variations in quantitative parameters like species richness and species diversity are related to various factors such as edaphic features, elevation, slope aspect and micro-climatic conditions between the sites. Comparative assessment of all sites depicted species diversity highest at site I (2.238) due to moderate level of grazing/ anthropogenic disturbances such as fuel folder collection by local population and due to increase in tourist activities. However, seasonal trend depicted increase in diversity pattern as season changes which are due to various environmental and climatic factors prevailing in the area such as edaphic features, elevation, slope aspect and micro-climatic conditions. Ssubstantially higher herbaceous species diversity was observed at protected sites (I & III) compared to unprotected one (II & IV). In agreement with these results [120] and [121] reported that grazing by domestic livestock is commonly associated with changes in species composition in rangelands throughout the world. High dominance at site I and site II was shown by *Bellis perennis, Capsella bursa-pastoris, Cynodon dactylon, Fragaria nubicola, Oxalis corniculata, Plantago lanceolata, Poa annua, Stipa sibirica, Taraxacum officinale* and *Trifolium pratense* whereas at site III and IV *Bellis perennis, Cynodon dactylon, Plantago lanceolata, Poa annua, Taraxacum officinale* and *Trifolium pratense* indicated their dominance due to environmental suitability and ability of the species against grazing activities and other disturbances during different seasons. These observations can be correlated with the other studies [106,92]. Based on the scientific observations recorded during the study, it is suggested that protection measures are required in the study selected forest area to prevent further degradation. However, seasonal monitoring of degraded sites followed by their temporary closure at least for a period of 5 to 10 years are urgently recommended which can encourage and improve regeneration, enhance plant diversity in the study forest sites. Other strategies needed for biodiversity conservation in the study area include reduction of pressure on resources, rehabilitation of sensitive species, and restoration of degraded sites, sustainable extraction of fuelwood/small timber and sustainable tourism management.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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