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Floristic composition of alpine grassland in Gulmarg, Kashmir

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Abstract
Floristic composition of high-altitude alpine grassland, located in Baramulla district of Jammu and Kashmir, was investigated under three different seasons. The grassland comprised of two sites- protected and grazed site with diverse habitat types and seasonal effect. The disturbance was severed on the protected site, while at grazed site, grazing was main disturbance factor. A total of 64 species belonging to 23 families and 56 genera were recorded in Gulmarg grassland. The dominant families were Poaceae (14 spp.), Asteraceae (6 spp.), Lamiaceae (6 spp.), Fabaceae (5 spp.), Polygonaceae (5 spp.), Caryophyllaceae (4 spp.), Plantaginaceae (4 spp.), Rosaceae (4 spp.) and Apiaceae (2 spp.). The number of species were found higher (42) in the protected site, while it was lower (21) in grazed site. In terms of life form spectrum, the vegetation was characterized by high proportion of hemicryptophytes indicating a heavy biotic interference in the form of overgrazing. The maximum similarity index value (74%) was found in the autumn seasons. Although the species richness was found highest in protected site and occurrence of some rare and useful herbaceous species in this site demands a long term conservation plan, if their survival was to be continued in this grassland.

Keywords: Alpine grassland, Conservation, Floristic composition, Grazing, Species richness

Introduction

Grassland vegetation is broadly inferred to include grasses, legumes and other forbs and sometimes, woody species (Allen *et al.,* 2011). Grasslands are subjected to various disturbances (grazing, fire, drought etc.), thus are ideal settings to study both the effects of single disturbance type and potential interaction effects (Collins, 1992; Hobbs and Huenneke, 1992). Even in months, grasslands are very sensitive to climate fluctuation. At a regional scale, human activities and natural disturbances can also alter grassland floristic composition (Collins and Smith, 2006). The alpine grass--lands of Jammu and Kashmir account for 77% of the total alpine grassland area of 171464 km^2 of the Indian Himalayas (Lal *et al.,* 1991). Because of the availability of these rangeland resources, over 25 per cent population of Jammu and Kashmir are nomads and semi nomads namely Gujjars, Bakerwals, Chopans, Chongpas and Gaddies whose livelihoods are dependent on rangeland based pastoral or agro pastoral systems. Available grazing area in sub-alpine and alpine pastures of Kashmir decreased from 0.15 ha/animal in 1977 to 0.10 ha/animal in 1982 (Misri, 2003) and continued to decrease thereafter (Qureshi *et al.,* 2007). Grasslands of the Kashmir valley known for their aesthetic, biological and cultural values, which are being subjected to varied disturbances like grazing, mowing, trampling etc. owing to overgrazing and as such degradation of pastures has achieved critical dimensions all across the globe. The end results of such changes have been an alteration in the composition of these grassland ecosystems (Dad and Khan, 2009). The continuous and intensive grazing has deteriorated the status of these grazing areas to a great extent. Jammu and Kashmir has 40% deficit in fodder on dry matter basis and deficiency is more pronounced in segments of green fodder and concentrates (Wani *et al*., 2014). The increasing trend in the livestock population in the Kashmir valley has resulted in sharp increase in density of livestock per unit grazing land (Singh *et al.,* 2018). The total area under productive grassland is about 9595 km^2 (4.32%), whereas other grazing lands including scrubs and other unpalatable grasslands are 10455 km^2 (9.81%) of the total geographical area of Jammu and Kashmir (Singh *et al.,* 2018). Plants that lose tissues due to grazing must use assimilated carbon and nutrients to regrow their parts (leaves and roots), leaving less palatable species to grow taller and increase in number (Baer *et al.,* 2005). Grasslands at present time are readily exploited resource for domestic grazers. However, if not managed properly, grasslands can be easily overexploited with subsequent land degradation, nutrient loss, and susceptibility to invasion by undesirable plant species. In grassland

communities, topography, edaphic factors and disturbances produce regional variations in composition and structure of vegetation (Belsky, 1988). In the present study also, all these three factors were perhaps responsible for differences in the composition and structure of vegetation on the protected and grazed site. Hence, the main objective of this study was to assess the short-term (3 seasons) effects of grazing and non-grazing on floristic composition and seasonal variation on vegetation existence.

Materials and Methods

***Study site*:** Jammu and Kashmir is located in north-western extremity of India between 32° 17′ and 38° 58′ N latitude, and 73° 35′ and 80° 36′ E longitude (Anonymous, 2001). Gulmarg lies in a cup shaped valley in the PirPanjal Range of the Himalayas, at an altitude of 2650 m and situated at 34.2° N and 74.4° E. The climate in general is temperate type. Winter is severe, extending from December to March. The region faces a wide temperature range from a minimum of -8° C in winter to a maximum of 33° C in the summer for short period. The area receives an annual precipitation of 675 to 1193 mm.

Gulmarg grassland is high altitude (2600 m) grassland and remains snow free from late April to late October. The grassland is grazed for 7 months by livestock population of Baramulla district. Grazers such as cattle, sheep, goats and horse are seen in the herds. However, sheep (herds) were found the most common grazers over goats, cattle and horses during the investigation. Gulmarg grassland comprised of two sites. Protected site, which was protected by Ecology Society along with Forest Department of Baramulla district of Kashmir through wire fencing and another was grazed site, which was not fenced and open for grazing throughout the year. The observed grazers moved freely in the grazed site of the grassland for grazing and affecting the life form and structure of studied grassland.

***Vegetation survey*:** Vegetation survey on the floristic composition of selected grassland was carried out from May to October 2017 in three prominent seasons *viz*., spring (May-June), autumn (July-August) and summer (Sept-October). The grassland comprised of two sites *viz*., protected and grazed, were selected to give an insight into the overall change in the floristic composition of the selected grassland due to grazing.

Vegetation assessment were conducted with 30 quadrates in each season *viz*., spring, summer and autumn season at protected as well as grazed sites, and thus a total of 180 quadrates were placed randomly at both sites during the course of investigation. The size of laid quadrate was $1m^2$ (1m×1m) for herbaceous species. The size and number of quadrates were decided based on the species-area curve (Misra, 1968). The numbers of plants were counted for each species in all the laid quadrates of both sites. Plants samples were collected, dried and analysed using a conventional method (Curtis and McIntosh, 1950). Collected samples from both sites were identified with the help of Department of Botany Science, Kashmir University, India.

Importance value index (IVI): Herbaceous species phytosociological characters were evaluated by analyzing the frequency, density, abundance and importance value index (IVI) using a formula recommended by Curtis and McIntosh (1950).

Species diversity: Shannon-Wiener index (Shannon and Wiener, 1949) measured the species diversity within the community of an ecosystem. It was zero if the sample in consideration had only one species and it was maximum when all species of the sample in consideration had even abundances (Sagar and Singh, 1999). It was calculated as:

$$H' = - \Sigma \text{ pi } ln \text{ pi} \quad \text{..... (i)}$$

Where, H' = Shannon index of diversity, pi = the proportion ni and N *i.e*, pi = ni/N; ni = total number of individuals of one species and N = total number of individuals of all species.

Margalef's index of richness (Dmg): Margalef's index was used as a simple measure of species richness (Margalef, 1958). It was calculated as:

$$Dmg = (S-1)/ln \text{ N} \quad \text{..... (ii)}$$

Where, Dmg = Margalef's index of richness, S = total number of species, N = total number of individuals in the sample.

Similarity index: Similarity Index is used to compare vegetation communities of various sites. Indices of similarity and dissimilarity were calculated by using Sorensen (1948) formula which was as follows:

$$\text{Index of similarity (S)} = 2C/A+B \quad \text{..... (iii)}$$

Where, S = Similarity, A= number of species in the community A, B= number of species in the community B, C= number of common species in both the communities. While index of dissimilarity was calculated as:

Index of dissimilarity = 1-S..... (iv)

Index of dominance: Simpson index (Simpson, 1949) measured the strength of dominance. A value of Simpson index ranged from 0 to 1, where '0' represented no dominance and 1, for maximum dominance means only one species in the sample (Berger and Parker, 1970). Simpson index also varied from 0 to 1, where zero represents no diversity and 1 for maximum diversity. It was calculated as:

$$D = \Sigma (pi)^2 \quad \text{..... (v)}$$

Where, D= Simpson index of dominance, pi= the proportion ni and N *i.e*, pi= ni/N; ni= total number of individuals of one species, N= total number of individuals of all species. As D increased, diversity decreased and Simpson's index was expressed as 1-D or 1/D.

Results and Discussion

***Floristic composition*:** Vegetation composition is a measure of species diversity in community. Consequently, it helps in identifying systematic types. Although it is a long term process to give conclusive information of vegetation composition in an area as it is expected to change with season. Effects of biotic as well as abiotic variables in a community and their interactions influence the vegetations (Whittaker, 1970). A total of 64 species belonging to 23 families and 56 generas were recorded during the study in Gulmarg grassland. Out of the total families recorded, Poaceae was the dominant family represented by fourteen species (Fig 1). Out of the total recorded genera, the highest numbers of two species were represented by six genera *viz*., *Festuca, Mentha, Plantago, Poa, Rumex* and *Trifolium* (Table 1) at protected site. Dad and Khan (2009) also recorded a total of 88 plant species belonging to 35 families and 70 genera in the temperate grasslands of Kashmir. The number of species was highest (40) in the site protected to nomads in the upper slope, while it was lowest (18) in an abandoned site in the flat valley.

***Change in floristic composition*:** The analysis of data of protected site revealed that presence of forty one herbs species in the spring season (Table 1). Highest density, maximum frequency, highest basal area and maximum importance value index was recorded for *Cynodon dactylon* in all three seasons. However, *Veronica laxa* was not found in the spring and autumn seasons which was found in the summer season. Thirteen species which were reported in summer season were not found in the autumn season. However, all the forty two species were found in the summer season, since summer season had more favorable conditions for the growth and development of the herbs species.

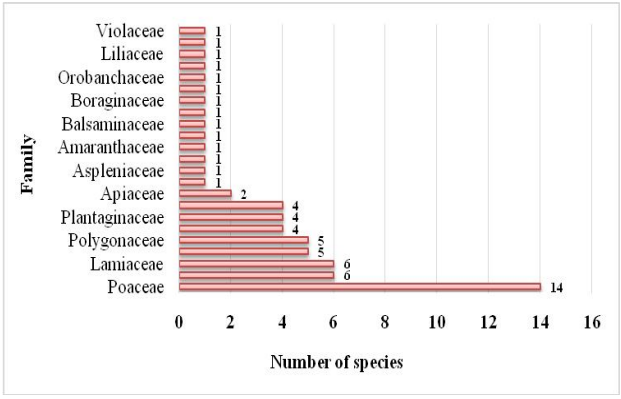

Fig 1. Family statistics of Gulmarg grassland

At grazed site, results revealed that presence of twenty one herbs species in the spring and summer season. Highest density, maximum frequency, highest basal area and maximum importance value index was also recorded for *Cynodon dactylon* in all three seasons, However, *Daucus carota, Fragaria nubicola, Prunella vulgaris* and *Tulipa stellata* were not found in the autumn season at grazed site (Table 1). Grazing is one of the most important disturbances of grasslands in terms of both grassland production and vegetation dynamics (Tietjen and Jeltsch, 2007; Baba *et al.,* 2017). The impact of grazing showed decline in the number of species at grazed site as compared to protected site during the study in Gulmarg grassland.

The magnitude of changes in plant community was studied through phytosociological attributes, mainly by density, frequency, abundance and total basal area for vegetation. In the present study, plant community at both sites was analyzed in different seasons for various parameters necessary to describe a plant community. This spatial cum temporal analysis depicted a considerable change in the composition of plant species due to the grazing pressure and also loss of vegetation cover at the grazed site. At grazed site, the number of plant species declined overtime, mainly the palatable species due to the selective grazing behaviour of animals, thereby decreasing the ratio of palatable to non-

palatable species. It was observed that some species were absent in the grazed site from summer onwards which were otherwise reported in spring season whereas all species were present in the protected site in summer season too. Similar observations were also reported by other workers elsewhere (Vesk and Westoby, 2000; Sher *et al.,* 2005; Kukshal *et al.,* 2006; Baba *et al.,* 2017).

Table 1. Importance value index of herbs under different seasons at protected and grazed sites

Name of species	Protected site			Grazed site		
	Spring	Summer	Autumn	Spring	Summer	Autumn
Achillea millifolium L.	8.38	7.89	12.25	14.71	12.98	13.78
Agrostis canina L.	6.31	6.56	7.62	0	0	0
Argemone maxicana L.	7.46	6.74	12.05	9.21	11.83	20.43
*Artemisia biennis*Willd.	7.83	6.82	0	0	0	0
Capsella bursa pastoris Medik.	7.87	6.65	11.72	0	0	0
Cerastium vulgatum L.	6.63	6.23	7.51	9.46	10.03	8.36
Cynodon dactylon Pers.	31.64	30.99	48.88	39.71	33.90	53.26
Daucus carota L.	8.72	7.47	11.53	9.43	10.64	0
Digitalis purpurea L.	4.42	5.04	0	0	0	0
Festuca arundinacea Schreb.	8.82	8.26	10.37	0	0	0
Festuca rubra L.	6.41	6.43	0	0	0	0
Fragaria nubicola Hook. f.	8.25	7.50	8.77	6.44	9.23	0
Geranium rotindifolia L.	6.99	7.09	10.93	0	0	0
Heracleum maximum W. Bat.	5.57	5.79	0	13.77	12.40	14.88
Hypericum perforatum L.	9.66	9.15	15.55	0	0	0
Impatiens glandulifera Royle	4.68	5.19	0	0	0	0
Lolium perenne L.	9.85	7.98	0	0	0	0
Marticaria chamomilla L.	9.08	8.21	12.24	23.39	21.16	25.51
Medicago minima L.	0	0	0	15.72	15.55	14.09
Mentha longifolia Huds.	7.57	6.88	8.06	0	0	0
Mentha spicata L.	9.14	8.22	11.38	0	0	0
Nepata cataria L.	4.92	5.75	6.53	0	0	0
Pedicularis punctate L.	5.26	6.05	0	0	0	0
Plantago lanceolata L.	7.39	6.61	9.78	15.40	14.50	16.62
Plantago major L.	5.84	6.65	7.74	12.55	12.65	14.01
Poa annua L.	5.58	6.30	6.48	10.91	12.28	9.42
Poa pratensis L.	8.99	6.44	8.01	10.91	13.37	10.40
Polygonum hydropiper L.	7.10	5.75	7.41	11.44	12.61	7.06
Potentilla nepalensis Hooker	3.68	4.6	0	0	0	0
Prunella vulgaris L.	5.24	5.47	3.45	10.27	12.34	0
Ranunculus hirtellus L.	6.22	6.36	6.39	0	0	0
Rumex dentatus L.	9.80	8.08	13.17	17.44	15.48	17.86
Rumex nepalensis L.	8.05	7.64	8.76	15.66	14.63	16.43
Silene vulgaris Garcke	3.93	4.51	0	0	0	0
Sorghum helpense Pers.	5.17	6.08	6.75	0	0	0
Stipa siberica L.	4.96	5.88	6.48	0	0	0
Taraxacum officinale Weber	6.60	7.46	8.65	17.46	16.85	20.99
Thymus linearis L.	5.77	6.26	7.66	0	0	0
Trifolium pretense L.	6.56	7.20	0	16.44	15.77	17.77
Trifolium repens L.	5.92	6.81	0	16.27	15.68	19.09
Tulipa stellata Hook.	3.73	5.36	3.90	3.71	6.12	0
Urtica dioica L.	3.99	4.90	0	0	0	0
Veronica laxa L.	0	4.70	0	0	0	0
Total	**300**	**300**	**300**	**300**	**300**	**300**

Importance value index (IVI) of herbs: The IVI of the *Cynodon dactylon* (Table 1) was higher in the protected site as well as grazed site as it was the dominant species not only at the study area but also in the Kashmir valley (Baba *et al.,* 2017; Hailu, 2017; Dad and Khan, 2009). But the IVI of *Cynodon dactylon* at grazed site was higher in all the three seasons as compared to protected site which may be attributed to competition among various herbaceous species on a limited area on the account of nutrient availability, moisture content of soil, space and light in the fenced area. *Cynodon dactylon* had the highest IVI and density in the enclosure areas as compared to open area (Hailu, 2017). Supporting the findings of Mandal and Joshi (2014) on open grazing areas, the findings in the present investigation indicated that vegetation experiencing stresses from biotic pressure were under serious threat. However, some of the herb species in the open grazing areas managed to survive. This could be attributable to their broad ecological amplitude and greater adaptability against biotic influences (Hailu, 2017). The dynamics of vegetation in a rangeland are determined by array of factors which include fire frequency and intensity, grazing regime, climatic fluctuations and to some extent the soil characteristics. Studies revealed that depending on the seasons, the density of grazers influences both species diversity, spatial heterogeneity and the vegetation structure (Adler *et al.,* 2000; Metzger *et al.,* 2005). The growing dominance of non-palatable species and others in pastureland is probably an indication of adaption against herbivory and adverse climatic conditions (Collins and Smith, 2006; Belsky, 1988). Bhandari *et al.* (1999) made similar observation in pasturelands of Garhwal Himalaya. The possible reason of higher IVI at protected site might be that grazing attributed to increase disturbances at grazed site, making micro-sites available for many opportunistic weed species and reduce the number of palatable species. So this study depicted that at herbaceous level the anthropogenic interference and overgrazing decreases palatable species or species diversity, similar observation was made earlier also (Hailu, 2017; Kukshal *et al*., 2006; Mushtaq and Pandit, 2010; Skornik *et al*., 2010).

***Indices (dominance, species diversity, species richness) of herbs*:** Indices like dominance index, species diversity and species richness were found higher at protected site as compared to the grazed site (Table 2). So this study depicted that at herbaceous level the anthropogenic interference and grazing decreased species richness, species diversity or evenness index and dominance index, similar observations were also made by other workers (Kukshal *et al.,* 2006; Skornik *et al.,* 2010; Mushtaq and Pandit, 2010; Baba *et al.,* 2017). Species diversity is one of the most important characteristics of a plant community. It is a mechanism which generates stability. The nature of plant community at a place is determined by other species that grow and develop in such environment (Bliss, 1962). The general structure of species at both the natural sites indicated increasing trend in their numbers mostly during spring. The maximum occurrence of species during spring and summer season at both sites could be due to availability of moisture provided mostly by rains and through other environmental factors. Similar pattern of observations were also mentioned by others from India and elsewhere (Sharma and Upadhyay, 2002; Baba *et al.,* 2017). Alhassan *et al.* (2006) in their study reported similar climatic factors responsible for the variation in species number and diversity from Nigeria.

The species diversity in the present investigation was found higher at protected site. Indeed, diversity was highest at protected site than grazed site in all the three seasons. Similar results were obtained by Dad and Khan (2009) where Shannon-Wiener diversity index (H) value was highest at protected site. Comparatively, values of Shannon diversity obtained in the present investigation at both sites were within the range reported earlier by many workers (Lalfakawma *et al.,* 2009; Yadav and Gupta, 2007; Kharkwal *et al.,* 2004; Baba *et al.,* 2017). An increasing trend in species diversity was observed from spring onwards which declined with the commencement of autumn at both sites. This characteristic was attributed to the fact that during spring season new species go on sprouting and depending upon the viable root/seed stock in the soil and thereby adding to species in total and resulted in more diversity. During autumn season the rate of sprouting of root/seed stock gets diminished and species number declines owing to adverse climatic conditions (Shadangi and Nath, 2005).

Table 2. Shannon wiener diversity index (H), Margalef's species richness index (Dmg) and Simpson's index of dominance (D) of herb species in three different seasons at protected and grazed sites

Sites	Season	H	D	Dmg
Protected	Spring	2.93	0.95	2.24
site	Summer	3.06	0.97	2.47
	Autumn	2.87	0.94	2.14
Grazed	Spring	1.92	0.58	1.31
site	Summer	2.05	0.36	1.95
	Autumn	1.86	0.25	1.27

***Similarity and dissimilarity index at both sites*:** The selected sites, when compared on the basis of species similarity index, had maximum similarity (74%) in autumn and maximum dissimilarity (33%) in summer (Table 3). Results in the present study were in line with the results obtained by Hailu (2017). During summer season herbaceous flora showed more diversity due to favorable climatic conditions and maximum growing period, while in the autumn season, due to snow fall, in temperate grasslands, few herbaceous species grew and showed less diversity and more similarity. Sharma and Upadhyaya (2002) observed an increase in the soil nutrients and species diversity at the protected site from Aravalli hills. A high degree of dissimilarity of herbs and grasses in such land uses was also reported by Verma *et al.* (2005) and Baba *et al.* (2017). Variation of herb distribution in the enclosure areas might be attributed to the survival and reproduction of maximum species due to moderate level of species competition during early regeneration which led to the domination of only a few species (Hailu, 2017).

Table 3. Similarity and dissimilarity index of herb species in different seasons between protected and grazed sites

Season	Similarity index	Dissimilarity index
Spring	0.68	0.32
Summer	0.67	0.33
Autumn	0.74	0.26

Conclusion

A total of 64 species belonging to 23 families and 56 genera were recorded in Gulmarg grassland, indicating that Gulmarg grassland has less floral diversity as compared to other Himalayan grasslands. The number of species were found higher (42) in the protected site, while it was lower (21) in grazed site. Thus, Gulmarg grassland is facing more human interference and overgrazing pressure and the establishment of enclosures had positive effects in restoring the diversity and productivity of grassland vegetations.

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