The Bioscan 6(2) : 185-190, 2011
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF CLIPPING AND GRAZING ON VARIOUS VEGETATIONAL PARAMETERS OF GRASSLAND COMMUNITIES IN BUNDELKHAND REGION (U.P.)

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KEY WORDS
Diversity
Dominance
Grassland communities
Moderate grazing
Clipping

Received on :
30.12.2010

Accepted on :
27.04.2011

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ABSTRACT

Two grassland communities of Bundelkhand region, one on the managed (periodically clipped) and protected site of G.I.C. ground (site I) and the other moderately grazed, open natural site of D.V. (P.G.) College Campus (site II) were selected and analysed for the comparison of various vegetational parameters. Out of the total 46 species, 19 were common to both sites, 7 species occurred exclusively at site I and 20 species at site II. The majority of the species at both the sites were fortuitous. On managed site, only a few species showed high values of phytosociological indices while open natural and moderately grazed site showed more even distribution of values. Upper strata species like *Desmostachya bipinnata, Fimbristylis dichotoma* and *Vernonia cinerea* were rare in abundance at managed site while *Chrysanthellum indicum, Dactyloctenium aegypticum* and *Cassia tora* were rare at natural site. The community at site I showed markedly higher dominance and the lower diversity and evenness values as compared to those at site II. A high species turnover of 8.8 indicates considerable differences between the managed and natural sities with respect to species richness and population size of key species.

INTRODUCTION

The various aspects of plant community of grassland vegetation in different parts of India have been studied by a number of workers at grassland vegetation of Bombay (Bharucha and Dave, 1944); Varanasi (Ambasht *et at.,* 1972; Misra, 1972; Singh, 1967); Jodhpur (Gupta and Sharma, 1973); Kurukshetra (Singh and Yadava, 1974); Sagar (Trivedi, 1976); Jhansi (Trivedi, 1991) and Orai (Gupta, 1993; Ratan, 2004).

Inspite of these efforts, the grassland communities of western U.P. specially the Bundelkhand region largely remained under un-explored except for a few studies on population interaction, and productivity of selected species (Ashthana, 1975; Dwivedi, 1978). Least informations are available on the impact of disturbance on these communities. In general the effect of disturbance on the richness and abundance of species within old-field communities have been assessed (Armesto and Pickett, 1985; Tilman and Pacala, 1993; Cole, 1995; Hulme, 1996). Liddle (1975) made a selective review of the ecological effects of human trampling on natural ecosystems.

The present analysis, therefore, compares the quantitative characters of a natural grassland vegetation, open to moderate grazing and a managed and closed grassland community facing periodic clipping and moderate trampling.

MATERIALS AND METHODS

The Study Site

The present study site located at 25°59′ NL and 79°37′ E L and 141.61 m above mean sea level, represents a dry sub-humid typically monsoonic climate with average annual rainfall about 1186.8 mm (90% rainfall during monsoon period). The mean annual temperature of study site (Orai) is 24.8°C but mean monthly values considerably vary from their annual means (14.5 to 35.5°C) and consequently their ranges are high. The temperature start rising rapidly in March and reaches at a maximum of 42°C in May. In winter season the temperature varied between 10 to 25°C and the night temperature some times dropped below 6°C. The soil of the region is alluvial, sandy loam and usually light olive brown in colour, having a slightly alkaline pH range (pH 7.3-7.6).

Due to human settlement and agricultural practices, natural vegetation has been degraded to thiny scrub forest and grassland vegetation which represents a state of arrested succession. The G.I.C. ground (site I), a managed grassland, is periodically clipped and faces moderate trampling. The site is about 40 years old and covers over 2 hectares area within close boundaries. The grassland (site II) at the campus D.V. (P.G.) College is open to moderate grazing. It is over 35 years old and covers about 1.5 hectares area.

The two grasslands, selected as representative grassland communities of western part of Bundelkhand region (U.P.), were analysed for the comparison of various phytosociological attributes on the basis of data recorded during the peak growing season (August-November). The requisite size of quadrat (50x50 cm) was determined through species-area-curve method (Mueller-Dombois and Ellenberg, 1974). A total of 100 quadrats were laid within each community. The occurrence and numerical strength of each species was noted carefully in each quadrat for assessment of frequency and density. The number of quadrats of occurrence of a species, expressed as percentage of the total number of quadrats sampled, was taken as frequency, and the number of individuals of a species in all quadrats, expressed as the function of the number of total quadrats sampled, as density of that species. The basal cover, however, was estimated through quadrat method (Misra, 1968). The sum of area covered by the individuals of a species, expressed as basal area per unit area (cm^2/m^2). The relative value of these vegetational parameters were calculated to derive Importance Value Index (IVI) for each species (Mueller-Dombois and Ellenberg, 1974).

The frequency diagrams for the communities at the two sites were compared with the normal frequency diagram of Raunkiaer's (1934). Phytograph, a device to show the IVI of a species along with its constituent indices-relative frequency (RF), relative density (RD) and relative basal cover relative dominance (RDo) was also drawn to compare the overall phytosociological importance of the species common to both the communities. The stratification within each communities was based on percent number of species occupying different strata which were based on height classes and were represented in the form of histogram.

The exclusives (species restricted to a particular community), the top ten species having maximum share to the values of above indices and the most rare species having very low values of frequency (<5%) and density (<0.5 individuals m^{-2}) were grouped separately. The contribution of these groups to the sum values of different phytosociological indices like frequency, density and IVI was determined for each of the two communities. The χ^2- values were estimated on the basis of frequency of observed value (fo) and that of expected value (fe) as $\chi^2 = \Sigma (fo - fe)^2/fe$. The fe was taken as the average of values of any index at the two sites. The significance of difference was considered at 5% probability level.

The log number of individuals on Y-axis was plotted against the species sequence from most to the least abundant ones on X-axis. It provided the dominance-diversity curves (Whittaker, 1975) for the two sites. Species diversity index (H), however, was determined with the information function on the basis of abundance values as $H = - \Sigma \; (ni/N) \; 1n \; (ni/N)$. Where, H is the Shannon-Weiner index of diversity, ni is the total number of individuals of i^{th} species, N is the total number of individuals of all the species in the community and 1n is the natural log (Magurran, 1988). The Simpson's index (Simpson, 1949) or the concentration of dominance (Cd), was derived as $Cd = \Sigma (ni/N)^2$. Where, ni and N are same as given above. Species evenness or equitability (E), was calculated following Pielou (1975) as $E = H/\log_2 S$, where, S is the total number of species. β-diversity (Hβ) was derived to compare the species turnover between the two communities (I and II) on the basis of formula $H\beta = Ha \; 1.2\text{-}0.5 \; (Ha_1 - Ha_2)$, where a_1 and a_2 are the α-diversity of the two communities (Ramade, 1984).

RESULTS

In all 46 species were encountered within the sampled quadrats at two sites (Table 1). Both the sites were rich in fortuitous species-frequency class A (*i.e.* species with low frequency), which constituted 53% of the total species content, showed very close similarity class B was comparable to normal value at site II but it was higher at site I. Class C was low at site I and high at site II but class D was comparable to normal frequency at both the sites. No species at either site was abundant enough to represent Class E (Fig. 1A). The proportion of species at different strata varied between two sites. A similar proportion of species fell under lower height range at both the sites. However, the proportion of species belonging to upper stratum was comparatively much higher at site II (Fig. 1B). The dominance-diversity curves for the two sites showed that most of the available niches at site I were occupied by relatively few species compared to site II. The pattern of the curve for site II was comparatively more convex and flattened (Fig. 1C).

A scrutiny of species having higher values of frequency, density, basal cover and IVI shows that 24 species can be included as top ranking which assumed maximum values under different indices (Table 2). *Heteropogon contortus* had maximum importance followed by *Chrysopogon montanus* at site I and *Vetiveria Zizanioides* at site II. *Fimbristylis dichotoma* showed comparatively high values of different indices at site II, while *Spermacoce stricta* did so at site I. At site I, only a few species had high values of these indices, whereas at site II, these values were more evenly distributed among other species. *Evolvulus alsinoides, Paspalum scrobiculatum* and *Vandellia crustacea* showed high IVI primarily due to their high density. The high IVI of *Cassia tora* at site I, can be attributed to higher density and frequency values. As evident from the phytography of 10 common species (Fig. 2), in general *H. contortus, Spermacoce stricta, S. hispida, Cassia tora* and *Eragrostis tenella* showed greater importance at site I. On the other hand, *Desmostachya bipinnata*, and *Vandellia crustacea* exhibited greater importance at site II primarily due to their density values. The phytographs of *Eragrostis gangetica* and *Convolvulus pluricaulis* were quite comparable at both the sites.

Table 3 compares the level of differences in the IVI and relative density of species between the two sites. IVI of *A. monilifer, B. brachiata* and *F. dichotoma* was significantly greater at site II ($p < 0.01$) while that of *C. tora* and E. *tenella* was so at site I. Further the relative density of *A. monilifer, B. brachiata* and *F. dichotoma* was also significantly higher ($p < 0.05$) of site II and that of *C. tora* at site I. The values of above two indices for the species of *Phyllanthus niruri* and *Rungia repens* showed marked differences between the two sites.

Table 4 shows the total number of species, IVI, basal cover and the density and frequency of exclusive species at the two sites. Exclusives were less in number (7:9.8%) at site I compared to site II (20:22.0%), Some of the important exclusives of site I and II are given in Table 4. The total number of species and

Table 1: Species composition of grassland communities at the managed site (I) and natural site (II)

Variables	Site I	Site II
Total number of species	26	39
Species common to both sites	19	
Species exclusive to either site	07	20

Table 2: Top ten species with respect to IVI, basal cover (BC%), density (individuals/quadrat) and/or frequency (%) at the two sites

Name of species	IVI		Basal Cover		Density		Frequency	
	Site I	II	I	II	I	II	I	II
Heteropogon contortus Roem. et Schult.	83.0		36.6	0.6	58.2		88.0	
Vetiveria zizanioides Nash		78.9		46.0		22.3		84.0
Chrysopogon montanus Trin.	64.9		26.6		46.6		80.0	
Fimbristylis dichotoma Vahl.		27.6		94.6		31.5		92.0
Spermacoce stricta Linn.	30.9		1.6		28.2	8.8	96.0	
Paspalum scrobiculatum Linn.		19.7		13.7		5.7		48.0
Bothriochloa pertusa (Linn.) A. Camus	18.1		7.3		7.1		52.0	
Vandellia crustacea Lees.		17.6						
Spermacoce hispida Linn.	15.8		1.7		10.2		64.0	
Bonnaya brachiata Link and Otto		13.7				13.3		80.0
Aneilema nodiflorum R. Br.		12.3		1.9		11.5		64.0
Desmostachya bipinnata Stapf.	10.7	25.9	9.0	23.9		7.4		44.0
Cassia tora Linn.	9.6						64.0	
Evolvulus alsinoides Linn.		10.2		0.5		8.1		72.0
Eragrostis tenella (Linn.) Roem. and Schult.	8.5		5.0		1.6		24.0	
Phyllanthus niruri Linn.		9.6				6.2		80.0
Rungia repens Nees.		8.6		0.6	3.3			
Eragrostiella bifaria Vahl.	7.9		2.9		1.7		28.0	
Cassia kleinii W. and A.	7.8				2.8		40.0	
Eragrostis gangetica Steud.			2.8	1.9	2.5		24.0	
Aristida adscenscionis Linn.			3.3	6.0				
Eragrostis uniloides Nees.								
Vernonia crustacea Benth.						17.3		96.0
Desmodium triflorum D.C.								48.0

their densities were significantly much greater ($p < 0.05$) at site II.

The most rare species at the two sites, identified on the basis of their relative values of frequency and density, are presented in Table 5. *Alysicarpus monilifer, Euphorbia hirta* and *Oldenlandia corymbosa* were the rarest species at both the sites. The relative density of rare species accounted only for 0.03%. They had a relative frequency of around 0.3%. A comparison of contribution of different group of species at the two sites shows that the top ten species accounted for 70% of the total IVI, basal cover and density at both the sites. The exclusive group showed much greater contribution towards the above indices at site II as compared to site I. The contribution of rare species towards the sum values of above indices at the two sites was quite comparable. The rest of the species which has major share of species richness, showed almost similar contribution at both the sites (Table 6). The community at site I, however, exhibited markedly higher dominance and the lower diversity and evenness as compared to that at site II. A high species turnover of 8.8 indicates considerable differences between species richness and density of key species between two sites (Table 7).

Table 3: Species showing significant differences in Importance Value Index (IVI) and Relative Density (RD) between two sites based on χ^2 -values as given in the table

Name of species	IVI		RD	
	Site I	II	I	II
**Alysicarpus monilifer*	2.5	12.3	0.2	6.8
**Bonnaya brachiata*	2	13.7	0.3	7.9
**Cassia tora*	9.6	2	0.9	0.2
**Eragrostis tenella*	8.5	2.8	0.9	1
**Fimbristylis dichotoma*	2.1	26.6	0.8	18.7
Phyllanthus niruri	1.1	9.6	0.1	3.7
Rungia repens	4.8	8.6	1.3	2.8

*The χ^2 - values were significant at 5% probability level

DISCUSSION

Variability in various vegetational parameters on the two study sites occurs in both space and time. The seasonal changes are the most important for this variation. The observation of grassland communities at the two sites exhibited maximum number of species producing seedlings and sprouts just after the first few showers of monsoon rains. Expectedly, the species richness in these communities was maximum during August-November (the sampling period). Earlier observations have indicated that the grassland community at site I, logged behind by about a fortnight as regards to peak flowering (Tripathi, 2000). Relatively higher number of species at site II can be attributed to moderate grazing. Grazing may develop mutulism between the grazers and grazed species and the animal saliva and dung may also promote the growth of some species.

Table 4: Contribution to IVI, basal cover (BC%), density (per quadrat) and frequency (%) for communities at the two sites by exclusive species (the χ^2- values were calculated on the basis of percent values for different indices given in parentheses)

Attributes	Site I	Site II	χ^2-Values
No. of species	7.00 (9.80)	20.0 (22.00)	8.40*
IVI	9.60 (3.20)	35.1 (11.90)	2.89
% BC	4.10 (3.60)	09.2 (07.70)	3.5
Density	0.40 (1.14)	05.7 (11.00)	6.10*
% Frequency	33.00 (5.03)	18.9 (19.40)	2.3

*The χ^2-values were significant at 5% probability level; *Aristida adscenscionis* Linn. *Aneilema nodiflorum* R. Br.; *Bothriochloa pertusa* (Linn.) A. Camus;*Cyperus aristatus* Rottb.; *Chrysopogon montanus* Trin.; *Dichanthium annulatum* (Forsk.) Stapf.; *Justicia simplex* D.; *Kyllinga triceps* Rottb.; *Setaria glauca* (Linn.) P. Beauv.; *Vetiveria zizanioides* Nash.

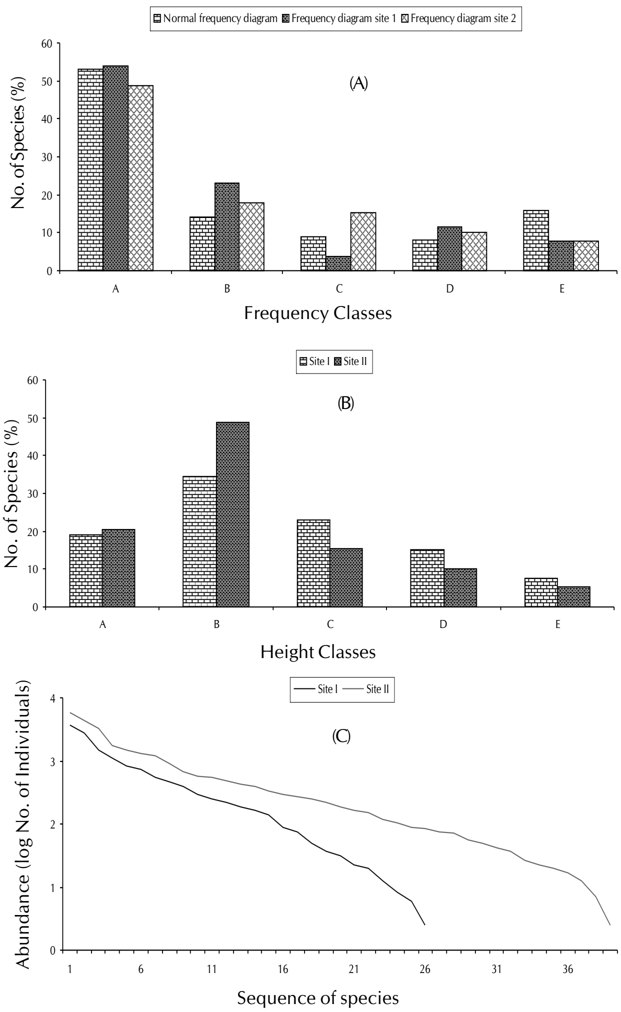

Figure 1: (A) The comparison of frequency diagrams of sites I & site II with Raunkiaer's Normal Frequency Diagram; (B) The % number of species under different height classes (A <5cm; B 6-10 cm; C 11-20 cm; D 21-50 cm; E >50cm) at managed (I) and natural (II) sites, and (C) Dominance-diversity curves, exhibiting the cascade in the number of individual of most to least abundant species at the two sites

Herbivory may prevent competitive exclusion by suppressing the dominance and by preventing dead biomass accumulation (Gough and Grace, 1998). On the other hand, the number of species in the managed or recurrently clipped community of site I is likely to be low as periodic clipping and trampling

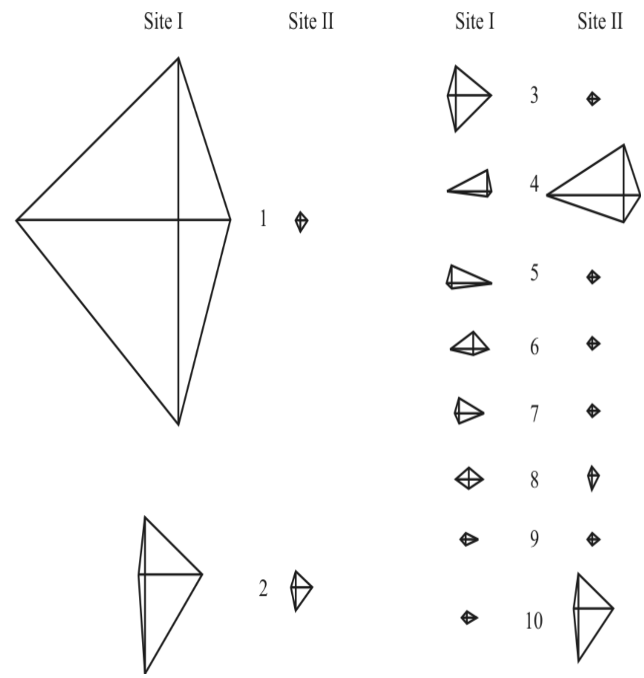

Figure 2: Comparison of phytographs of species common to both the sites. The polygon compares the values of IVI and its constituent indices, relative frequency, relative density and relative basal cover of 10 species; 1. *Heteropogon contortus* 2. *Spermacoce stricta* 3. *Spermacoce hispida* 4. *Desmostachya bipinnata* 5. *Cassia tora* 6. *Eragrostis tenella* 7. *Cassia kleinii* 8. *Eragrostis gangetica* 9. *Convolvulus pluricaulis* 10. *Vandellia crustacea*

render the conditions in hospitable for most of the species of upper strata. A major share of species falling under frequency class A indicates considerable floristic heterogeneity resulting from the large number of fortuitous species. Since these grasslands were subject to frequent small-scale stochastic disturbances, a member of new entrants could grow their propagules irrespective of their vitality level to the community. At finer spatial scale, the dense crown cover of tall erect species like *Vernonia crustacea* and *Desmostachya bipinnata* suppressed the subordinate species at site II. Since these tall species were not so palatable and faced no clipping and little trampling, they showed local dominance. Such dominance is known to promote simplification of the community (Armesto and Pickett, 1985). The degree and type of disturbance which were quite random at this site, however, resulted into number of patches with diverse species composition and, therefore, greater species richness. On the contrary, almost uniform and

Table 5: Most rare species at site I, site II and at both the sites on the basis of lowest values of relative frequency (< 0.3) and relative density (<0.03)

Site 1	Site 2	Species rare at both the sites
Aristida adscenscionis	*Cassia tora*	
Bonnaya brachiata	*Chrysanthellum indicum*	*Alysicarpus monilifer*
Desmostachya bipinnata	*Cyperus aristatus*	
Evolvvlus alsinoides	*Dactyloctenium aegypticum*	
Justicia simplex	*Dichanthium annulatum*	*Euphortia hirta*
Setaria glauca	*Hoppea dichotoma*	
Vernonia cinerea	*Minisurus granulatus*	*Oldenlandia corymbosa*
	Oplimenus burmannii	
	Zornia diphylla	

Table 6: Per cent contribution of rare species, exclusive species, top ten species and other species to community total for IVI, basal cover (BC%), density (per quadrat) and frequency (%) indices at both the sites

Attributes-	IVI		% BC		Density		Frequency	
% Contribution of	Site I	II	I	II	I	II	I	II
Rare species	2.3	2.9	0.60	0.40	1.12	2.7	3.90	4.50
Exclusive species	3.2	11.9	3.60	7.70	1.14	11.00	5.03	19.40
Top ten species	85.7	74.3	92.10	89.30	92.50	73.3	73.70	56.20
Other species	8.7	10.9	4.00	3.00	5.30	13.0	17.30	19.9
Whole community	300	300	115.6	120.5	171.5	181.5	732	998

periodic clipping inhibited the establishment of most of upper strata species and promoted dominance of only a few species of prostrate habit at site I.

The resource sharing and occupancy of rich spaces are frequently expressed by dominance- diversity curves (Whittaker, 1975). As evident from these curves, fewer species pre-empted most of the niches at site I as compared to site II. The conditions like moderate grazing, and the least clipping and trampling at site II allowed relatively greater number of species to share community resources, thus reducing the degree of dominance at community level, as evident from the less steeper and more flattened curve (Raizada *et al.*, 1998) at the site. Disturbance had positive effects on frequency and density values of some species and negative effect on others as reported earlier by some workers (Sundriyal *et al.*, 1987). Further, disturbances caused by herbivores may reduce the effect of competition (Grace and Jutila, 1999). *D. triflorum* has been reported to occur most frequently within low disturbance zone (Dwivedi, 1978). This was further strengthened by present study. The much higher basal cover and dominance of species like *Alysicarpus monilifer, Cassia tora, Heteropogon contortus, Spermacoce stricta* and *S. hispida* at site I may be related to their characteristic growth pattern showing profuse sprouting and flowering even at highly disturbed spots. They behaved as stress-tolerant category of Grime (1979). On the other hand, species like *Desmodium triflorum, Phyllanthus niruri* and *Bonnaya brachiata* had much greater dominance at site II. Despite general similarity in edaphic and climatic conditions, the species like *Alysicarpus monilifer, Bonnaya brachiata* and *Fimbristylis dichotoma* showed significantly higher IVI and relative density at site II while *Cassia tora* and *Eragrostis tenella* did so at site I. The difference in these values may be attributed to the type and level of disturbance at the two sites.

The extent of the occurrence of exclusive species may also be related to the nature of disturbance and available resources at the two sites. Several exclusive species of site II like *Aneilema nodiflorum, Cyperus aristatus* and *Kyllinga triceps* had erect habit and distinct crown, least preferred by grazing animals and also faced no clipping. On the other hand, the much fewer number of exclusives at site I was probably due to the availability of lesser niches. Upper strata species like *Justicia simplex*, *Setaria gluca* and *Evolvulus alsinoides* at site I and *Minisurus granulatus* and *Dactyloctenium aegypticum* at site II were the rarest species. These species seemed to be recent immigrants. *Alysicarpus monilifer* and *Oldenlandia corymbosa* were rare at both sites probably due to their habitat specificity. Similarly *Euphorbia hirta* was also very rare. In the context of IVI *Dactyloctenium aegypticum* was among the rarest ones. Hubbell and Foster (1986) found that most rare species are specialists either in habitat or in regeneration niche.

Table 7: Values of indices of dominance (Cd), species diversity (H), evenness (E) and β -diversity (H β) of the two grassland communities

Variables	Site I	Site II
H	3.0	3.7
Cd	0.16	0.06
E	0.7	0.8
H β	8.8	

The pattern of diversity change has often been related to the degree of disturbance in non-equilibrium ecosystems (Whittaker, 1975; McNanghton, 1983). As evident from the observations, disturbance in the form of moderate grazing increased the species diversity and evenness at site II. This pattern has also been observed by Reddy (1998). It is reported that such low level of disturbance may reduce the competitive ability of dominant species and promote inferior competitors (Pacala and Crawley, 1992; Tilman and Pacala, 1993). On other hand, a more severe disturbance in the form of periodic clipping at site I caused greater dominance and low diversity, and the species of prostrate habit dominated the site. It was further evident by high species turnover (β-diversity) between the two sites indicating significant difference in composition and structure between the two communities. The moderate disturbance not only enhanced species diversity but also improved the composition of grassland by preventing the dominance of only a few species.

ACKNOWLEDGEMENTS

We thanks the Head, Department of Botany, for providing laboratory facilities and Dr. Vinod Shankar, Senior Scientist, I.G.F.R.I., Jhansi for his help in identification of plant species. We are thankful to the anonymous referee for helpful criticism and Dr. M.P. Sinha for his guidelines for revision to improve the manuscript. The help of the Principal and the co-operation of the keeper and assisting staff of G.I.C. Orai during field observations are gratefully acknowledged.

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