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Impact of fire and grazing on plant diversity of grassland ecosystem of Cherrapunjee

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Abstract

Fire and grazing are the two most common disturbances found in the grassland ecosystems of Cherrapunjee. There are many species that have attributes which enable them to tolerate disturbances. The present study was conducted to examine separately as well as in combination the effects of fire and grazing on grassland ecosystem of Cherrapunjee. The results of the study reveal that the impact of fire and grazing on vegetation structure of grassland ecosystem at Cherrapunjee are highly variable. While grazing tends to favour the diversity of perennial grasses, fire influences the richness of annual grasses and other monocots. However, the combined effect of grazing and fire tend to increase the diversity of forbs.

Keywords

Fire, grazing, species diversity, grassland

Introduction

Most of the grassland ecosystems in the humid and sub humid regions of the world have developed due to forest clearing, grazing, burning and other anthropogenic activities. They form sub-climax vegetation and are maintained by grazing, burning or combinations of both. Grasslands play an important role by providing vegetation cover, protecting the soil from erosion and ensuring production of feed for animals. Grazing and fire regimes are found to be the most important causes of disturbances on semiarid and arid grassland communities (Feldman & Lewis 2005). Evidence indicates that there is a positive relationship between plant species diversity and ecological stability in response to drought, overgrazing, or other stresses in grassland ecosystems (Tilman & Downing 1994).

The structure and dynamics of arid, semi-arid and sub-humid grasslands of India have been studied extensively (Misra 1983; Singh *et al.* 1985; Ramakrishnan and Ram 1988; Uma Shankar *et al.* 1991; Karunaichamy and Paliwal 1994; Mylliemngap 2013). Ramakrishnan and Ram (1988) observed that some new species colonize and some species showed high density after exposure to fire, whereas, the density of some shrubs species declined. Similarly, Uma Shankar *et al.* (1991) observed that at the high altitude site the grassland under short-term protection from fires and grazing had a higher species richness, density and basal cover than unprotected grassland. It was also observed that all grasslands show a clear seasonality, albeit with different patterns, with a maximum in density and basal cover in rainy season. Mylliemngap (2013) observed that there was a decrease in species richness, diversity and plant density in the mining-affected and recovering grasslands as compared to the undisturbed grasslands due to vegetation removal prior to mining. The Cherrapunjee grasslands are extended over a huge expanse of land and are being maintained by regular grazing and burning of varying intensities and they have developed on acidic and highly impoverished thin soil layer which cannot support the growth of forest. However, there is a glaring gap in the research pertaining to impact of fire and grazing on grassland communities of India in general and humid subtropical region of the country in particular.

Study Area

The study was conducted at Sa-I-Mika Park which is 1.3 km north of Cherrapunjee town (Latitude 25° 17′18.2″N and Longitude 91°42′21″ E; Elevation 1419 m a.s.l) in East Khasi Hills District of Meghalaya. The Park is 50 km south of Shillong, the capital city of Meghalaya. Cherrapunjee receives extremely high rainfall that results into loss of sediment and nutrients that impoverishes the soil.

Experimental Design

In the year 2011, 20 plots of size 20m by 20m, were established with 3m buffer in between the plots. Three treatments and one control were assigned randomly to each plot within a block, viz., (i) the control plots were fenced and left ungrazed and unburnt (UGUB). (ii) an open grazed but unburnt plots i.e. the plots were left unfenced for grazing purpose and no burning took place (GUB). (iii) burnt and ungrazed i.e., the plots were burnt (prescribed) but they were fenced with no grazing allowed (BUG). (iv) open grazed and burnt plots i.e. where both grazing and burning took place (GB). For each treatments and control plots five replicates were maintained.

Materials and Methods

From each plots of different treatments, plants were sampled seasonally using 1x1m quadrat. The specimens were identified with the help of regional flora (Balakrishnan 1981-1983; Shukla,1996) and by consulting with the herbarium at Botanical Survey of India, Shillong. Community parameters such as frequency, density of the species were determined according to Misra (1968) and Muller-Dombois & Ellenberg (1974). IVI was determined as sum of relative frequency and relative density. Species diversity and dominance indices viz., Shannon's diversity

Table 1. Species richness and plant density during different seasons in the experimental plots under different treatments

Parameters	Treatments			
	UGUB	GUB	BUG	GB
Winter				
Species	11	11	10	10
Genera	10	10	9	9
Families	5	5	4	4
Density (plants m^{-2})	400	396	392	389
Spring				
Species	25	26	30	31
Genera	21	22	25	26
Families	10	12	13	14
Density (plants m^{-2})	740	689	612	625
Rainy				
Species	29	31	32	35
Genera	25	27	28	30
Families	13	14	14	16
Density (plants m^{-2})	928	867	774	740
Autumn				
Species	27	29	31	33
Genera	23	25	26	28
Families	11	13	13	16
Density (plants m^{-2})	701	651	580	555

(H), Dominance (D), Evenness (J) and Fisher's alpha diversity (α) were calculated using PAST software, Version 2.17c (Hammer *et al.* 2001).

Sorensen's Similarity Index (β) = 2C / S1 + S2

Where, S1 = Number of species in Community 1
S2 = Number of species in community 2
C = Number of species common to both communities

Results

A total of 35 species belonging to 30 genera and 16 families were recorded in all the treatment plots. The highest number of species was recorded in the grazed and burnt (GB) (35) plots followed by burnt and grazed (BUG) (32), grazed and unburnt (GUB) (31) and ungrazed and unburnt (UGUB) (29). The results indicate that species richness increased with fire and grazing treatments. The species richness varied significantly with seasons in all the treatments. The species richness was highest (29-35) during the rainy season and lowest (10-11) during the winter seasons and was dominated by plants belonging to families Poaceae and Cyperaceae (Table *1*). Plant Density was highest in the control (UGUB) plots (400-928 plants m^{-2}) followed by GUB plots (396-867 plants m^{-2}), BUG plots (392-774 plants m^{-2}) and GB (389-740 plants m^{-2}). Similarly the plant density was highest during rainy season and lowest during winter season in all the treatment plots (Table *1*).

Shannon-Wiener index of diversity (H') was highest in the GUB plots in winter whereas during spring, rainy and autumn seasons it was highest in GB plots followed by BUG, GUB and UGUB plots. Dominance index (D) was highest in the UGUB plot during spring, rainy and autumn. Evenness index was higher in the BUG and GB plot than in GUB and UGUB plots during the rainy season but it did not differ significantly among the treatments. Fisher's alpha diversity was highest in GB plots followed by BUG, GUB and UGUB plots during spring, rainy and autumn seasons, however in winter it was higher in GUB and UGUB than BUG and GB plots (Table *2*).

Table 2. Diversity indices in the different treatment plots

Parameters	Treatments			
	UGUB	GUB	BUG	GB
Winter				
Shannon's diversity (H)	2.11	2.12	2.05	2.06
Dominance (D)	0.15	0.15	0.16	0.16
Evenness (J)	0.75	0.75	0.78	0.79
Fisher's alpha diversity (α)	2.50	2.51	2.22	2.22
Spring				
Shannon's diversity (H)	2.88	2.91	3.10	3.17
Dominance (D)	0.08	0.08	0.07	0.06
Evenness (J)	0.71	0.70	0.74	0.76
Fisher's alpha diversity (α)	7.54	7.97	9.86	10.31
Rainy				
Shannon's diversity (H)	2.99	3.13	3.25	3.28
Dominance (D)	0.07	0.06	0.05	0.05
Evenness (J)	0.68	0.74	0.81	0.76
Fisher's alpha diversity (α)	9.34	10.29	10.73	12.44
Autumn				
Shannon's diversity (H)	2.90	3.06	3.18	3.21
Dominance (D)	0.08	0.06	0.06	0.06
Evenness (J)	0.67	0.74	0.77	0.75
Fisher's alpha diversity (α)	8.43	9.24	10.20	11.25

Similarity index

Sorensen's similarity index in winter shows complete overlapping of species, the reason could be because of the disappearance of forbs and the presence of only some perennial plant species in all the treatment plots. Though there was large overlap between treatments, mean richness and diversity in BUG and GB, was significantly higher than for UGUB plots. However, means of UGUB and GUB sites were not significantly different. Similarity was highest between UGUB and GUB and between BUG and GB during spring, rainy and autumn seasons (Table *3*).

Importance value index

The dominance – diversity curve exhibit higher dominance in the UGUB compared to GUB, BUG and GB plots. The species sequence curves show a log-normal pattern of distribution for UGUB, GUB and BUG plots indicating that there was more or less an even apportionment of resources among the members of the important species and broken stick type pattern for GB plots were attributed due to stress environments with clubbing of different species due to grazing and fire treatments (Fig. 1). Perennials were the most dominant plant group in all the treatment plots. In UGUB plots, the perennials contributed 90.78% and the annuals contributed 9.22%; annual monocots contributed 6.91% and forbs contributed 8.53% to the total IVI. In GUB plots, the perennials contributed 88.84% and the annuals contributed 11.16% to the total IVI; annual monocots contributed 8.06% and forbs contributed 11.28% to the total IVI. In BUG plots, the perennials contributed 85.34% and the annuals contributed 14.66% to the total IVI; annual monocots contributed 10.70% and forbs contributed 12.40% to the total IVI. At GB plots, the perennials contributed 84.71% and the annual contributed 15.29% to the total IVI; annual monocots contributed 9.67% and forbs contributed 16.19% to the total IVI (Appendices I, II, III and IV).

Table 1. Species richness and plant density during different seasons in the experimental plots under different treatments

Parameters	Treatments		
	UGUB	GUB	BUG
Winter			
UGUB	1		
GUB	1	1	
BUG	1	1	1
GB	1	1	1
Spring			
UGUB	1		
GUB	0.94	1	
BUG	0.87	0.86	1
GB	0.86	0.84	0.92
Rainy			
UGUB	1		
GUB	0.97	1	
BUG	0.94	0.95	1
GB	0.91	0.94	0.97
Autumn			
UGUB	1		
GUB	0.96	1	
BUG	0.90	0.90	1
GB	0.83	0.87	0.94

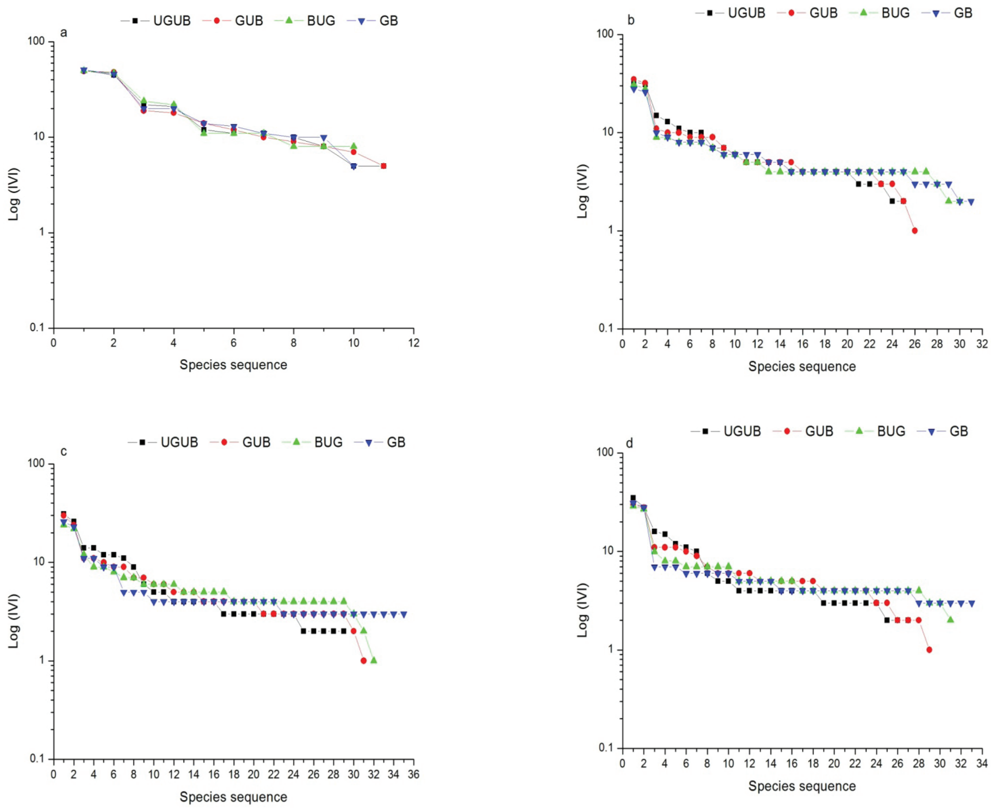

Fig. **1**. Dominance-diversity curves for species in the different treatment plots during (a) winter (b) spring (c) rainy and (d) autumn seasons

DISCUSSION

Compared to the ungrazed-unburnt plots, there was an increase in species richness and diversity in the grazed-unburnt, burnt-ungrazed and grazed-burnt plots during the growing season, the reason being that annual plant species, mainly forbs, can successfully regenerate only in gaps, created by grazing and by burning treatments. Analysis of vegetation showed that burnt plots had significantly greater forb cover, which might have provided greater food resources, and also lower biomass (Underwood and Christian 2009). Conversely, plant density was highest in the ungrazed-unburnt plots compared to the other treatments. Mean density was highest in UGUB (692 plants m^{-2}) followed by GUB (651 plants m^{-2}); BUG (590 plants m^{-2}) and GB (577 plants m^{-2}). Shannon-Wiener Index of diversity (H') was highest in the GB plots (3.28) and lowest in UGUB plots (2.99) during the rainy season. Dominance index (D) was highest in UGUB (0.07) compared to GUB plots (0.06), BUG (0.05) and GB (0.05) during rainy season. The low abundance of annual monocots and forbs in the control plots might result from suppression by dominant species and/or the occurrence of unfavourable environmental conditions for seedling establishment.

The species sequence curves showed the log-normal distribution pattern as observed in the ungrazed-unburnt, grazed-unburnt, burnt-ungrazed plots which suggested that there was more or less an even apportionment of resources among the members of the important species. However, the broken-stick model curves in the grazed-burnt plots were attributed to stress environments resulting into clubbing of species due to grazing and fire treatments. These models describe how species break up resource pool in multi-dimensional space, determining the distribution of abundances of individuals among species. Species diversity was low in UGUB plots and the species that grow here appear to have developed tolerance. The diversity index for herbaceous species increased with fire and grazing treatments suggesting that these treatments enhanced the colonization of certain species. The annual monocots and forbs significantly increased after the fire and grazing treatment application. The increase in the abundance of annual species occurred because of the available space following grazing and burning treatments. The potential sources of seeds for these species could be the soil seed bank and the surrounding vegetation. Their absence or low abundance in the ungrazed-unburnt plots might result from suppression by dominant species and/or the occurrence of unfavourable environmental conditions for seedling establishment.

The decrease in perennial species and increase in annual species following treatment application are consistent in relation to grazing following increased soil nutrient status and the creation of gaps for seedling establishment (Peco *et al.* 2006; Guretzky *et al.* 2007). Also the more frequently burnt plots tended to have a higher proportion of forbs and the result agrees with Ramakrishnan and Ram (1988) and Reich *et al.* (2001). Nevertheless that the perennial species continues to thrive in all the treatment plots could be because of their well developed rhizomes that help in regeneration even after the occurrence of fire or grazing separately and also their combined interaction.

It may be concluded that the impact of fire and grazing on vegetation structure of grassland ecosystem at Cherrapunjee are highly variable, while grazing tend to favour the diversity of perennial grasses; fire influence the richness of annual grasses and other monocots. The combined effect of grazing and fire increases the diversity of forbs. Fire and grazing are ecological factors that frequently interact to modify landscape patterns of vegetation. While grazing alone promotes uniform distribution of plant diversity, which creates homogenization of the vegetation. Fire alone cannot maintain the heterogeneity but fire with grazing play a vital role in the creation and maintenance of the diverse habitats. The result also suggests that annual burning and grazing had profound negative effects on vegetation structure, particularly on grasses.

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Appendices

Appendix 1: Density (D, m^{-2}) and Importance value index (IVI) of species in ungrazed-unburnt (UGUB) plots.

Name of the species	Family	UGUB							
		Winter		Spring		Rainy		Autumn	
		D	IVI	D	IVI	D	IVI	D	IVI
Arundinella khasiana Nees ex Steud.	Poaceae	149	50	207	33	240	31	210	35
Borreria articularis (L.f) N.F.William	Rubiaceae	-	-	-	-	2	2	2	4
Brachiaria villosa A. Camus.	Poaceae	-	-	7	6	7	4	3	4
Carex cruciata Wahlenb.	Cyperaceae	3	8	3	4	2	2	1	3
Carex stramentite Booh ex Beeck	Cyperaceae	-	-	2	3	2	2	1	2
Centella asiatica (L.) Urb.	Apiaceae	-	-	-	-	3	3	2	2
Chrysopogon gryllus (L.) Trin.	Poaceae	133	45	195	31	198	26	157	28
Cyanotis vaga (Lour.) Schult. & Schult.f.	Commelinaceae	-	-	1	4	1	2	-	-
Cyperus rotundus Linn	Cyperaceae	-	-	2	4	2	4	2	3
Drosera peltata Thunb.	Droseraceae	-	-	2	5	2	4	2	5
Emilia sonchifolia (L.) DC.	Asteraceae	-	-	-	-	2	3	-	-
Eragrostiella leioptera Stapt, Bor.	Poaceae	15	11	76	15	87	14	73	16
Eragrostis gangetica Steud. Valuable fodder	Poaceae	14	11	40	10	54	11	43	11
Eragrostis nigra Nees ex Steud.	Poaceae	10	10	43	11	65	12	44	12
Eriocaulon browananum Mart.	Eriocaulaceae	2	5	5	5	3	3	3	3
Eriosema chinense Vogel.	Fabaceae	1	5	-	2	1	3	1	3
Eulalia quadrinervis (Hack.) O. Kuntze.	Poaceae	38	22	58	13	89	14	68	15
Fimbristylis hookeriana Beeck	Cyperaceae	-	-	4	4	11	5	2	3
Fimbristylis shoenoides vahl.	Cyperaceae	-	-	14	7	18	6	8	4
Fimbristylis thomsonii Beeck	Cyperaceae	-	-	6	5	6	4	6	4
Habenaria goodyeroides D. Don	Orchidaceae	-	-	-	2	1	3	2	5
Hypoxis aurea Lour.	Hypoxidaceae	-	-	2	4	1	3	1	2
Impatiens chinensis Linn.	Balsaminaceae	-	-	2	3	3	3	4	4
Ischaemum goeblii Hack.	Poaceae	34	21	42	10	69	12	35	10
Jansenella griffithiana (C. Muell.) Bor	Poaceae	-	-	22	7	46	9	21	6
Kyllinga brevifolia Rottb	Cyperaceae	-	-	4	5	3	2	5	4
Osbeckia capitata Benth.	Melastomaceae	1	12	1	4	4	4	3	4
Peristylus parishii Reichb.	Orchidaceae	-	-	-	-	6	5	1	3
Smithia ciliata Royle	Leguminosae	-	-	1	3	1	3	1	4
Total		**400**	**200**	**740**	**200**	**928**	**200**	**701**	**200**

(-) Indicates absence

Appendix II: Density (D, m^{-2}) and Importance value index (IVI) of species in grazed-unburnt (GUB) plots.

Name of the species	**Family**	**GUB**							
		Winter		**Spring**		**Rainy**		**Autumn**	
		D	**IVI**	**D**	**IVI**	**D**	**IVI**	**D**	**IVI**
Arundinella khasiana Nees ex Steud.	Poaceae	148	49	213	35	229	30	170	30
Borreria articularis (L.f) N.F.William	Rubiaceae	-	-	-	-	5	4	2	4
Brachiaria villosa A. Camus.	Poaceae	-	-	-	-	8	4	5	5
Carex cruciata Wahlenb.	Cyperaceae	3	8	3	4	4	4	2	5
Carex stramentite Booh ex Beeck	Cyperaceae	-	-	1	3	2	3	1	3
Centella asiatica (L.) Urb.	Apiaceae	-	-	2	4	5	3	1	3
Chrysopogon gryllus (L.) Trin.	Poaceae	145	48	192	32	177	24	153	28
Cyanotis vaga (Lour.) Schult. & Schult.f.	Commelinaceae	-	-	2	4	3	3	2	4
Cyperus rotundus Linn	Cyperaceae	-	-	2	4	6	5	2	5
Drosera peltata Thunb.	Droseraceae	-	-	3	5	5	4	5	5
Emilia sonchifolia (L.) DC.	Asteraceae	-	-	-	-	3	3	-	-
Eragrostiella leioptera Stapt, Bor.	Poaceae	17	14	41	10	62	11	47	11
Eragrostis gangetica Steud. Valuable fodder	Poaceae	12	10	30	9	44	9	34	9
Eragrostis nigra Nees ex Steud.	Poaceae	9	9	34	9	47	9	37	10
Eriocaulon browananum Mart.	Eriocaulaceae	2	5	3	4	8	4	8	5
Eriosema chinense Vogel.	Fabaceae	1	7	1	1	3	2	2	2
Eulalia quadrinervis (Hack.) O. Kuntze.	Poaceae	30	19	42	11	65	11	45	11
Fimbristylis hookeriana Beeck	Cyperaceae	-	-	14	7	20	6	16	7
Fimbristylis shoenoides vahl.	Cyperaceae	-	-	13	6	25	7	14	6
Fimbristylis thomsonii Beeck	Cyperaceae	-	-	7	5	17	6	9	6
Gentiana quadrifaria Blume	Gentianaceae	-	-	1	3	1	3	1	4
Habenaria goodyeroides D. Don	Orchidaceae	-	-	1	2	1	1	-	1
Hypoxis aurea Lour.	Hypoxidaceae	-	-	3	5	4	4	4	5
Impatiens chinensis Linn.	Balsaminaceae	-	-	5	5	8	5	6	4
Ischaemum goeblii Hack.	Poaceae	27	18	37	10	57	10	47	11
Jansenella griffithiana (C. Muell.) Bor	Poaceae	-	-	31	9	34	7	21	6
Kyllinga brevifolia Rottb	Cyperaceae	-	-	3	5	7	3	3	2
Murdannia nudiflora (L.)	Commelinaceae	-	-	-	-	2	3	-	-
Osbeckia capitata Benth.	Melastomaceae	2	12	4	4	9	5	9	6
Peristylus parishii Reichb.	Orchidaceae	-	-	-	-	3	3	1	4
Smithia ciliata Royle	Leguminosae	-	-	2	4	2	3	2	2
Total		**396**	**200**	**689**	**200**	**867**	**200**	**651**	**200**

(-) Indicates absence

Appendix III: Density (D, m^{-2}) and Importance value index (IVI) of species in burnt-ungrazed (BUG) plots.

Name of the species	Family	BUG							
		Winter		Spring		Rainy		Autumn	
		D	IVI	D	IVI	D	IVI	D	IVI
Arundinella khasiana Nees ex Steud.	Poaceae	144	50	170	31	164	24	150	29
Borreria articularis (L.f) N.F.William	Rubiaceae	-	-	6	4	8	4	3	4
Brachiaria villosa A. Camus.	Poaceae	-	-	4	4	14	5	10	5
Carex cruciata Wahlenb.	Cyperaceae	2	8	5	4	6	4	3	4
Carex stramentite Booh ex Beeck	Cyperaceae	-	-	3	4	4	4	2	4
Centella asiatica (L.) Urb.	Apiaceae	-	-	4	4	5	4	2	4
Chrysopogon gryllus (L.) Trin.	Poaceae	132	47	148	28	145	22	138	27
Commelina benghalensis L.	Commelinaceae	-	-	-	-	3	4	2	4
Cyanotis vaga (Lour.) Schult. & Schult.f.	Commelinaceae	-	-	3	4	3	4	2	4
Cyperus rotundus Linn	Cyperaceae	-	-	2	4	7	4	1	4
Drosera peltata Thunb.	Droseraceae	-	-	5	4	7	4	4	4
Emilia sonchifolia (L.) DC.	Asteraceae	-	-	-	-	5	4	-	-
Eragrostiella leioptera Stapt, Bor.	Poaceae	13	11	34	9	70	12	40	10
Eragrostis gangetica Steud. Valuable fodder	Poaceae	14	11	27	8	32	7	30	8
Eragrostis nigra Nees ex Steud.	Poaceae	10	11	31	8	31	7	25	8
Eriocaulon achiton Koern	Eriocaulaceae	-	-	3	3	14	5	8	5
Eriocaulon browananum Mart.	Eriocaulaceae	2	8	5	4	11	5	7	5
Eriosema chinense Vogel.	Fabaceae	-	-	3	4	3	4	2	4
Eulalia quadrinervis (Hack.) O. Kuntze.	Poaceae	41	24	34	9	41	9	19	7
Fimbristylis shoenoides vahl.	Cyperaceae	-	-	20	7	33	8	19	7
Fimbristylis hookeriana Beeck	Cyperaceae	-	-	18	6	23	6	20	7
Fimbristylis thomsonii Beeck	Cyperaceae	-	-	14	6	20	6	23	7
Habenaria goodyeroides D. Don	Orchidaceae	-	-	1	2	1	1	1	2
Hypoxis aurea Lour.	Hypoxidaceae	-	-	6	4	5	4	4	4
Impatiens chinensis Linn.	Balsaminaceae	-	-	10	5	13	5	10	5
Ischaemum goeblii Hack.	Poaceae	33	22	29	8	44	9	19	7
Jansenella griffithiana (C. Muell.) Bor	Poaceae	-	-	4	4	6	3	6	3
Kyllinga brevifolia Rottb	Cyperaceae	-	-	6	4	19	6	5	4
Murdannia nudiflora (L.)	Commelinaceae	-	-	2	2	2	2	2	3
Osbeckia capitata Benth.	Melastomaceae	1	8	9	5	12	5	10	5
Peristylus parishii Reichb.	Orchidaceae	-	-	3	4	3	4	2	4
Polygonum bistorta L.	Polygonaceae	-	-	5	4	19	6	8	5
Total		**392**	**200**	**612**	**200**	**774**	**200**	**580**	**200**

(-) Indicates absence

Appendix IV: Density (D, m^{-2}) and Importance value index (IVI) of species in grazed-burnt (GB) plots.

Name of the species	**Family**	**GB**							
		Winter		**Spring**		**Rainy**		**Autumn**	
		D	**IVI**	**D**	**IVI**	**D**	**IVI**	**D**	**IVI**
Arundinella khasiana Nees ex Steud.	Poaceae	150	50	152	28	173	26	153	30
Borreria articularis (L.f) N.F.William	Rubiaceae	-	-	5	4	5	4	5	4
Brachiaria villosa A. Camus.	Poaceae	-	-	3	3	8	4	9	5
Carex cruciata Wahlenb.	Cyperaceae	2	10	4	4	5	4	4	4
Carex stramentite Booh ex Beeck	Cyperaceae	-	-	2	2	5	4	4	4
Centella asiatica (L.) Urb.	Apiaceae	-	-	3	4	4	3	2	3
Chrysopogon gryllus (L.) Trin.	Poaceae	140	47	133	25	151	23	137	27
Commelina benghalensis L.	Commelinaceae	-	-	1	3	4	3	2	3
Cyanotis vaga (Lour.) Schult. & Schult.f.	Commelinaceae	-	-	2	4	4	3	4	4
Cyperus rotundus Linn	Cyperaceae	-	-	2	4	3	3	3	3
Drosera peltata Thunb.	Droseraceae	-	-	4	4	6	4	2	3
Emilia sonchifolia (L.) DC.	Asteraceae	-	-	2	2	4	3	2	3
Eragrostiella leioptera Stapt, Bor.	Poaceae	18	14	41	10	59	11	19	6
Eragrostis gangetica Steud. Valuable fodder	Poaceae	12	10	30	8	58	11	20	6
Eragrostis nigra Nees ex Steud.	Poaceae	9	10	29	8	48	9	19	6
Eriocaulon achiton Koern	Eriocaulaceae	-	-	4	3	11	4	8	4
Eriocaulon browananum Mart.	Eriocaulaceae	2	5	9	3	11	4	8	4
Eriosema chinense Vogel.	Fabaceae	-	-	2	4	4	3	2	3
Eulalia quadrinervis (Hack.) O. Kuntze.	Poaceae	31	20	28	8	18	5	19	6
Fimbristylis hookeriana Beeck	Cyperaceae	-	-	16	6	18	5	19	6
Fimbristylis shoenoides vahl.	Cyperaceae	-	-	14	5	18	5	17	6
Fimbristylis thomsonii Beeck	Cyperaceae	-	-	14	5	11	4	18	6
Gentiana quadrifaria Blume	Gentianaceae	-	-	2	4	1	3	3	3
Habenaria goodyeroides D. Don	Orchidaceae	-	-	1	2	1	3	3	3
Hypoxis aurea Lour.	Hypoxidaceae	-	-	7	4	10	4	6	4
Impatiens chinensis Linn.	Balsaminaceae	-	-	18	6	11	4	12	5
Ischaemum goeblii Hack.	Poaceae	31	20	34	9	45	9	22	7
Jansenella griffithiana (C. Muell.) Bor	Poaceae	-	-	5	3	7	3	6	3
Kyllinga brevifolia Rottb	Cyperaceae	-	-	7	4	6	4	5	4
Murdannia nudiflora (L.)	Commelinaceae	-	-	2	3	2	3	3	3
Osbeckia capitata Benth.	Melastomaceae	2	13	7	4	11	4	10	5
Peristylus parishii Reichb.	Orchidaceae	-	-	1	1	2	3	4	4

Polygonum bistorta L.	Polygonaceae	-	-	18	6	11	4	9	4
Smithia ciliata Royle	Fabaceae	-	-	6	4	3	3	2	3
Torenia diffusa D. Don	Scrophulariaceae	-	-	2	3	2	3	4	4
Total		**398**	**200**	**610**	**200**	**740**	**200**	**563**	**200**

(-) Indicates absence