European Journal of Ecology, 11.1, 2025, pp. 35-44

PHYTOSOCIOLOGICAL STUDY OF FIRE IMPACTED TROPICAL GRASSLANDS IN NORTHEAST INDIA

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Abstract.

Tropical grasslands in South Assam, northeast India originated as a result of secondary succession on the abandoned lands after cultivation or deforestation. The grasslands are dominated by Imperata cylindrica and maintained under fire management as a customary practice. The rice farming communities exploit these grasslands for obtaining thatch leaves. The present article therefore, explores the culturally managed grassland located in Dorgakona, South Assam, northeast India with an objective to study (1) the floristic composition of vegetation and (2) life-forms, biological spectrum and phenology of the grassland's herbaceous flora. Imperata cylindrica emerged as the dominant species based on IVI values (132. 27 and 141.68) for the burnt and unburnt plots respectively. Spermacoce pusilla (co-dominant species) with IVI of 63.10 and 29.75 sequentially placed for burnt and unburnt plots respectively was fire dependent species. Grasses such as Chrysopogon aciculatus and Sacciolepis indica and tuber particularly Colocasia esculenta were confined to burnt plot. There was multifold proliferation of therophytic and cryptophytic flora and therefore termed as thero-cryptophytic vegetation when compared with Raunkiaer's biological spectrum. Plant phenological study revealed sequential changes in the phenological events. The tropical grasslands of the study area are predominated with fire resistant I. cylindrica and adapted to the indigenous management schemes adopted by the rural communities. It is recommended that the findings of the current study will lead to accumulation of important database for formulating policies and guidelines in carrying out future researches on the degraded grasslands of the region.

Key words: *Imperata cylindrica, Spermacoce pusilla, Poaceae, Importance Value Index, annuals, cryptophytes, life-form, perennials, phenophases, propagation, therophytes, vegetative*

Introduction

Grasslands in India cover around 24% of the geographical area and demonstrate a wide range of ecological features throughout various phytogeographic regions (Singh et al. 1983). Tropical grasslands in the country are anthropogenic in origin and are successional in nature emerged under the consequence of fire, grazing, deforestation and extreme climate (Bor 1960; Singh et al. 1983). Grasslands of South Assam, northeast India are mostly marginal sized lands (0.25 ha – 2 ha) naturally colonized by *Imperata cylindrica* maintained under the influence of fire (Usmadi et al. 2020; Astapati and Das 2023). It is the invasive grass belonging to family Poaceae and extensively distributed throughout the tropics and subtropics of the globe (USDA 2020). The practice of customary fire in the tropical grasslands of South Assam resulted in the dominance of *I. cylindrica*, with the coexistence of other herbaceous species as well (Usmadi et al. 2020). The intra-inter village grasslands of the region built up a cultural landscape that follow random distribution pattern and exploited for both subsistence and profit earning (Rusdy 2020; Astapati and Das 2023).

In ecosystem analysis, vegetation is believed to be a crucial factor in resolving the issues pertaining to structure and function (Astapati and Das 2012). Species diversity is an important attribute of the current study that regulates the functioning of an ecosystem (Hengeveld 1996). Also, in the current vegetation study, life-form is a key descriptor only after floristic composition (Sen and Bhakat 2021). Raunkiaer (1934) after his extensive study has prepared a normal biological spectrum that is considered as a standard for comparing various spectra. Hence, in present investigation, assessment of biological spectra will give conclusive ideas on stratification of the plant community and the nature of phytoclimate (Malik et al. 2006). The study of plant phenology, a part of present study is the observation of various phases that take place throughout the year (Shafi et al. 2018).

Literature review revealed a few researches available on grasslands of northeast India by Ramakrishnan and Ram (1988); Kakati and Yadava (1990), Pandey et al. (1993), Radzirani (1994), Devi et al. (2000, 2004), Astapati and Das (2010, 2012, 2023, 2024), Pathak et al. (2015, 2018), Thokchom and Yadava (2016), Khan et al. (2022).

Table 1. Density (ind. m^{-2}), Abundance (ind. m^{-2}), Basal cover (cm^2 m^{-2}) and IVI of participating species in the burnt and unburnt plots of tropical grassland.

SPECIES	BURNT PLOT				UNBURNT PLOT			
	D	A	BC	IVI	D	A	BC	IVI
Grasses & Sedge								
Chrysopogon aciculatus (Retz.) Trin.	2.70	8.21	1.08	2.35	---	---	---	---
Cyperus haspan L.	8.93	12.22	1.33	4.08	17.77	20.61	2.66	4.74
Digitaria ciliaris (Retz.)Koel.	29.93	33.63	5.67	8.71	60.83	60.91	11.82	12.63
Digitaria longiflora (Retz.) Koeler	8.07	13.3	1.64	7.89	42.73	41.30	9.58	23.18
Digitaria setigera Roth	4.07	12	0.59	4.36	4.73	10.46	0.71	3.94
Imperata cylindrica (L.) Raeusch.	294.83	294.80	147.58	132.27	298.30	296.48	147.87	141.68
Sacciolepis indica (L.) Chase	1.83	8.61	0.85	1.28	---	---	---	---
Setaria glauca (L.) P. Beauv.	24.50	22.56	22.80	30.64	15.30	19.58	17.54	27.89
Setaria pumila (Poir.) Roem. & Schult.	0.27	1.67	0.05	0.19	0.90	1.8	0.18	0.50
Forbs								
Achyranthes aspera L.	0.97	2.77	0.09	0.83	8.13	9.35	0.80	4.06
Ageratum conyzoides L.	1.40	5.77	1.17	2.72	1.57	6.22	1.21	2.70
Chromolaena odorata R. M. King & H .Rob.	2.33	6.3	1.79	7.11	3.67		2.99	9.71
Clerodendrum infortunatum L.	0.87	4.22	0.95	2.47	1.23	6.95	1.26	3.04
Colocasia esculenta (L.)Schott.	1.20	5.24	0.29	1.36	---	---	---	---
Desmodium caudatum (Thunb) D.C.	1.13	5.77	0.39	2.58	1.83	5.69	0.50	4.54
Desmodium triflorum (L.) D.C.	---	---	---	---	0.43	1.61	0.02	0.37
Dioscorea alata L.	0.13	0.50	0.02	0.16	0.10	5.67	0.01	0.16
Ipomoea pes-tigridis L.	4.43	6.58	1.00	6.16	3.53	4.99	0.77	5.20
Leucas plukenetii (Roth.) Spreng	1.20	5.38	0.29	1.56	1.10	6.50	0.25	1.86
Lindernia crustacea (L.) F. Muell	9.03	11.18	0.46	4.19	18.83	20.06	0.99	5.32
Lygodium japonicum (Thunb.) Sw.	0.87	4.83	0.19	1.41	0.23	0.83	0.06	0.44
Mikania micrantha Kunth	0.40	3.50	0.06	0.61	0.83	5.33	0.13	1.28
Mimosa pudica L.	0.70	3.21	0.42	1.13	0.80	3.74	0.45	1.65
Murdannia nudiflora (L.) Brenan.	2.33	4.17	0.12	2.12	0.83	1.83	0.04	0.70

However, a composite study on the quantitative analysis and physiognomy of grasslands are lacking particularly in South Assam, northeast India. Therefore, in order to have a lucid understanding of the ecological processes more particularly impact of fire on grassland vegetation, we made an attempt to study the phytosociology, life-forms and phenology in a fire impacted tropical grassland of South Assam, northeast India. The data obtained from the present study may serve as baseline information of the floristics in grassland ecosystem which will be worthy for future monitoring, conservation and management of plant species.

Materials and Methods

Study area

The study site was located at Dargakona village (24°40' N latitude and 92°46' E longitude) of Cachar district, South Assam, northeast India. The region lies between the North Cachar hills on the north and the Mizo hills on the south. The regional landscape marked the presence of hills, hillocks, low-lying stagnant water bodies and the plains. The climate is hot and humid type with total annual rainfall of 2365 mm during the study period. The year is divisible into three distinct seasons viz. short summer (March–April), rainy (May–October) and winter (November–February). Total annual rainfall during the study period was 2365 mm. The mean maximum temperature ranges from 25.4°C in January to 32.6°C in August and the mean minimum temperature ranges from 11.1°C in January to 25.1°C in August. Soil in the study site was characterized by grayish brown colour (10YR, 5/2); texture sandy loam; water holding capacity varied from 36.99% to 47.35%; soil pH ranged from 4.94 to 5.16; organic carbon from 0.77% to 0.39% and nitrogen 0.14%

Table 2. Mode of propagation (vegetative/sexual), life span, plant habit and life-forms of enumerated plant species in the tropical grassland.

Sl. No.	Name of Species	Mode of Propagation	Life span	Habit	Life-form
1	*Achyranthes aspera*	Seed	Annual	Herb	Th
2	*Ageratum conyzoides*	Seed	Perennial	Shrub	Ph
3	*Cajanus cajan*	Seed	Perennial	Shrub	Ph
4	*Chromolaena odorata*	Seed	Perennial	Shrub	Ph
5	*Chrysopogon aciculatus*	Stolonifer/seed	Perennial	Grass	He
6	*Clerodendrum infortunatum*	Seed	Perennial	Shrub	Ph
7	*Colocasia esculenta*	Corm	Perennial	Herb	Cr
8	*Cyperus haspan*	Seed	Annual	Sedge	Th
9	*Desmodium caudatum*	Seed	Annual	Herb	Th
10	*Desmodium triflorum*	Seed/stolon	Annual	Herb	Th
11	*Digitaria ciliaris*	Seed	Annual	Herb	Th
12	*Digitaria longiflora*	Stolonifer/seed	Perennial	Herb	He
13	*Digitaria setigera*	Seed	Annual	Herb	Th
14	*Dioscorea alata*	Tuber	Perennial	Climber	Cr
15	*Imperata cylindrica*	Rhizome/seed	Perennial	Grass	Cr
16	*Ipomoea pes-tigridis*	Seed	Annual	Herb	Th
17	*Leucas plukenetii*	Seed	Annual	Herb	Th
18	*Lindernia crustacea*	Seed	Annual	Herb	Th
19	*Lygodium japonicum*	Rhizome/spore	Perennial	Climber	Cr
20	*Melastoma malabathricum*	Seed	Perennial	Shrub	Ph
21	*Mikania micrantha*	Seed/rosette roots	Perennial	Climber	Ph
22	*Mimosa pudica*	Seed	Perennial	Herb	Ph
23	*Murdannia nudiflora*	Seed/stolon	Annual	Herb	Th
24	*Oxalis corniculata*	Runner/seed	Annual	Herb	Ch
25	*Phyllanthus fraternus*	Seed	Annual	Herb	Th
26	*Sacciolepis indica*	Seed	Annual	Grass	Th
27	*Setaria glauca*	Seed/rhizome	Annual	Grass	Cr
28	*Setaria pumila*	Seed/rhizome	Annual	Grass	Cr
29	*Spermacoce pusilla*	Seed	Annual	Herb	Th
30	*Triumfetta rhomboidea*	Seed	Annual	Shrub	Th
31	*Urena lobata*	Seed	Annual	Shrub	Th

Ph= Phanerophyte He= Hemicryptophyte Th= Therophyte Ch= Chamaephyte
Cr = Cryptophyte Cs= Climbing shrub

(Astapati and Das 2024).

The study site was a farmers' managed tropical grassland with activities like annual cutting of matured thatch grass followed by burning practice on an annual cycle. The grassland covered an area of 0.40 ha, equally divided into two adjacent study plots: (i) burnt plot where annual burning was applied and (ii) unburnt plot. The study area was well protected against grazing animals during the study period and field sampling done in the last week of every month for vegetation study.

Methodology

Phytosociological analysis was carried out using 10 quadrats randomly placed in each burnt and unburnt plot for the assessment of species composition, density, abundance and basal cover of all enumerating species. The required quadrat size for the study was 50 cm x 50 cm ascertained from the species-area curve method (Mueller-Dombois and Ellenberg 1974). The number of individuals of a species in all quadrats, expressed as the fraction of number of total quadrats sampled, was density of that species and the number of individuals of a species in all quadrats expressed as the fraction of number of quadrats of occurrence of a species was abundance of that species. Basal area (cover) was estimated by measuring the basal diameter of 10 individuals of each species using a caliper. From these data, Importance Value Index (IVI) was computed using the standard method (Misra 1968).

Life-forms of different species in the study site were determined after detailed floristic studies. The

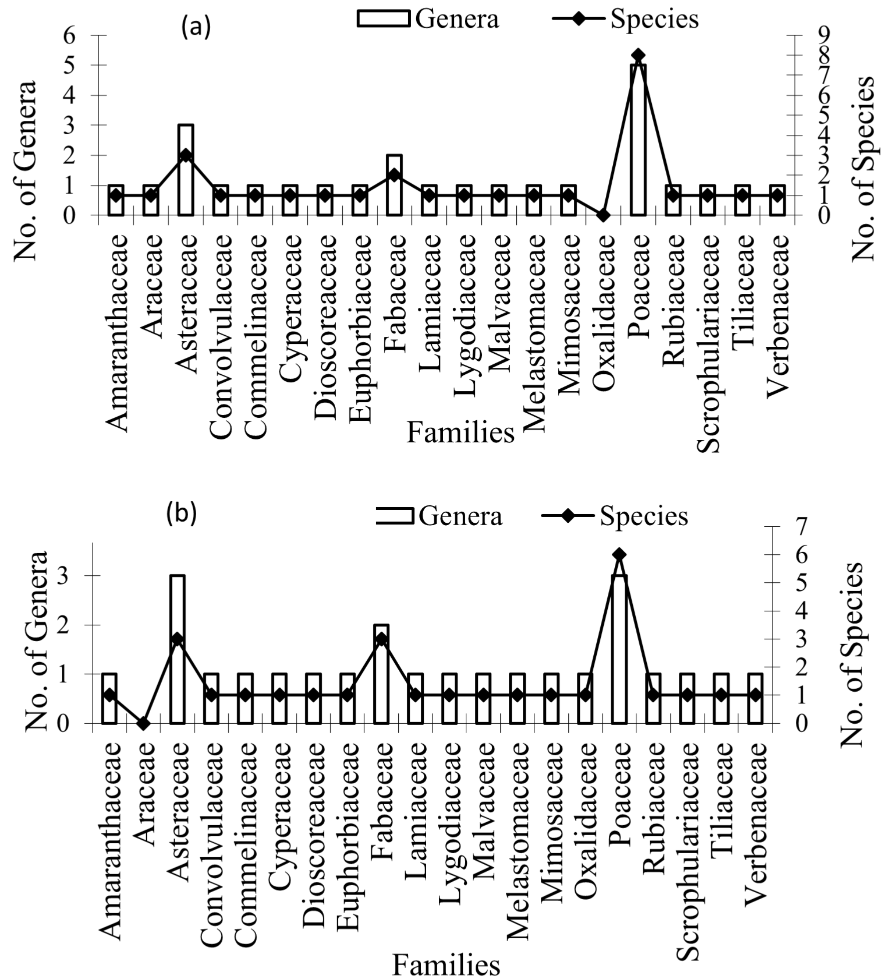

Fig. 1. Diversity pattern of plant families, genera and species in the tropical grassland (a) burnt plot (b) unburnt plot.

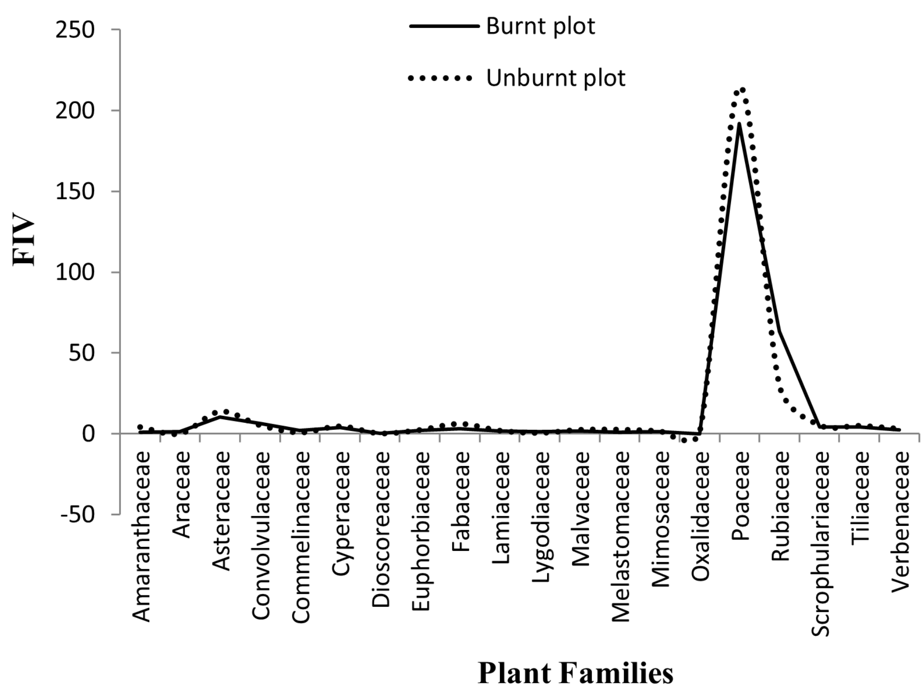

Fig. 2. Plant family characteristics in the burnt and unburnt plots of tropical grassland.

Table 3. Life-forms, total number of species, experimental biological spectrum in the burnt and unburnt plots of tropical grassland and their comparison with Raunkiaer's normal spectrum

Life-forms	Total No. of Species		Biological Spectrum (%)		Raunkiaer's Normal Spectrum (%)	Deviation (%)	
	Burnt Plot	Unburnt Plot	Burnt Plot	Unburnt Plot		Burnt Plot	Unburnt Plot
Phanerophyte	7	7	24.2	25.0	46	- 21.8	- 21.0
Therophyte	14	14	48.3	50.0	13	+35.3	+37.0
Cryptophyte	6	4	20.7	14.3	6	+14.7	+ 8.3
Hemicryptophyte	2	2	6.9	7.1	26	- 19.1	- 18.9
Chamaephyte	----	1	----	3.6	9	----	-5.4

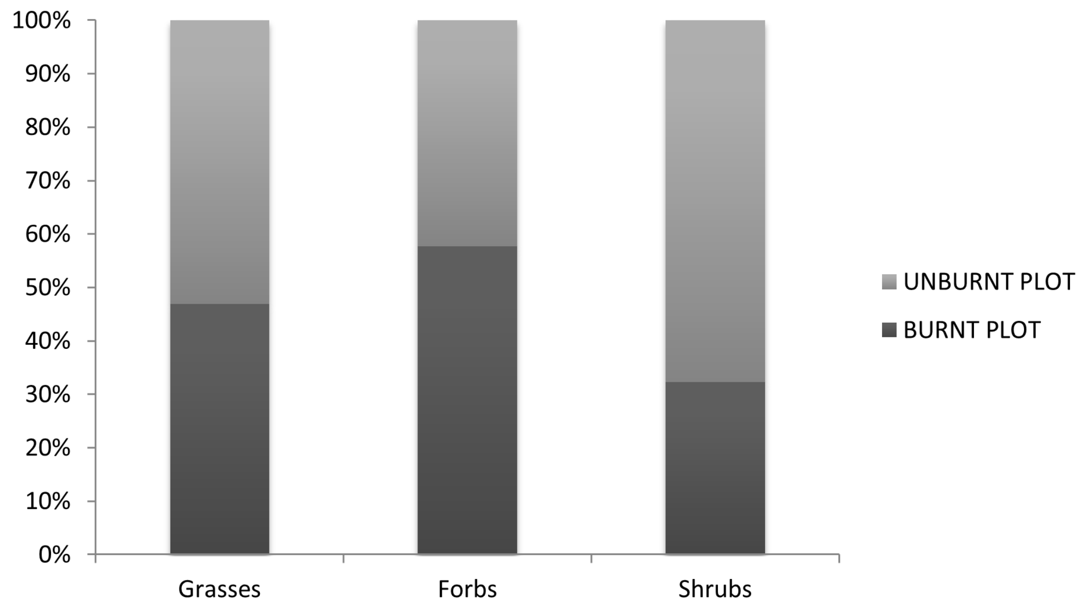

Fig. 3. IVI distribution pattern within the major plant groups in the burnt and unburnt plots of tropical grassland.

morphological characters of each species – life-form, habit, lifespan and nature of perennating buds were examined in the field. Biological spectrum was determined as shown by Raunkiaer (1934) on the basis of percentage species composition in each life-form category.

Phenology of the flora was recorded each month during study period following Singh and Yadava (1974). Six phenophases viz. germination stage, vegetative phase, flowering stage, fruiting stage, seed maturation stage and senescence stage were considered in the study. Phenological observations initiated when phenophases noticed in about 10 percent of individuals of the species followed by peak in more than 80 per cent of individuals (Jeeshna and Paulsamy 2011). The data was recorded from the month of April of the study period after completion of annual burning process and continued till March next year.Statistical analysis (t-test) was performed using MS Excel software.

Results

Floristic composition and structure

Taxonomic findings indicated 20 different plant families in the tropical grassland. Genera and species were in order of 26 and 29 respectively in burnt plot. Correspondingly, 24 genera and 28 species recorded in unburnt plot (Fig. 1a, b). Plant species were assigned to various ecological groups and accordingly there were 8 grasses, 1sedge, 18 forbs, and 2 shrubs in the burnt plot whereas the corresponding values were 6,1,19 and 2 in unburnt plot (Table 1). Family Importance Value (FIV) indicated Poaceae as the dominant family with 63.9% share in burnt plot and 71.5% in unburnt plot followed by Rubiaceae (Fig. 2). IVI of grass members ranged from 0.19 to 132.27 (burnt plot) and 0.50 to 141.68 (unburnt plot). Correspondingly, the values were in the range of 0.16 to 63.10 and 0.16 to 29.75 for herbaceous forbs. Species-wise data indicated highest values of IVI in *I. cylindrica* 132.27 (burnt plot) and 141.68 (unburnt plot) (Table 1). Amid the annual forbs, *Spermacoce pusilla* revealed significant increase ($p < 0.01$) in IVI with 63.10 in burnt plot and 29.75 in unburnt plot (Table 1). The proportionate IVI sharing of the ecologically defined groups representing the ground flora differed in the burnt and unburnt plots of the tropical grassland. As such, IVI distribution of grasses indicated variation from 46.84% and 53.16% in the burnt and unburnt plots respectively. The corresponding values for species other than grasses (forbs) were 57.71% and 42.29% (Fig. 3).

Table 4. Observations of different phenological stages of plant species in the tropical grassland.

Sl. No.	Name of Species	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1	*Achyranthes aspera*	G	G/V	V	V	V/F	Fr/S	S	Sn				
2	*Ageratum conyzoides*	G/V	V	V	V	V	V	V/F	F	F/Fr	Fr/S	S/Sn	S/Sn/G
3	*Cajanus cajan*	G	G/V	G/V	V	V	V	V/F	V/F/Fr	F/Fr	Fr/S	S/Sn	Sn
4	*Chromolaena odorata*	G/V	V	V	V	V	V	V/F	F	F/Fr	Fr/S	S/Sn	S/Sn/G
5	*Chrysopogon aciculatus*	V	V	V	V	V	V/F	F/Fr	Fr/S	S/Sn	Sn	G	G/V
6	*Clerodendrum infortunatum*	G/V	G/V	V	V	V	V	V	V	V/F	F/Fr	Fr/S	S/Sn
7	*Colocasia esculenta*		G	G/V	V	V	F	F/Fr	Fr/S	Sn			
8	*Cyperus haspan*		G	G/V	V/F	F	F/Fr	Fr/S	S/Sn	S/Sn	Sn		
9	*Desmodium caudatum*	G	G/V	V	V	V	V	V/F	F/Fr	S/Sn	Sn		
10	*Desmodium triflorum*	G	G/V	G/V	V	V	V/F	F/Fr	Fr/S	Sn			
11	*Digitaria ciliaris*		G	G/V	V	V	V/F	F/Fr	F/Fr/S	S/Sn	Sn		
12	*Digitaria longiflora*	G	G/V	G/V	V/F	V/F/Fr	F/Fr	F/Fr	Fr/S	S	S/Sn	Sn	
13	*Digitaria setigera*	G	G	G/V	V	V/F	F	F/Fr	Fr	S/Sn	Sn		
14	*Dioscorea alata*		G	V	V	V	V	V	V/F	F/Fr	F/Fr	Fr/S	S/Sn
15	*Imperata cylindrica*	G/V	V/F	F/Fr	Fr/S	V	V	V	V	V/Sn	Sn		G
16	*Ipomoea pes-tigridis*		G	G/V	V	V	F	F/Fr	F/Fr	Fr/S	Sn		
17	*Leucas plukenetii*	G	G/V	V	V	V	V/F	F	F/Fr	Fr/S	S/Sn	Sn	
18	*Lindernia crustacea*		G	V	V/F	F/Fr	Fr/S	S/Sn	Sn				
19	*Lygodium japonicum*	G	G/V	V	V	V	V	V/F	F/Fr	F/Fr	Fr/S	Fr/S	Sn
20	*Melastoma malabathricum*	Sn/G	G	G/V	V	V	V	V/F	F/Fr	F/Fr	Fr/S	S/Sn	Sn
21	*Mikania micrantha*	G	G/V	V	V	V	V	V	V/F	F	F/Fr	Fr/S	S/Sn
22	*Mimosa pudica*	Sn/G	G/V	G/V	V	V	V/F	F	F/Fr	F/Fr/S	Fr/S/	Fr/S	S/Sn
23	*Murdania nudiflora*		G	G/V	V	V/F	F	Fr/S	Sn				
24	*Oxalis corniculata*		G	G/V	V	V	F	Fr/S	S/Sn	Sn			
25	*Phyllanthus fraternus*	G	G/V	V	V	V	V/F	F	F/Fr	Fr/S	Sn		
26	*Sacciolepsis indica*	G	V	V	V	V/F	F	F/Fr	Fr/S	Fr/S	S/Sn	Sn	
27	*Setaria glauca*	G	G/V	V	V	V	V	V/F	F	F/Fr	Fr/S	S/Sn	S/Sn
28	*Setaria pumila*	G	G/V	V	V/F	F	F/Fr	Fr/S	S/Sn	Sn			
29	*Spermacoce pusilla*	G	G/V	G/V	V	V	V	F	F/Fr	Fr/S	S/Sn	Sn	G
30	*Triumfetta rhomboidea*	G	G/V	V	V	V	V	V/F	F/Fr	Fr/S	Sn		
31	*Urena lobata*	G	G/V	G/V	V	V	V/F	F	Fr/S	Fr/S	Fr/S/Sn	Sn	

***G= Germination phase, V= Vegetative phase, F= Flowering phase, Fr= Fruiting phase, S= Seed maturation, Sn=Senescence**

Life-form and biological spectrum

The floristic data indicated 18 (58.06%) species as annuals and 13 (41.93%) as perennials. The plant habits of the enumerated species were well segregated into 15 herbs, 7 shrubs, 5 grasses, 3 climbers and 1sedge (Table 2). Propagating methods signified the prominence of seed producing species as 61.29% of them propagated exclusively through seeds and 32.26% species preferred dual mode of reproduction i.e. both vegetative as well as sexual (Table 2). The vegetative propagules in the form of rhizome, stolonifer, stolon, rosette roots, tuber and runner facilitated vigorous multiplication of plant species which eventually lead to the composition of ground flora. Life form classes in burnt plot were represented by 14 therophytes, 7 phanerophytes, 6 cryptophytes and 2 hemi-cryptophytes. Unburnt plot revealed 4 cryptophytes and 1 chamaephyte whereas similarity with burnt plot existed in therophytes, phanerophytes and hemi-cryptophyte (Table 2). Therophytes contributed maximum species representing biological spectrum followed by phanerophytes and cryptophytes. However, hemi-cryptophytes and chamaephyte were meagerly represented when compared with Raunkiaer's spectrum (Table 3).

Phenology

The plant species of the present grassland revealed various phenological events that are illustrated in Table 4. Actually the phenophases occurred as events that begun with sprouting and culminated with seed maturation. Majority of the seeded plants commenced germination in the month of April, especially after fortnight of annual burning and first shower of rain. Fire triggered fresh re-growth and quick transition from vegetative to reproductive phase in *I. cylindrica.* Subsequently, elongated floral stalks with silky white spikelets emerged at the end of April and continued till May. After completion of early reproductive phase, vegetative growth continued to flush during the monsoon season. In non gramioid species, phenophases followed the sequence of germination, vegetative growth, flowering, fruiting and seed maturation. Ephemeral dicot forbs as *Achyranthes aspera* , *Lindernia crustacea* and *Murdannia nudiflora* are short lived (April – November) with respect to other inhabiting species. The understorey ground cover was respresented as *Desmodium caudatum*, *D. triflorum, Ipomoea pes-tigridis*, *Leucas plukenetii*, *Oxalis corniculata, Phyllanthus fraternus*, *Triumfetta rhomboidea* and *Urena lobata* that emerged, flower, fruit and produce mature seeds within April to January. As that of herbaceous flora, grasses (annual and perennial) too manifested phenological variation. *Setaria pumila* with the shortest life span (April to November) whereas *Digitaria ciliaris, D. longiflora, D. setigera*, *Sacciolepis indica* and *S. glauca* were longer lived plants. The sedge, *Cyperus haspan* was also with a brief life cycle where flowering and fruiting peaked in September. The perennial alien weeds like *Ageratum conyzoides*, *Chromolaena odorata*, *Clerodendron infortunatum*, *Melastoma malabthricum, Mikania micrantha*, *Mimosa pudica* expressed wide phenoperiods covering the wet, cool, and drier months. In *A. conyzoides*, *C. odorata, C. infortunatum* and *M. malabathricum,* senescence occurred in between January to March. *Cajanus cajan* (legume) and *Lygodium japonicum* (fern) followed normal phenological changes likewise other perennial species.

Discussion

The species composition revealed maximum number of species commonly shared between burnt and unburnt plots thus agreeing with the findings in grazing lands at South India (Sundaravalli and Paliwal 2003). Certain graminoids such as *Chrysopogon aciculatus* and *S. indica* were restricted in burnt plot that might be attributed to their survival strategy through viable seeds in the soil seed bank (Ramakrishnan et al. 1997). *S. pusilla* proliferated in burnt plot because of successful seed germination and seedling recruitment after burning (Trabaud and Prodon 2002). In corroborating with the present study, the dominance of Poaceae was reflected in the grasslands of Brazil (Pinto et al. 2013) and Indonesia (Usmadi et al. 2020). *I. cylindrica* emerged as the dominant species in the study area because of its maximum density, abundance, basal cover and IVI at two study plots (Shrestha and Dangol 2006; Usmadi et al. 2020). Taking into consideration the ecological groups, forbs (annual herbs) proliferated greater in the burnt plot as compared to grasses indicated by the IVI distribution pattern. This development was primarily due to the higher values of *S. pusilla* in quantitative terms triggered by fire. Infact, fire seemed to maintain the diversity of plant species including forbs within the grassland vegetation (Walters et al. 2022). Amongst grasses, *S. glauca* (sprouting grass) showed increased density, cover and IVI in burnt plot benefited by burning (Paulsamy et al. 1997). Thus, floristically, the community structure of the present grassland provided an idea of grass-forb assemblage i.e. *Imperata-Spermacoce* association.

The propagating methods of the plant species contemplated the unfavorable growth period by means of perennating buds and appeared with the return of growing season (Haq et al. 2021). This study provided indication of few species (*C. aciculatus*, *S. pusilla* and *S. indica*) whose life-form was regulated by fire (Walters et al. 2022). The dominance of therophytes in the current study was found in conformity with the findings of Shukla and Mishra (2006); Al Shaye et al. (2020). Meager presence of hemi-cryptophytes and chamaephyte resulted in complete deviation of the current biological spectrum from the normal spectrum (Bhattacharjya and Sarma 2016; Al Shaye et al. 2020). With respect to Raunkiaer's spectrum, therophytes therefore, emerged as the leading life-form with maximum proportionate share of species (Al Shaye et al. 2020) followed by cryptophytes (Devi et al. 2004) and are indicative of warm climate. Identical dominance of therophytic flora over the other life-forms was also reported by Devi et al. (2000), Kukshal et al. (2009), Sahu et al. (2012), Hamid and Raina (2019), Das et al. (2020), Haq et al. (2021) from the study of vegetation in different places of India. The prevalence of therophytes in the present grassland are indicative of adaptation and surviving the unfavorable period of growth through seeds (Kensa and Pramila 2014) and annual stress (Kar et al. 2010) or fire (Thakur 2015). More cryptophytes in burnt plot was a strategy of survival by the perennial species under the stress conditions (Paulsamy et al. 1997) and fire (Sen and Bhakat 2021). Lesser phanerophytes and chamaephytes was an indication of perturbation of the grassland (Astapati and Das 2010) with the influence of hot and humid climate (Devi et al. 2000, 2004). Moreover, lower number of hemi-cryptophytes may be attributed to annual uprooting of weeds and slashing practices (Bhattacharya and Sharma 2016). Hence, on the basis of Raunkiaer's terminology, the grassland under present study depicted a thero-cryptophytic type of phytoclimate (Agrawal 2006; Devi et al. 2004).

The occurrence of periodicity in the progression of phenophases was marked in the present study (Ashwini et al. 2014). The preponderance of annual forbs after the first shower of rain may be attributed to the effect of fire (Trabaud and Prodon 2002) and invasion of fallow land (Astapati and Das 2012). Rhizomatic grasses are stimulated by fire with the breaking of dormancy and fresh re-sprouting of vegetative growth (Khatri and Barua 2011; Rawat and Adhikari 2015). Longer phenoperiods of perennial plant species may be attributed to sufficient sunlight and adequate moisture (Ashwini et al. 2014; Sakachep and Rai 2021). The grassland vegetation displayed peak flowering and fruiting in October and November respectively (Kensa and Pramila 2014) followed by seed maturation and senescence with the start of cold, dry and sunny weather condition (Ashwini et al. 2014). Hence, it was observed that the vegetative stage terminated with flower initiation and anthesis took over thereafter (Zhong et al. 2007). It can also be inferred that the present grassland was regulated by seasonal fluctuation in its floristic composition (Nautiyal et al. 2001) and periodicity in photoperiod and temperature (Kensa and Pramila 2014).

The tropical grasslands of the study region are a type of subsistence-earning system based on the wisdom of traditional management. From our study, it is clear that the adoption of customary fire lead to recurring flushing of dominant grasses and herbs, thereby retaining the plant species composition and diversity of the ecosystem. However, the outcome of the floristics and life-form analysis indicated certain level of degradation characterized by reduction in green coverage and variation in the species composition (Zhu et al. 2023). Our findings further recommended that for the effective grassland management, purposeful implementation of agroforestry practices would promote improvement of degraded and fallow landscapes.

Conclusion

It is presumed that the tropical grasslands dominated by *I. cylindrica* are adapted to the traditional fire management systems practiced by the smallholder farmers of Assam, northeast India. Such grasslands are typically small sized and maintained in the arrested successional state that further adds to rural landscape of northeast India. From the current study, it may be anticipated that the annual fire regime might not be a favorable event for the existence of these grasslands and therefore, global research network for devising strategies on land rehabilitation will be promising in the present scenario (Sanchez et al. 1994). Transformation of these grasslands into more productive lands by encouraging agroforestry practices such as plantations of locally suited economic species including legumes may be incorporated that would further facilitate to restore fertility and enrich biodiversity of degraded condition. Bamboos, a key bioresource are often used by the indigenous people as hedges of the grassland systems. In this context, future researches may be undertaken on bamboo agroforestry through diversification of products and thereby creating platform for employment and marketing opportunities. Moreover, taking confidence of the village people and harnessing their local ecological knowledge will indeed be a comprehensive approach of future researches towards regeneration and improvement of managed grassland systems of Assam, northeast India.

Acknowledgements

We acknowledge our gratefulness to the Department of Ecology and Environmental Sciences, Assam University, Silchar for providing support in carrying out the laboratory works. We are also thankful to the rural community of the region for sharing their land to conduct field works.

Conflict of Interest

The authors declare no conflict of interest.

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