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Species Composition and Diversity Pattern in various Grassland Communities with Respect to Different Disturbance and Light Regimes

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ABSTRACT: The grassy landscape of north-eastern Uttar Pradesh showed quite high species richness and a total of 287 plant species belonging to 183 genera under 53 families were encountered within the sampled communities. We categorized each of 31 locations under 12 disturbance types under two light regimes. Their effects were observed in relation to different diversity attributes of grassland communities. In general, the number of species and genera was much greater in open condition as compared to that under partial shade condition. Approximately, >55% herbs, 55.5% shrubs and 50% climbers were common to both the light conditions. Over 31% herbs were common under open and >39.54% under partial shade condition at all the three disturbance levels. Nearly 14.28% species were common to all the disturbance level under open condition. In both, open as well as partial-shade conditions, the grassland communities were significantly different in terms of species richness, diversity, dominance and evenness with respect to three different levels of disturbance. The mean value of species richness, diversity and evenness were maximum in partially shaded communities as compared to open communities. The diversity and evenness were higher in moderate level of disturbance under both the light conditions except species richness. Our results also support Intermediate Disturbance Hypothesis (IDH) as the communities facing moderate level of disturbance showed high species diversity. A few species like *Astercantha longifolia, Cassia absus, Euphorbia hypercifolia, Evolvulus alsinoides, Leucas cephalotus, Perotis indica* and *Teramnus labialis* which were quite uncommon to general grassy landscape were encountered in communities facing low disturbance. Our analysis showed that the moderate level of disturbance in the form of grazing, trampling and cutting are necessary to maintain optimum species diversity. Nevertheless, the degree of exposure did affect the species richness and diversity pattern of the community.

Key words: Grassland community, Species diversity, Disturbance, Light regimes, north-eastern Uttar Pradesh.

INTRODUCTION

It is well established that communities are organized at multiple scales and that the interactions between these scales determine both the local and the regional patterns of species richness (Ricklefs, 1987; Levin, 1992; Zobel, 1997; Lorea, 2000). The variability within plant communities at any one time is due to a number of environmental and biological factors. Of all the environmental factors light is probably the most heterogeneous limiting factor affecting the plant growth and survival (Pearcy, 2007). If the hypothesis that light gradient causes niche differentiation (Denslow, 1980) holds true, then the species should be specialized for a certain range of this light gradient at which they perform better than others. Evidently, the shade tolerant species can germinate, grow and survive in low light, whereas light-demanding species need a high-light environment for their seedling establishment (Osunkoya *et al.,* 1994).

The early successional series involves competition for several resources but in dense stands the competition for light appears more important and the plant stature may play a significant role (Wilson, 1988; Anten and Werger, 1996). Species richness is expected to increase monotonically with increasing light intensity if water is not a limiting factor (Wright, 1983). The variation in species richness is often linked to various environmental gradients (Huston, 1994; Wang *et al*., 2002; Sharma *et al*., 2009).

Indian grasslands are early successional ecosystems that are maintained by frequent disturbances. Some of the disturbances such as drought are natural but additional disturbances are anthropogenic and often in the forms of grazing, fire, trampling etc. (Briggs *et al.,* 2005). These disturbances create a complex spatio-temporal successional state (Collins, 1987).

The role of disturbance in the dynamics of ecological system can be seen as one of the basic ideas in modern ecology (Pickett and Whyte, 1987). Disturbance has been considered as an important factor structuring communities (Collins *et al.,* 1995) and contributes to long-term maintenance of ecological diversity (Huston, 1994). They are also essential to the survival and growth of many species (Walker *et al.*, 1999; Tripathi and Shukla, 2009).

The different quantum of disturbance may have differential impact on the pattern of community and existing plant diversity (Pandey and Shukla, 1999, 2005). The community may undergo changes that are sudden or gradual, dramatic or subtle (Jenkins, 2003; Hooper *et al.,* 2005). Without disturbance in the form of grazing, trampling and fire, the species composition of many grassland communities gradually shifts over time (Srivastava, 2015). Several species manage to grow in a number of subsequent stages of the successional series, though their growth performance may differ between those stages (Chaurasia and Shukla, 2016). The high species richness in sal stands of lower age has been attributed to the greater number of herbaceous species owing to more open canopies causing greater light to reach the understorey (Gupta and Shukla, 1991). The plant species may also be able to persist by modifying their pattern of biomass allocation in favour of plant organs affecting light harvesting capacity (Shukla and Ramakrishnan, 1984).

The grassland of the plains of north-eastern U.P., however, received little attention especially in terms of its community composition and diversity pattern. The present study was attempted with two major objectives 1. To observe the species composition and diversity pattern in various grassland communities with respect to different disturbance and light regimes. 2. To compare the species richness and diversity indices between the communities facing high, medium or low disturbance under two different light regimes. Such information may be necessary to assess the threshold level of disturbance and light regimes for optimum biodiversity of grassland species.

STUDY AREA, CLIMATE AND VEGETATION

Study area. The plains of north-eastern U.P. cover 16 districts of eastern Uttar Pradesh and the region abounds in agricultural fields and grassy landscapes, heavily traversed by rivers, rivulets, nullahs, lakes and ponds. Though the climatic conditions favour forest as climax vegetation but recurrent and severe disturbances in the form of grazing, trampling and burning has arrested the ecological succession since long over most part of the land area except those covered by forests. The abandoned arable lands also develop into natural grasslands as a result of secondary succession and tend to be stable under the influence of biotic disturbances such as fire, grazing and clipping practices. The grassland vegetation of north-eastern Uttar Pradesh is bordered by Nepal in the north and Bihar state of India in the east. The regional plain slopes gently from North-West to South-East. The landscape presents a mosaic of plant communities with varying amount of grasses and forbs of contrasting life-forms.

Climate. The climate of the region is typically tropical monsoonal with three distinct seasons *viz.* summer (March to mid June), monsoon (mid June to mid October) and winter (mid October to February). The total average annual rainfall is about 1814 mm and 87% of it occurs during wet summer or rainy season. The rest 13 percent is distributed in the form of occasional showers from November to May. The number of rainy days per annum is 51±3.2 and the annual mean of relative humidity is about 87% in the morning and 74% in the evening. For most part of the year, the area is practically dry but without any significant water crisis. The eastern *Terai* plains receive better rainfall for longer period and, therefore, possess much richer plant biodiversity as compared to western and southern districts of the state. Mean maximum temperature during wet summer, winter and dry summer season is 35.2°, 27°, and 39.3°C and mean minimum temperature is 26.2°, 12.1° and 24.2°C respectively (based on climatic data for 2000-2005).

Soil. The region touches bhabhar tract bordering the foot hills of Shivalik range and mostly has alluvial soil formed by the deposition of silt carried by seasonal floods. The soil of this region is a part of trans-Sarju Plain and comprises Gangetic alluvium brought down by rivers like Ghaghara, Rapti, Rohin and Gandak from the Himalayas in the north. The texture is sandy loam and the soil reaction is circumneutral. In the northern area there are a few elevated mounds, locally called *Dhus*, which range in size from a few hundred meters to 4-5 km and have brown sandy soil. The Mound or *Dhus* which is clearly a sloppy undulations of large deposits of brown sandy soil formed by local geographic alterations since antiquity.

Vegetation. The period between mid-June to mid–September represents the growing season when most plants attain peak biomass followed by their reproductive phase. Majority of the species of community enter into flowering and fruiting stages. Many annuals complete their life cycle and decay by the end of October, dispersing their seeds on the immediate ground where they remain dormant till the next rainy season at least. The shoots of the perennial species dry out during winter. In some cases, however, tillers may appear from the underground rhizome after occasional winter rains caused by retreating monsoon. Seasonal changes in the environmental constraints of these areas may lead to differences in plant community structure and dynamics.

METHODS OF STUDY

We started this study with the survey of a vast stretch of grassy landscape of *Terai* of north-eastern Uttar Pradesh which covers about 3,54,80,000 ha area encompassing over 11 districts. The vegetation was closely observed and finally 31 different locations, showing marked differences in habitat conditions, were selected (Map 1) and sampled during August 2011 to March, 2014. Difference in habitat conditions appeared mainly in the degree of exposure, soil moisture and soil texture as related to topography and disturbances. 20 square quadrats, each of 50 cm × 50 cm size were randomly laid at each location. Thus, a total of 620 quadrats were sampled across 333.075 ha area of the regional grassland.

Various phytosociological and diversity indices were derived through conventional methods (Mueller-Dombois and Ellenberg, 1974). Importance Value Index (IVI) was taken as the sum of relative values of frequency, density and vegetal cover. The dominance was measured as Simpson's index ($Cd = \Sigma p_i^2$) and species diversity as Shannon's index ($\bar{H} = - \Sigma pi \ln pi^2$), where pi represents the proportional abundance of i^{th} species in the community. The degree of evenness was calculated by Pielou's index ($E = \bar{H}/\ln S$), where S is the total species richness of the community (Magurran, 1988).

Grasslands are closely related to agro-ecosystems. The encroachment and conversion for agriculture, plantation, infrastructure developments, their massive extraction for fodder, fuel and the overgrazing are some of the pressures of disturbance. A reconnaissance survey with participation of local elders and range managers was conducted to identify patches facing low, moderate and high disturbance. We categorized each of 31 locations under 12 disturbance types (Table 1a, 1b). The periodicity of occurrence of each disturbance type was classed as rare, occasional and recurrent.

Table 1a: Different types of disturbances operating at the study sites across grassy landscape of north-eastern Uttar Pradesh. The degree of each disturbance type was based on the frequency of its occurrence and was classes as 1. Rare, 2. Occasional and 3. Recurrent occurrence.

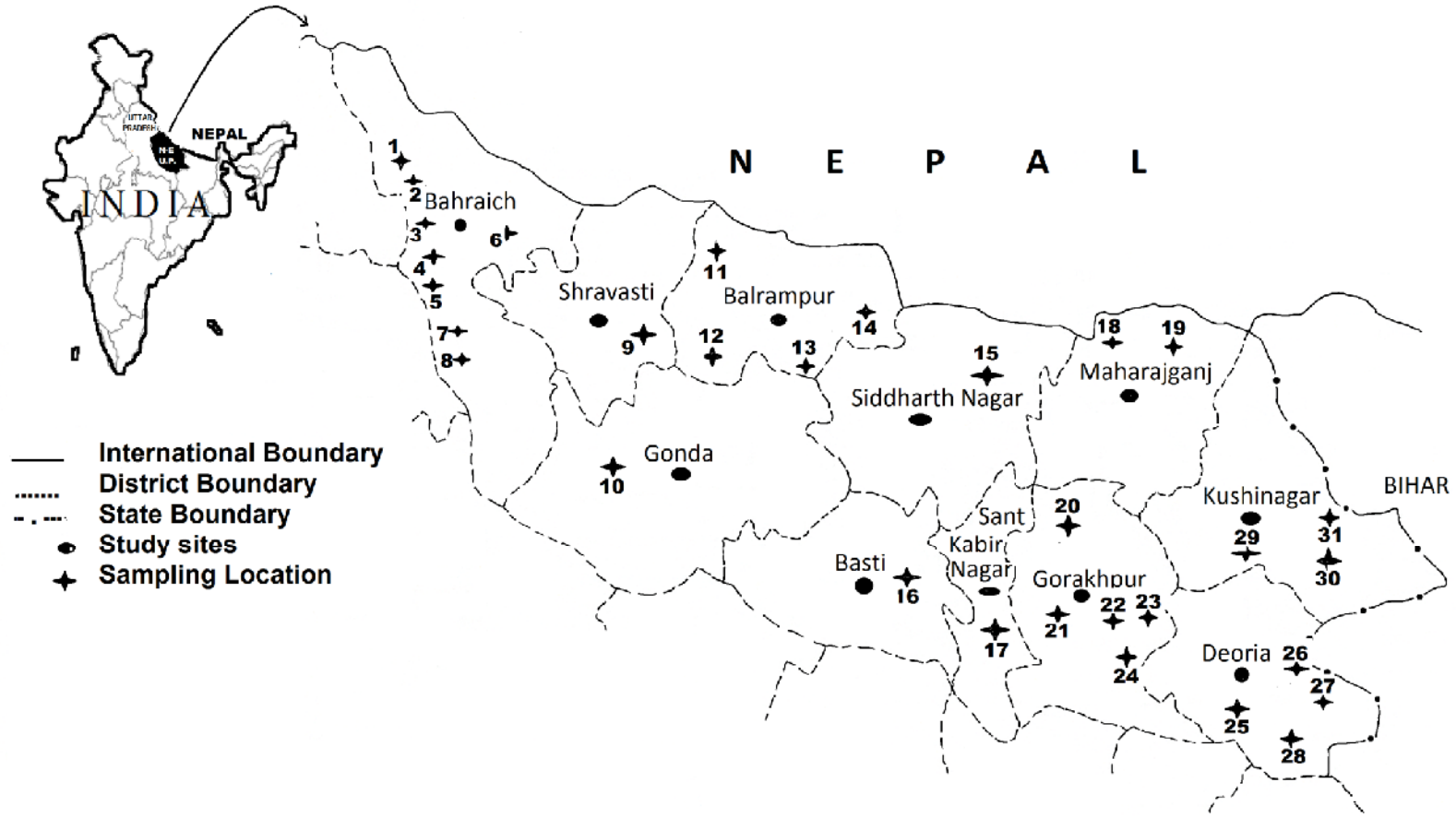
Disturbance type	Rare occurrence	Occasional occurrence	Recurrent occurrence
Agricultural practices	1	2	3
Horticultural practices	1	2	3
Forage removal	1	2	3
Fuel wood collection	1	2	3
Grazing	1	2	3
Fire	1	2	3
Invasion	1	2	3
Litter collection	1	2	3
Mining of soil	1	2	3
Root collection	1	2	3
Trampling	1	2	3
Flood	1	2	3

Table 1b: The weightage score based on the degree of disturbances.

Disturbance level	Weightage score
Low	1 or 2 or 3 = (1/2/3)
Medium	1 and 2 or 1 and 3 = (1+2/3)
High	1 and 2 and 3 = (1+2+3)

The degree of exposure was measured by an illuminometer (Kyoritsu-5200) at 10 random and nearly equidistant points on the floor of each of the communities during sunny days of November at mid-day. The light regime of open communities ranged from 70 to 75 thousand lux and that of partially shaded communities was below 10, 000 lux.

The statistical analysis was carried out using Graph pad Prism (Graph Pad software) Version 5.01.



Map 1. Map showing the study sites and sampling locations (1-31). Inset map of India shows the position of study zone in Uttar Pradesh (U.P.).

RESULT

A total of 287 species belonging to 183 genera under 53 families was recorded within 22 grassland communities of north-eastern Uttar Pradesh. The number of species and genera was much greater in open condition as compared to that under partial shade condition (Fig. 1). Among the three different growth forms, viz. herbs, shrubs and climbers were noticed within grassland communities. Approximately, >55% herbs, 55.5% shrubs and 50% climbers were common to both the conditions. The number of herbaceous species was higher in grassland communities at moderate disturbance in open condition and at high disturbance in partial- shade condition. Of about >31 % herbs were common under open and >39.54 under partial shade conditions present at all disturbance levels. At low disturbance, herbs were lesser in both the light conditions (Fig. 2a).

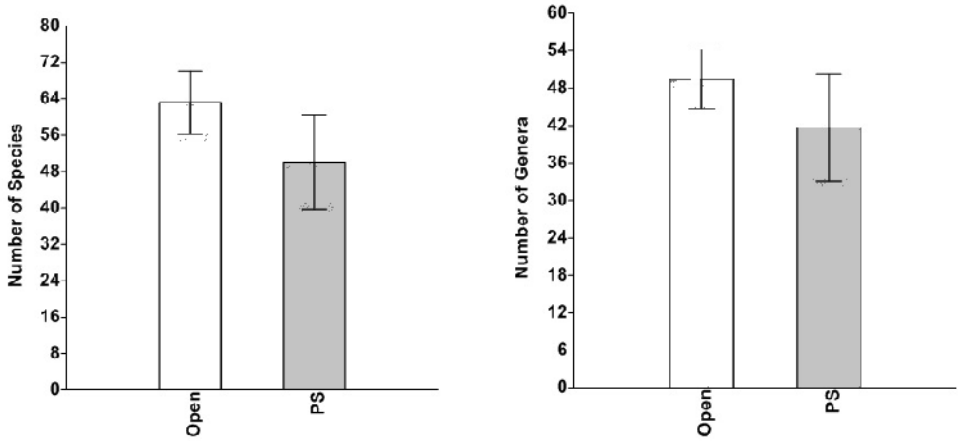


Fig. 1. The number of plant species and genera (Mean± Standard error) within grassland communities under two light regimes, Open (O) and Partial shade (PS).

The shrub was greater in number at low disturbance under open condition and at high disturbance under partial-shade condition. Nearly 14.28 % species were common in all the disturbance level under open condition. *Ficus heterohhylla* and *Lippia alba* were noticed in exposed communities under open condition and *Lantana camara* and *Jatropha curcus* were also present in partial-shade condition. The equal number of shrubs was reported in both open as well as partial shaded communities facing moderate level of disturbance (Fig. 2b). *Clerodendron indicum*, *Triumfetta rhomboidea* and *Urena lobata* were found in exposed communities facing moderate level of disturbance and the last two species were reported in high level of disturbance under-partial shade condition. The better growth of *Desmodium gangeticum* was observed in communities facing low and moderate level of disturbance under partial-shade condition as compared to exposed communities facing low disturbance.

A vine is an herbaceous climber with thin stems and mainly colonizes the high light habitat facing disturbance. The maximum number of climbers, namely *Cayretia trifolia, Cucumis melo, Cuscuta chinensis, Ipomoea aquatica, Ipomoea pes-tigridis, Lathyrus sativus, Mukia maderaspatana, Operculina terpethum* and *Tiliacora acuminata* were found only in exposed communities facing moderate level of disturbance and *Basella alba, Cissampelos prariara, Cucumis melo, Hemidesmus indicus, Momordica dioica, Teramnus labialis* and *Tinospora cordifolia* were also reported in communities of low disturbance under the partial-shade condition. The minimum number of climbers was noticed at high disturbance under open condition as compared to that under partially shaded habitats facing moderate disturbance condition (Fig. 2c). Few climbers such *as Lathyrus odoratus, Oxystelma secamone, Cissampelos pariera* and *Teramnus labialis* were present in exposed communities containing high moisture. The first two species were facing high disturbance and the last two species were facing low disturbance. *Tinospora cordifolia* was found in all level of disturbance under open condition and *Coccinia indica* and *Ichnocarpus frutescens* were observed in partial-shade condition.

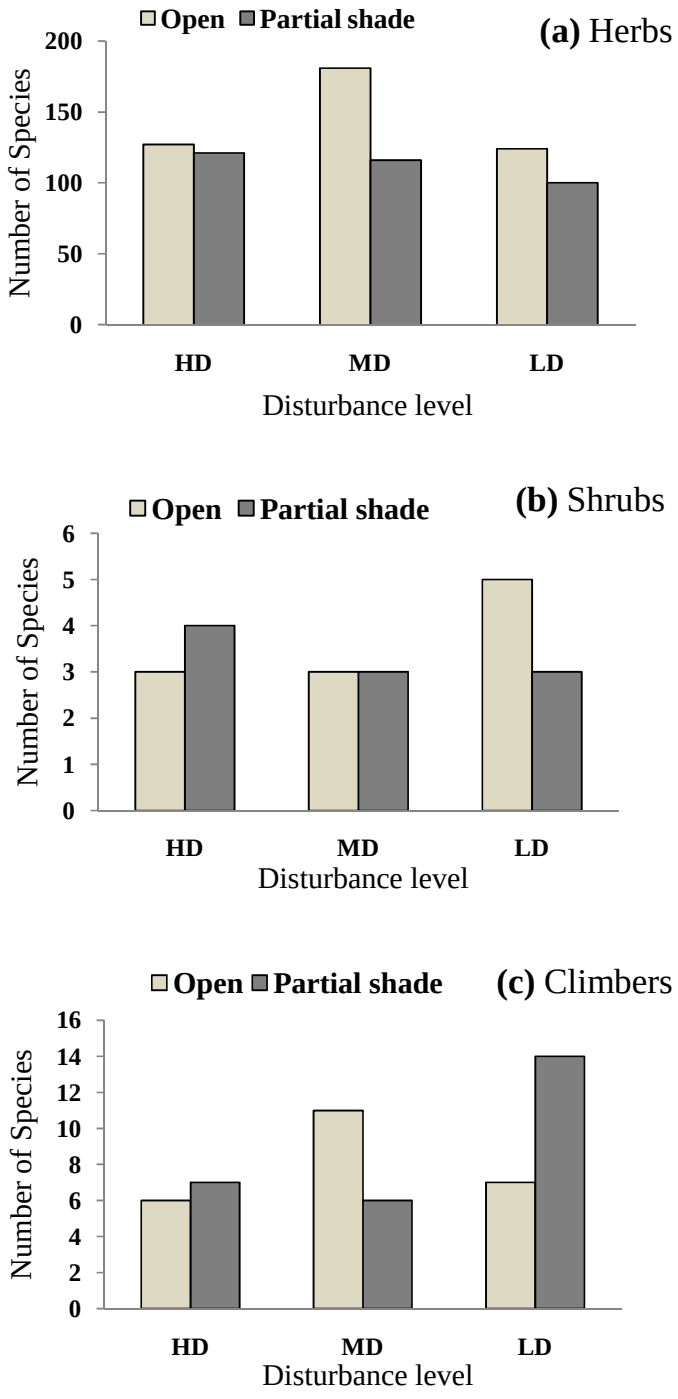


Fig. 2 (a-c). Habit-wise number of species under each of the three types of disturbance (HD = High Disturbance, MD = Medium Disturbance and LD = Low Disturbance) across the grassland vegetation of north –eastern Uttar Pradesh.

In both the open as well as partial-shade conditions the grassland communities were significantly different in terms of species richness, diversity, dominance and evenness with respect to 3 different level of disturbance (Fig. 3). The mean value of species richness, diversity and evenness were maximum in partially shaded communities as compared to open communities.

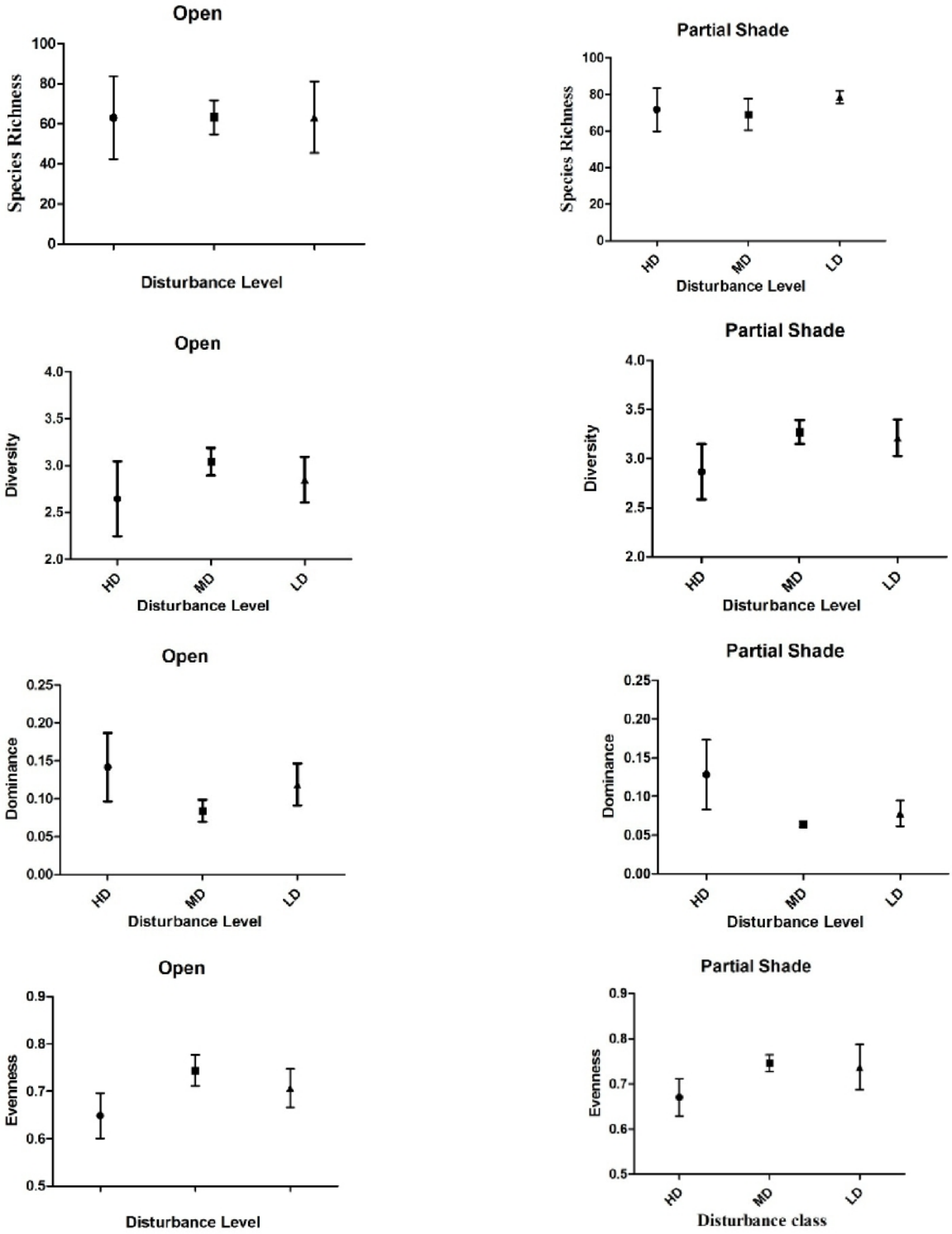


Fig. 3. Species richness, diversity, dominance and evenness of the grassland communities facing three types of disturbance (HD = High disturbance, MD = Moderate disturbance, LD = Low disturbance) under open and partial shade condition.

The diversity and evenness were higher at moderate level of disturbance under both the light conditions except species richness. The species richness, however was also high at low level of disturbance in exposed as well as partial shade conditions. Further, the slight difference in species richness was recorded between communities facing moderate or low level of disturbance under open condition.

DISCUSSION

Disturbance is ubiquitous, inherent and unavoidable affecting all levels of biological organization. Communities are influenced by various kinds of natural and anthropogenic disturbance such as fire, flooding, logging, grazing, trampling and mining of soil (Collins, 1987; Collins *et al*., 1998; Knapp *et al.,* 1999) and they may undergo sudden or gradual changes (Hooper *et al*., 2005). The grassy landscape of north-eastern Uttar Pradesh showed quite high species richness and a total of 287 plant species were encountered within the sampled communities. The high species richness may be attributed to the most favourable conditions due to high rainfall and good insolation. The effect of 12 forms of anthropogenic disturbances (Table 1a), was observed in relation to the species diversity indices of various grassland communities sampled under different set of ecological conditions as determined primarily by the degree of exposure and level of disturbance.

Light is a major determinant of the structure and dynamics of plant communities (Welssing and Huisman, 1994). The partially shaded communities showed much greater diversity and evenness as compared to open communities under moderate level of disturbance. Some degree of disturbance is essential to the survival of many species (Walker *et al.,* 1999). The fully exposed communities, on the other hand, showed quite low species richness and diversity at high disturbance mainly due to high trampling. Trampling damages plant aerial parts and suppresses vegetation height (Cole & Bayfield, 1993) which promotes changes in the microenvironment of vegetation by modifying the availability of resources (Liddle & Moore, 1974).

Several species of trampled communities have been found to show tussock, rosette and prostrate growth forms. Such forms are especially adapted to trampling (Sun and Liddle, 1993). Evidently, the high intensity of grazing and trampling in the observed communities has caused the dominance of prostrate perennial herbs. Grazing animals affect plant communities by ways of defoliation, nutrient removal, nutrient redistribution through excreta and mechanical impacts on soil and plant material through trampling. The diversity of flowering plants is suppressed in heavily grazed areas (Polunin and Stainton, 1984). Heavy grazing not only reduces plant diversity but also causes soil erosion and promotes the growth of ruderals and weeds (Kala and Rawat, 1999).

Disturbance is a discrete event that abruptly destroys or displaces individuals and creates an opportunity for new individuals to become established (Robin and David, 2001; Srivastava *et al*., 2015). Hayashi (1994) reported that disturbance such as mowing or clipping increased species richness suggesting that removal of dominants may produce an opportunity for the colonization of subordinate species. Disturbances may occur at a range of spatial scales. As the disturbance ceases to occur or its intensity goes down, the big size tussock plants increase to dominate and gradually stabilize the grassland community by homogenizing its structure (Overbeck *et al*., 2005).

The herbaceous species showed a mosaic pattern which was more pronounced in drier months. The dominance of such species changed with sites and seasons and it was more pronounced for exotic species like *Parthenium hysterophorus* and *Hyptis suaveolens* (Srivastava *et al.*, 2014). The ability of large, fast growing perennial herbs to suppress the growth of smaller neighbours was particularly evident in the studied communities. Annuals are suggested to act as opportunists having a short life span and high fecundity that enables them to rapidly colonize the open spaces generated as a result of disturbances (Gupta and Narayan, 2006). Such species have also been reported to show increasing abundance along the grazing disturbance gradient in semi-arid grassland of Australia (Fensham *et al*., 1999).

Predictions of the intermediate disturbance hypothesis (IDH) that species diversity would be highest at a moderate intensity of disturbance, has been found true in many ecosystems (Connell, 1978; Floder and Sommer, 1999; Buckling *et al.,* 2002). Our results also supports this hypothesis as the communities facing moderate level of disturbance in the form of grazing, trampling or clipping showed high species diversity in both light conditions. Morris *et al.* (1992) reported that light but constant grazing has greater impact on species composition than infrequent grazing. van der Maarel (1971) and Grime (1979) found that moderate trampling may increase in diversity while small disturbances in the form of vegetation removal release resources that favour subordinate species (Armesto and Pickett, 1985). The communities facing moderate disturbance showed the dominance of species like *Lindernia deccusata, Rungia repens, Lindernia ciliata, Evolvulus nummularis, Desmodium triflorum, Zornia gibbosa, Spermacoce pusilla, Cynodon dactylon, Setaria glauca* and *Gomphrena globosa*. A number of short-statured annual species including members of Poaceae were also present on the site. Annuals are known to respond more positively to moderate disturbance than perennial species and short perennials respond more positively than long perennials (Belsky, 1986).

Collins *et al.* (1995) argued that richness should be highest at intermediate frequencies of disturbances when condition favours competitive species which can also tolerate disturbance. The intensity and frequency of disturbance are important determinants of plant diversity which promotes ecosystem stability (McNaughton, 1967). Low disturbance also supports considerable species richness but lesser as compared to communities facing moderate disturbance. A few species like *Astercantha longifolia, Cassia absus, Euphorbia hypercifolia, Evolvulus alsinoides, Leucas cephalotus, Perotis indica* and *Teramnus labialis* which were quite uncommon to general grassy landscape were encountered in communities facing low disturbance.

Similar results were noticed under partial shade condition and showed very minute difference from fully exposed communities in species richness. The high disturbance showed dominance of *Fimbristylis bisumbellata.* At moderate and low disturbance, *Ageratum houstonianum, Cynodon dactylon, Oplismenus burmannii* and *Phyllanthus urinaria* and other non-grass species were dominant. *Desmodium triflorum, Evolvulus nummularis, Lindernia deccusata* and *Rungia repens* were dominant within grassland communities facing any level of disturbance and *Evolvulus nummularis* and *Oplismenus burmanii* were the most shade-tolerant species of the region. The shaded communities perhaps check severe drying due to relatively low temperature at the soil surface (Kobayashi *et al*., 1997). The communities facing the moderate and low levels of disturbance have been found to show greater diversity of life-forms, dispersal morphology and reproductive modes (McIntyre *et al.*, 1995) and showed the dominance of *Desmodium triflorum* and *Rungia pectinata* which may be attributed to moderate grazing and trampling. In such conditions, the short-statured species could escape the onslaught. Kobayashi *et al.* (1997) also reported that at partial shady site, soil water availability was not affected by trampling which allowed the survival of many species and fairly high species diversity.

Climbers had limited contribution under the grassland vegetation as compared to forest as well as wasteland as also reported by other workers (Mishra, 2013). Few climbers as *Basella alba, Momordica dioca* and *Tecomaria capensis* were present in partially shaded communities facing only low level of disturbance. They could not withstand high disturbance. *Coccinia indica* and *Ichnocarpus frutescens*, however, occurred in all the habitats irrespective of disturbance level and their dominance increased in partially shaded communities facing low disturbance. Exposed communities at moderate level of disturbance supported a distinct set of climbers such as *Hemidesmus indicus, Lathyrus aphaca* and *Oxystelma secamone.* The moderate disturbance and exposed conditions promoted the density and abundance of climbing species (Gianoli *et al.*, 2010).

The periodically flooded communities faced disturbance mainly in form of periodic inundation. This condition was probably related to low species richness in the communities on the site. However, the species like *Ficus heterophylla* and *Lippia alba* showed its dominance in the communities facing high disturbance under the open condition. The distribution of these species was largely random but *Lippia alba* was locally aggregated on different spatial scales. The species showed aggregation either due to localized seed falls or simply by vigorous vegetative proliferation through sprouts. Pacala (1997) also reported that local or intra-specific aggregation is generated by limited seed dispersal, clonal growth and patchy environments. *Ficus heterophylla* mostly grows through seed and the seed may get dispersed by flood water, animals as well as human beings (Srivastava *et al.,* 2015). Its seeds quickly germinated especially in disturbed area under open condition. Gudrun & Claude (1996) also reported decreased species richness at high intensity of flood disturbances.

Disturbances associated to fire and grazing may be important to the maintenance of the structure and diversity of communities, if they are not very frequent or intense. Few grass species such as *Imperata cylindrica, Setaria glauca,* and *Saccharum spontaneum* could grew in dense, impenetrable stand and increased their dominance in exposed communities facing high disturbance in the form of fire and grazing. *Saccharum spontaneum* is highly invasive; grow in partial shaded communities facing moderate and low level of disturbance. This species is adapted to drought, burns frequently and has deep rhizomes that make it difficult to eradicate through deep ploughing, and fire (Panje, 1970). The fire increases the species richness, which can peak within a few years. This greater species richness can be achieved by the presence of great numbers of opportunistic, pioneer, annual and perennial species (Vogi, 1974; McIntyre *et al.,* 2003) by the development of interstitial species, mainly little herbs that are able to grow due to the opening of dominant grasses canopy (Overbeck *et al.,* 2006).

Grasses are adapted to fire mainly due to their regeneration capacity after disturbance (Pelaez *et al.,* 2003). According to Bond and Midgley (1995), grasses evolved under the influence of burn, they are highly inflammable, and by being the main fire fuel, they eliminate neighbour plants and rapidly reoccupy the space. This is due to the continuous growth of intercalary meristems at the base of leaves and new tillers arising from protected meristems underground (Bond and Wilgen, 1996) which also favours them under continuous grazing.

Heavy trampling, grazing and recurrent clipping provided extreme conditions of biotic disturbance (Srivastava, 2015). Some grasses notably, *Eragrostis tenella, Fimbristylis bisumbellata, Imperata cylindrica*

and *Setaria glauca* few leguminous forbs like *Desmodium triflorum,* and *Evolvulus nummularis* and a few forbs *Lindernia decussata* and *Lindernia ciliata* could cope up with such a high degree of composite disturbance. Prostrate Species showing aggregation often formed compact mat and allowed minimum associates which resulted into low species richness of the local community. The erect species, on the other hand, allowed significant number of species within their aggregations. Stoll and Prati (2001) reported that local aggregation affects individual performance and has quite different effects depending on the species and competitive superiority. The Shannon diversity index was low for these communities. Kimmins (1987) also reported that single species dominance causes decline in diversity.

Disturbance and light regimes have always been considered as major factors capable of influencing species diversity. Disturbance intensity will cause more change in space and light availability in dense communities than in open communities where these resources are already more abundant (Safford and Harrison, 2004). According to Grime (1979), ruderals shall be more abundant under disturbed conditions and competitors under undisturbed conditions. Depending upon the intensity and frequency, disturbance can create vacant microsites, reduce competition, cause invasion and species replacement and affect reproduction and germination through seed as well as sprouts/ramets (Shanker and Singh, 1996). Species are less likely to specialize in communities where space and light are less limiting (Grubb, 1977). The presence of lowest number of species under most disturbed conditions is in conformity with the observation of Margutti *et al*. 1996).

CONCLUSION

The study explores the species composition and diversity pattern within various grassland communities at three levels of disturbance under two light regimes. The partially shaded communities showed much greater diversity and evenness as compared to open communities under moderate level of disturbance. The fully exposed communities, on the other hand, showed quite low species richness and diversity at high disturbance. The latter promotes changes in the microenvironment of community by modifying the availability of resources. Low disturbance also supports considerable species richness but lesser as compared to communities facing moderate disturbance. Prostrate species showing aggregation often formed compact mat and allowed minimum associates which resulted into low species richness. The erect species, on the other hand, allowed significant number of species inside their aggregates which increased the species richness of the community. The discrete severe disturbance may cause local extinction of a few rare plant species. Our analysis, however, showed that the moderate level of disturbance especially in the form of grazing, trampling and cutting in association with light regimes help maintain the optimum species diversity of grassland communities.

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