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Diversity of herbaceous layer in tropical dry deciduous forest: Effects of anthropogenic disturbance

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ABSTRACT

The present paper describes the effects of disturbance on the diversity of herbaceous layer along the disturbance gradient, viz., least disturbed, moderately disturbed and highly disturbed forest sites in the Katghora forest division of Chhattisgarh, India. The herbaceous layer was measured in 1 ha representative plots by randomly placing ten quadrats of 50 cm x 50 cm in size on each site. The density and diversity of herbaceous species were highest in moderately disturbed forests. The diversity at least disturbed forest sites was 70%, and at highly disturbed forest sites was 90% of moderately disturbed forest site. Similarly, the density at least disturbed forests was only 33%, and in the highly disturbed forest, 42% of moderately disturbed forest area. The study indicated that the density and diversity increase initially in response to human influence but rapidly decline when interference levels increase.

Key words: *Anthropogenic disturbance, Distribution, Herbaceous diversity, Importance Value Index, Tropical dry forest.*

Introduction

Despite their small structure, herbaceous plants are essential to forest biodiversity, ecological processes, and conservation (Gilliam, 2014). Herbaceous plants comprise over 80% of the vascular plant species in temperate forests (Gilliam, 2007; Spicer *et al.,* 2020) and up to 45% in tropical forests (Linares-Palomino *et al.,* 2009). This heterogeneous group has several biotic interactions (Whigham, 2004; Gilliam, 2014) and can filter tree regeneration (Royo and Carson, 2008). Forest herbs can be biodiversity indicators (Culmsee *et al.,* 2014) and have been employed as charismatic conservation concerns (e.g., orchids) to promote sustainable forest management (Swarts and Dixon, 2009). Climate change is causing herb phenology mismatches with the early springtime and higher temperatures (Heberling *et al.*, 2019), and diminishing bee numbers are reducing pollination possibilities for herbaceous plants (Hanula *et al.*, 2016).

The herbaceous layer plays a crucial role in the ecology of forests, and the increase in biomass is advantageous (Whittaker, 1966). The content and structure of the understory change depending on the type of forest (Hart and Chen, 2008). Several factors cause variation in understorey vegetation structure and composition, just as with overstorey species (Jhariya, 2017). The structure and composition of both upper-storey and understorey stratum are

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significantly influenced by soil moisture, nutrient status (Newbery *et al.*, 1996), vegetation management regimes (Ares *et al.*, 2009), forest fragmentation (Rasingam and Parthasarathy, 2009), forest fire, and anthropogenic disturbance regimes (Oraon *et al*. 2014). Investigating the ecological interactions and processes within the forest ecosystem requires quantifying the understory vegetation (Kumar *et al.*, 2017). The forest's reservoir of nutrients is its soil, which builds up those nutrients through ground vegetation, plant biomass and litter (Oraon *et al.*, 2018; Jhariya *et al.*, 2019).

Herbs are essential ground vegetation in the forest. They accumulate biomass, organic materials, and nutrients in soil ecosystems. Forest ecosystems lack the understanding to explore these phenomenal properly. Comparative analysis of herbaceous vegetation's biomass, organic matter, nutrient, and contributions is still needed. This study hypothesises that disturbance severity affects herb community succession, species composition, and diversity. Thus, our study illuminates herb species composition variations under tropical disturbance regimes.

Materials and Methods

The present study was conducted under the Katghora Forest Division of Chhattisgarh. The study area falls in Tropical Dry Deciduous Forest. The research sites comprised three disturbance levels, i.e. least disturbed forest (LDF), moderately disturbed forest (MDF) and highly disturbed forest (HDF). The disturbance levels were categorised based on geo-referenced forest density data and verified by Katghora Forest Division. Changes under various disturbance levels were estimated by measuring and characterising herbaceous vegetation. Herbaceous diversity and density were measured by ten randomly placed quadrats of 50 cm x 50 cm on each site. The herbs were identified at the species level. Field data were further analysed for frequency, abundance, and density (Curtis and McIntosh, 1950). The A/F ratio was used to analyse herbs' dispersal patterns (Singh *et al.* 2014).

Results and Discussion

The species structure of the herbaceous layer under different disturbance levels is summarized in Table 1. The present study identified 12 species representing 11 families in all three disturbance gradients.

Table 1. Species structure of herbaceous layer under different levels of disturbance

Species	LDF					MDF					HDF				
	F(%)	A	D (stemsha^{-1})	IVI	A/F	F(%)	A	D (stemsha^{-1})	IVI	A/F	F(%)	A	D (stemsha^{-1})	IVI	A/F
Andrographis paniculata (Burm. fil.) Nees						30	1.75	3500	17.84	0.058	30	1.00	4000	15.06	0.033
Andropogon gerardi (Vitman)						50	15.60	156000	104.65	0.312					
Asparagus racemosus Willd.											20	1.00	4000	15.06	0.050
Cynodondactylon (L.) Pers.						20	2.60	52000	44.42	0.130					
Cheilanthes tenuifolia (Burm. fil.) Sw.	60	2.67	32000	72.34	0.044										
Desmodium triflorum (L.)DC.	30	2.00	12000	37.16	0.067	40	1.60	16000	20.08	0.040	40	3.00	24000	48.07	0.075
Eriocaulon scariosum Sm.						50	2.33	28000	28.01	0.047	50	2.60	26000	50.19	0.052
Euphorbia hirta L.	30	2.67	16000	45.7	0.089	30	1.00	8000	13.77	0.033	30	1.33	8000	23.08	0.044
Evolvulus nummularius (L.) L.	40	1.75	14000	41.11	0.044	40	2.00	12000	15.91	0.050	40	1.00	8000	24.10	0.025
Hemidesmus indicus (L.) R. Br.	50	1.40	14000	42.45	0.028	30	1.75	14000	17.84	0.058	40	1.50	12000	30.09	0.038
Spermacocever ticillata L.	30	2.00	12000	37.16	0.067	50	3.33	20000	22.35	0.067	50	3.20	32000	58.27	0.064
Vernonia texana (A. Gray)	20	1.50	6000	24.08	0.075	40	1.25	10000	15.13	0.031	40	2.00	16000	36.09	0.050
Total			106000	300.00				319500	300.00				134000	300.00	

Note: F- Frequency;A- Abundance; D - Density; IVI - Importance Value Index

AF ratio: <0.025- Regular distribution; 0.025-0.050- Random distribution; and > 0.50- Contiguous distribution.

Poaceae (16.33%) had the highest number of species. In LDF, seven species belonging to 7 families were identified. The total density of this site was 106000 individuals ha^{-1}, with the highest numbers of *Cheilanthes tenuifolia* (32000 individuals ha^{-1}), a fern species and the lowest of *Vernonia texana* (6000 individuals ha^{-1}). The distribution pattern of species was contagious and random at this site. Ten species were measured at MDF, representing nine families. The density ranged between 3500 individuals ha^{-1} and 156000 individuals ha^{-1}, with a total density of 319500 individuals ha^{-1}. The *Andropogon gerardi* had the highest IVI and density, whereas *Euphorbia hirta* had the lowest IVI. The distribution of species was contagious and random at this site. At HDF, nine species belonging to 9 families were identified. *Evolvulus nummularius* showed regular distribution with a density of 8000 individuals ha^{-1}. Whereas *Asparagus racemosus, Desmodium triflorum, Eriocaulon scariosum, Spermacoce verticillate* and *Vernonia texana* were contagiously distributed, and *Andrographis paniculate, Euphorbia hirta* and *Hemidesmus indicus* were randomly distributed. The difference in the density of herbs along the disturbance gradient was significant at a 5% significance level.

The distribution of herbaceous species in the present study represented contagious and random patterns. The majority of LDF, MDF, and HDF distributions are contagious with an occurring random distribution. Due to little competition amongst the existing species following disruption at the study locations, only one species had a regular distribution (Kittur *et al.,* 2014; Pandey *et al.,* 2018; Khan *et al.* 2020). Biotic interference makes forests unstable, including burning, biomass removal, grazing, logging, NTFPs harvesting, hunting, lopping, and land-use change. MDF supports a more significant density and diversity of herb species. Additionally, it decreases in HDF. The properties of the forest floor and its soil are frequently altered by disturbance. The growth and maintenance of a herb layer in the forest may be hampered by the soil's high warmth caused by exposure. Our findings in the HDF clearly show decreased diversity and density of the herb layer, reinforcing this (Pandey *et al.,* 2018). The hypothesis of intermediate disturbance validated the current findings. Vegetation becomes vulnerable when there are variations in the frequency and intensity of disturbances. The current study found 12 different species of herbs, consistent with several past research results (Kafle, 2006). Numerous studies show that high levels of disturbance change vegetation composition, variety, and other properties. All species become more vulnerable to disturbance due to the higher intensity of forest disturbance since it significantly influences the vegetation. Consequently, vegetation exhibits successional development following disturbance and represents a change in its original community structure (Jhariya, 2017).

Conclusion

Herbaceous plant diversity is decreasing as a result of disturbance, and the effects are getting worse as the disturbance increases. Reduced species richness in the presence of disturbance is not directly correlated with either geography or climate. Herbaceous structure and diversity showed more variance in the study sites across different disturbance regimes. Vegetation characteristics were significantly altered by forest disturbance in comparison to LDF. Compared to other disturbance regimes, MDF showed a higher degree of biodiversity. As a result, it seems reasonable to assume that a medium-disturbed forest is not too damaging to the diversity and abundance of its inhabitants.

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Conflict of interest

The authors have no conflict of interest.

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