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SPECIES DIVERSITY AND COMMUNITY PATTERNS ALONG THE DISTURBANCE GRADIENT IN DRY TROPICAL FORESTS OF CHITRAKOOT, BANDA (U.P.) INDIA

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ABSTRACT

The magnitude and recurrence of disturbance is the main factor to affect the structure of the forest communities in a variety of ways. A forty KM long disturbance gradient was identified across the forest of Chitrakoot in Banda Forest Division and the impact of different degrees of disturbance on the community attributes and diversity pattern of the forests along this gradient, was observed. The sum of frequency for species components of different stands increased along the gradient with marked fluctuations. The sum of density, however, increased only upto a few peripheral stands and stabilized further. The trend of the two indices and fluctuations in these values indicated highly patchy and heterogeneous communities along the disturbance gradient. Several potential under trees like *Mallotus* and *Clerodendron* dominated the shrub layer with greater abundance under high disturbance while other non-leguminous species of shrubby habit dominated the stands facing intermediate disturbance. The relative density of leguminous shrubs decreased along the gradient. The efficiently sprouting trees like *Holarrhena* and *Terminalia* have maximum importance value index (IVI) at moderate disturbance while *Schleichera oleosa* did so toward the core. A maximum Shannon's Index of Diversity *H* of 3.53 was observed for the last but one stand towards the core. The trends of dominance and β-diversity were reverse to that of α-diversity along the gradient. From these observations, it may be inferred that the disturbance should be contained at the level suited for maximum diversity beside sparing a few 'disturbance-friendly' species in highly disturbed stands from complete destruction in order to provide bare minimum herbage cover, required for ecosystem attributes for the forests of the region.

Figures : 03 References : 24 Tables : 02
KEY WORDS : Communities, Density, Disturbance gradient, Diversity, Frequency, Importance value index

Introduction

Species diversity has been considered a rough proxy for diversity[14]. Therefore, species diversity has become important measure for the evolution of the structure and functioning of the ecosystem[8]. The conservation of plant diversity for present and future use is very essential[10,11]. Because of high biotic pressure since past several decades the dry deciduous forest cover in most part of central India is being converted into dry *deciduous scrub*, dry savanna and grassland which are progressively species poor[2]. Therefore, a detailed study of impact of disturbance on dry deciduous forest plant diversity is long overdue. The recurrent interventions into the forest communities for large-scale collection of fuel wood and minor forest products and the practices of grazing and trampling may alter the habitats of many species[23].

Disturbance has been considered as an important factor structuring communities[3,19] and its quantification is the major problem for study of the relationship between disturbance and community phenomenon[7]. A disturbance gradient has often been based on the percent number of stumps of cut trees[12]. In the present case, the Disturbance Index was also based on the intensity of lopping and cutting of branches for fuel wood. This index was determined on the basis of the number of cut of served woody individuals, expressed as the percentage of the total number of woody individuals per 100 m^2 area. A gradual decrease of dung per unit area also indicated the trampling by herds which was more severe towards the periphery and was least towards core. A disturbance gradient was, therefore, envisaged as a line on which the

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TABLE-1 : List of species encountered under different habit groups in different stands of plant communities along the disturbance gradient of Chitrakoot forest in Banda Forest Division. The actual habit of the species is shown against its name as T (tree), UT (undertree), S (shrub) and C (climber). Herbs are not mentioned here

Other trees (OTR)	Habit	Shrubby individuals and Climbers (SIC)	Habit	Leguminous shrubs (LGS)	Habit
Acacia catechu	T	*Alstonia scholaris*	T	*Bauhinia malabarica*	T
Aegle marmelos	T				
**Bridelia retusa*	T	*Antidesma ghaesmbilla*	UT	*Bauhinia purpurea*	UT
**Butea monosperma*	T				
Careya arborea	T	*Aristolochia sp.*	C	*Bauhinia vahlii*	C
Dillenia indica	T	*Asparagus racemosus*	C	*Caesalpinia honducella*	C
**Diospyros tomentosa*	T	*Azadirachta indica*	T	*Caesalpinia crista*	C
**Eugenia heyneana*	T	*Carissa spinarum*	UT	*Cassia fistula*	UT
Ficus benghalensis	T	*Casearia tomentosa*	UT	*Cassia nodosa*	UT
**Ficus glomerata*	T	*Coolebrookia oppositifolia*	S	*Crotalaria sp.*	S
Holarrhena	T			*Desmodim heterocarpon*	S
Antidysenterica	T	*Hymenodictyon sp.*	C	*Desmodium gangeticum*	S
Mangifera indica	T	*Psidium guajava*	UT	*Desmodium poulchellum*	S
**Miliusa velutina*	T	*Rauwolfia serpentina*	S	*Desmodium triangulare*	S
**Mitragyna parvifolia*	T	*Stereospermum suaveolens*	T	*Indigofera cassioides*	UT
**Morus laevigata*	T	*Thespesia lampas*	UT	*Moghania bracheata*	S
Phyllanthus emblica	T	*Tiliacora acuminata*	C	*Moghania bracteata*	UT
Randia dumetorum	T	*Triumfetta pentandra*	S	*Moghania chappar*	S
**Scleichera oleosa*	T	*Vitis sp.*	C	*Moghania lineata*	S
**Semicarpus anacardium*	T	*Woodfordia fruticosa*	UT	*Pithecolobium dulce*	UT
**Streblus asper*	T	*Zizyphus mauritiana*	UT	*Pongamia pinnata*	T
**Tectona grandis*	T			*Mallotus + Clerodendron*	(MCL)
**Terminalia tomentosa*	T			*Shorea trees + sprouts*	(STS)
*Terminalia arjuna	T				

* These tree species were mostly in the habit of shrub.

stands were situated at increasing distance from human habitation and from periphery to the core of the forest. The different quantum of disturbance may have differential impact on the patterns of community and existing plant diversity[5,6]. The present study, therefore, aims to enquire into the patterns of change in plant diversity and general community attributes along the disturbance gradient. Such information may be necessary to assess the threshold level of disturbance for maximum biodiversity and to formulate the strategy to conserve the under storey species within the forest.

Materials and Methods

The study site lies between 24^0 6' 52" – 24^0 26' 16" N latitude and 83^0 1' 86" – 83^0 9' 6" E longitude in dry tropical forest of Chitrakoot and Banda in Bundelkhand Region (U.P.) India. The elevation above the mean sea level ranges between 313 and 483m. The area experiences a dry sub-humid tropical monsoonic climate with three distinct seasons in a year *viz.* Summer (March-June), rainy (July-October) and Winter (November-February). The total average annual rainfall is about 1082 mm out of which about 80% rainfall is received during monsoon season (July-August). There is an extended dry period of 8 months in the annual cycle. The soil is residual sand loam in texture and reddish to dark grey in colour and poor in nutrients[17].

Fifteen random stands of approximately similar structure were identified along a 40 km long disturbance gradient across the forest belt covering the five ranges,

Karwi, Manikpur, Markundi, Raipur and Bargarh in Banda Forest Division. The Disturbance Index decreased rapidly from periphery (128) to core (21). The area of stands ranged from 3 to 10 ha per stand. Any two adjacent stands under observation, were 1000 to 5000 m apart. These stands had similar soil and topographic conditions. A sample plot or quadrat of 10x10m area was used for observation on community organization. The random sample plots per stand were observed and the occurrence of different species and the number and diameter of the individuals were recorded. The phytosociological data were analyzed using conventional methods[9]. The frequency, density, basal cover and relative values for each species of the community were calculated. The importance value index (IVI) for different species was calculated as a sum of relative frequency, relative density and relative basal cover of each species. These values for different species of common habit were summed to compare the species group within the same stand and those of different stands. The grand sum of frequency and density of all the species constituting different communities were also derived. The dominance (C) for each community was calculated by Simpson's index and diversity by Shannon's index ($H=\Sigma pi\ 1n\ pi$). Here, pi represents the proportional abundance of i^{th} species in any given stand. β-diversity on species turnover was calculated by using the formula, $\beta = \gamma/\alpha$, where α is the diversity of discrete stands and γ is the diversity of forested landscape of the region[13].

Results and Discussion

A common undulating pattern for the sum of frequency and the sum of density of the plant species in the forest stands was observed along the gradient. In general, sum of frequency showed a clear trend of increase along the gradient while sum of density did so only in the peripheral communities up to the 5^{th} stand on the continuum (Fig. 1). As also reported elsewhere[18], the sum of frequency may be much lower in highly disturbed stands because of greater abundance of fortuitous species. At a very high disturbance level, the pool of adopted species is often small[22] and therefore, the frequency sum is likely to be low. The peripheral stands showed lesser difference between the sum of the indices compared to those towards the core. Thus the increasing gap between the two sums is an indication of increasing diversity of composition from the periphery to the core

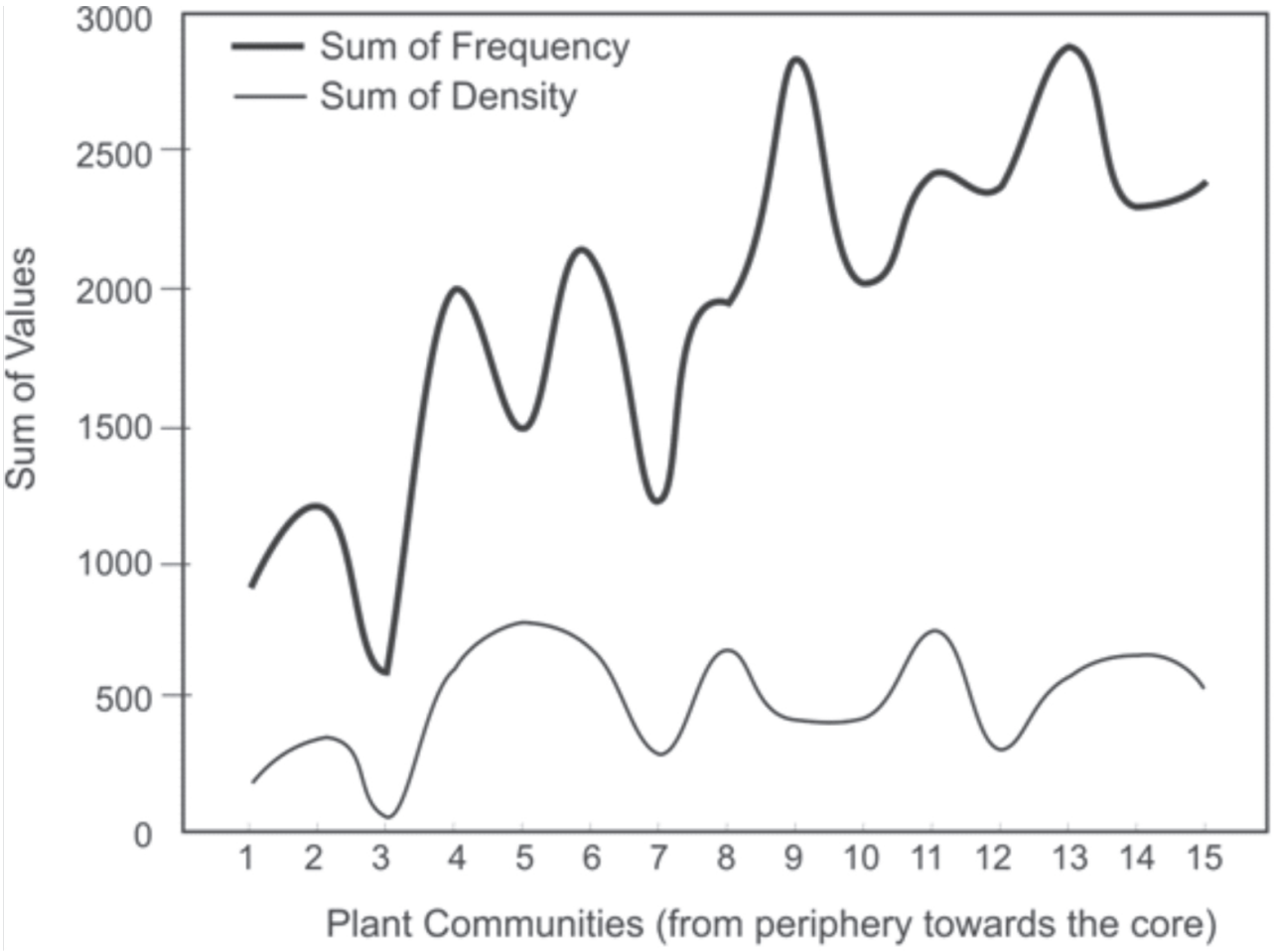

Fig.1: Sum of frequency and density of species in each of the 15 different communities along a disturbance grandient within a forest belt of Banda Forest Division.

along the disturbance gradient. The degree of fluctuation in the sums of frequency for different stands was more conspicuous compared to that of density. It may be attributed to sudden increase in the number and abundance of a few opportunistic weedy species which appeared in several stands in response to exposed conditions. The degree of fluctuation in both the sum values tends to dampen towards the core for successive stands.

Fig. 2 shows the sum of relative density of species grouped under major habit components. The two undershrubs, *Mallotus philippensis* and *Clerodendron infortunatum* (MCL) were generally encountered as shrubs and dominated the shrub layer specially in highly disturbed conditions. The ubiquity of dioecious *Mallotus* is due to its efficient sprouting at any growth phase[21] though the male and female *Mallotus* populations are known to show some bias with respect to prevailing light intensity[15]. *Clerodendron* regenerated through subsurface ramet proliferation from a horizontal root stock and the number of ramet per genet showed a direct relationship with the degree of disturbance. Several other apparent shrubs which are potential undertrees also showed efficient sprouting. All the other woody non-leguminous species of shrubby habit, irrespective of trees, shrubs or liana species, were grouped as shrubby individuals and climbers (SIC) which showed much greater density compared to other species group in majority of stands along the whole of the gradient. Leguminous shrubs (LGS) showed wide fluctuations towards periphery but their density was considerable in any stand compared to that of trees (>30 cm gbh) including *Shorea*. The relative density of trees other than sal (OTR) however, was very low especially in stands towards the core, primarily due to illicit cutting of timber. The difference in the value of relative density of different habit groups gradually decreased towards the core beyond the 11th stand along the gradient. Severe environmental perturbations may result due to the dominance of one or a few species[20] as evident here from the sum of relative density of different habit groups in some stands towards the periphery.

Fig. 3 shows the pattern of change in the IVI of six common tree species growing as common associates. All the individuals of a species, irrespective of tree or shrubby habit, were considered together. Of the six tree associates considered, *Holarrhena anti*dysenterica

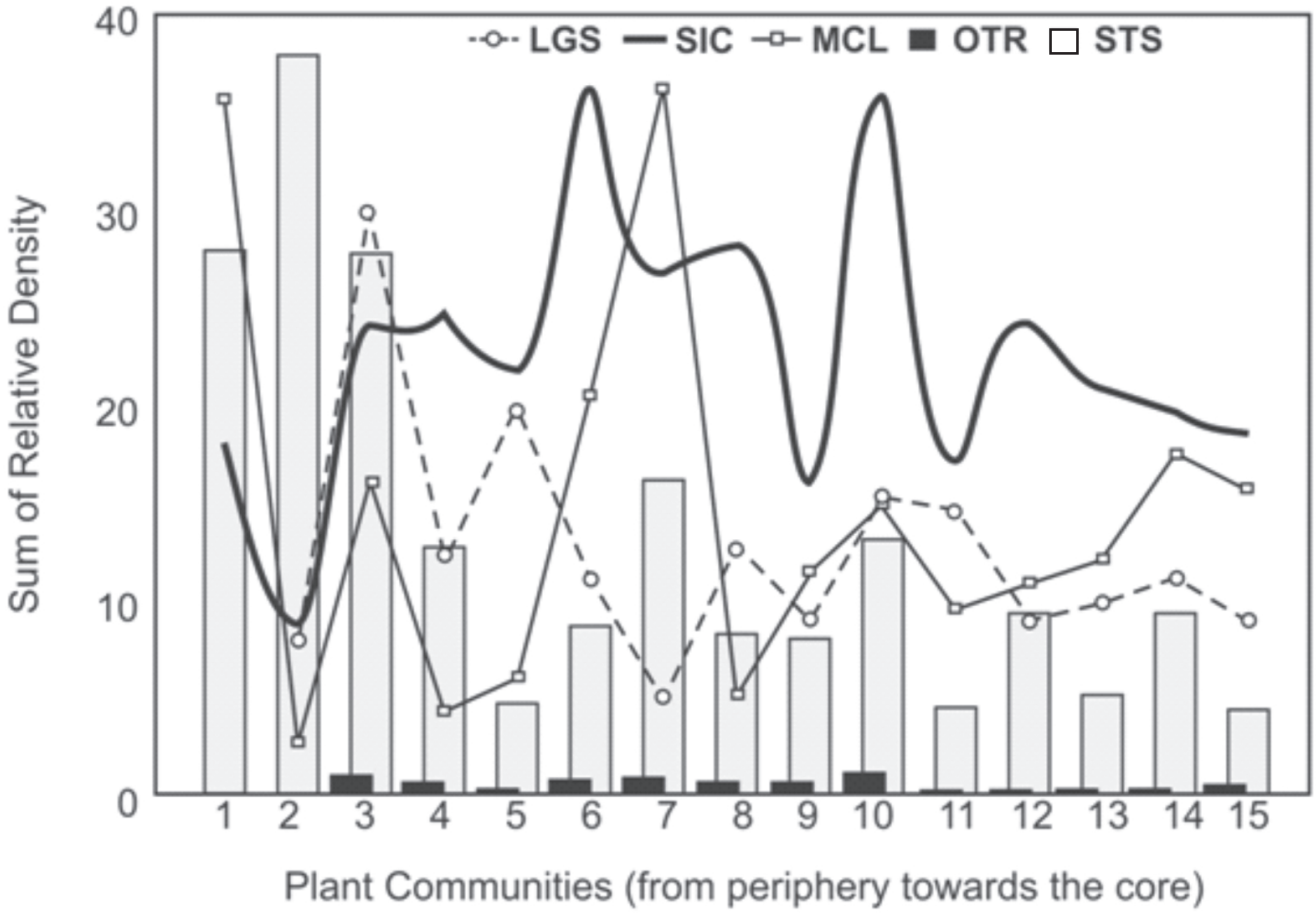

Fig.2: Sum of relative density of species grouped under 5 components of each of the 15 different stands along the disturbance gradient. LGS, leguminous shrubs; SIC; shrubby indiduals and woody climbers; MCL, *Mallotus philippensis + Clerodendron infortunatum,* OTR trees (>30 cm gbh); STS, sal trees and sal sprouts..

TABLE-2 : Dominance and diversity of 15 different communities of Chitrakoot forest in Banda Forest Division along the disturbance gradient

Community Sequence	Simpson's Index of dominance	Shannon's Index of α -diversity	Diversity (H) β-diversity
1	0.189	1.98	2.04
2	0.155	2.13	1.90
3	0.211	2.14	1.86
4	0.089	2.72	1.48
5	0.067	3.08	1.31
6	0.075	2.91	1.39
7	0.065	3.22	1.25
8	0.063	3.28	1.16
9	0.057	3.18	1.33
10	0.056	3.47	1.23
11	0.056	3.03	1.27
12	0.042	3.41	1.14
13	0.047	3.42	1.18
14	0.050	3.53	1.18
15	0.055	3.36	1.20

showed much greater IVI in stands towards the periphery facing greater disturbance while *Scleichera oleosa* did so in stands towards the core of the forest facing lesser disturbance. The importance of *Terminalia tomentosa* was considerable only in stands facing comparatively moderate disturbance. *Diospyros tomentosa* and *Bridellia squamosa,* however, showed consistently low IVI along the whole of the disturbance gradient. The occurrence of *Mitragyna parvifolia* was least consistent and it also showed much lower IVI in any stand. Almost all the above species showed comparatively greater IVI in stands located at intermediate positions, 4th to 10th stand along the gradient. The IVI of some species were much lower towards the periphery and higher towards the core and vice versa for some others. Earlier studies on tropical succession of woody species conclude that the species likely to survive the patchy, frequently disturbed environment are early successional trees, best equipped to exploit the habitat conditions for maximum extension growth[16] and these are called well-dispensing weed trees.

The dominance, expressed in terms of Simpson's index, was markedly higher in stands towards the periphery. In general, it decreased gradually. A slight increase in its value was noticed in the least disturbed stands towards the core. The *H* value ranged from 1.98 to 3.08 (1st to 5th stand) starting from the periphery. The intermediate stands (6th to 10th) had *H* in the range of 2.91 to 3.47. For the stands towards the core *H* ranged from 3.03 to 3.53. The values of *H* showed much greater fluctuations in stands towards the periphery than towards the core. Thus the diversity was maximum near the core which indicates that the disturbance in the core was enough for maximum diversity in the forests of the region. β-diversity, which shows the extent of species replacement[24] followed the reverse trend along the gradient (Table-2). It has been observed that diversity is lower in the absence of disturbance as well as in the presence of too much of disturbance[1]. Moderate levels of anthropogenic disturbances are compatible with maintenance of high biodiversity of landscape[4].

Conclusion

On the basis of above observations, it may be inferred that the disturbance must be contained at the intermediate level so as to have maximum plant diversity

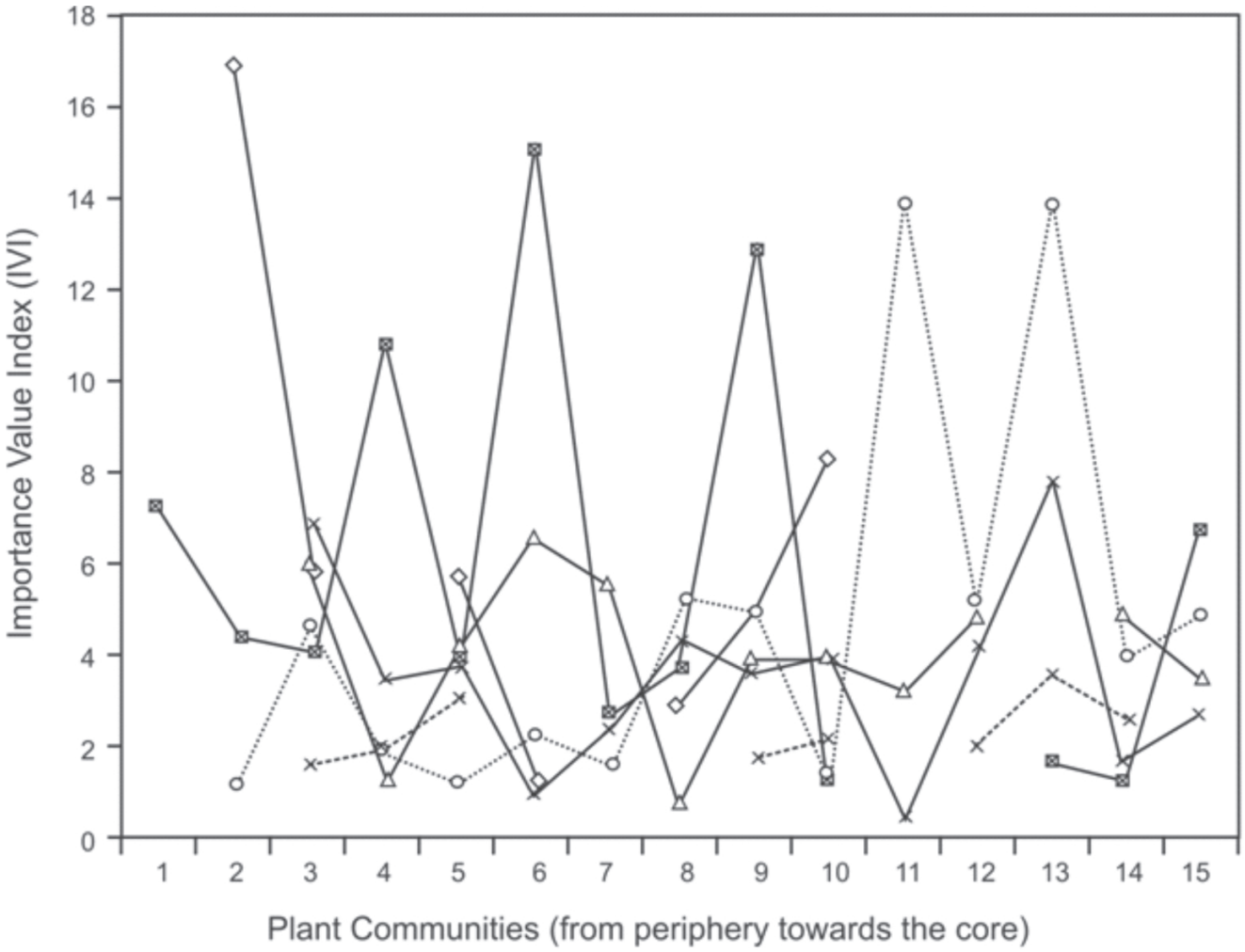

Fig. 3: Importance Value Index (the sum of relative frequency, relative density and relative basal cover) of six common trees. *Holarrhena antidysenterica*; *Diospyros tomentosa*; *Mitragyna parvifolia*; *Terminalia tomentosa*; *Bridelia squamosa*; *Scleichera oleosa*.

in these forests. Also, a few disturbance-friendly species like *Mallotus* and *Clerodendron* may be spared from complete destruction in peripheral stands (where high disturbance is inevitable) in order to have minimum herbage cover for conserving forest soil and to provide niches for under storey biota adapted to high disturbance zone. A threshold level of disturbance may, thus, be determined which can permit the extraction of resources without significant loss to the biodiversity of the region.

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