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Vegetation changes during fifty years in the forest-complex of Patharia hills, Sagar, India

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Abstract: The present study was undertaken to compare the changing status of the forest vegetation of Patharia hills, which was earlier described by Misra & Joshi (1952). Topography, soil properties and extent of human disturbance are attributed as the major factors influencing the vegetation in Patharia hills. Different phytosociological attributes showed that at present *Acacia leucophloea, Diospyros melanoxylon* and *Butea monosperma* are the dominant species showing highest IVI values (25.49 to 32.29); while, Misra & Joshi (1952) reported that *Anogeissus latifolia* and *Diospyros melanoxylon* were the dominant species during 1952 on the basis of high percentage frequency and dominance (cover). Most species of trees, shrubs and herbs showed contagious distribution and total composition of vegetation appears to be heterogeneous. During both the study periods common tree species at different subsites ranged from 7 to 15 and the similarity index between 35.89 and 57.69 %.

Resumen: El presente estudio se llevó a cabo con el fin de comparar la situación cambiante de la vegetación forestal de las colinas Patharia, la cual fue descrita con anterioridad por Misra y Joshi (1952). La topografía, las propiedades edáficas y la magnitud del disturbio humano fueron reconocidos como los factores principales que influyen sobre la vegetación en las colinas Patharia. Diferentes atributos fitosociológicos mostraron que en la actualidad *Acacia leucophloea, Diospyros melanoxylon* y *Butea monosperma* son las especies dominantes, mostrando los valores mayores de IVI (25.49 to 32.29), mientras que Misra y Joshi (1952) reportaron que *Anogeissus latifolia* y *Diospyros melanoxylon* eran las especies dominantes en 1952, con base en sus frecuencia y dominancia (cobertura) porcentuales altas. La mayoría de las especies de árboles, arbustos y hierbas mostraron distribuciones contagiosas y la composición total de la vegetación parece ser heterogénea. Durante los dos períodos de estudio las especies arbóreas comunes en diferentes subsitios fluctuaron entre 7 y 15, y el índice de similitud fluctuó entre 35.89 y 57.69 %.

Resumo: O presente estudo foi efectuado para comparar o estado de mudança da vegetação florestal das colinas de Patharia, as quais foram anteriormente descritas por Misra e Joshi (1952). A topografia, as propriedades do solo e a extensão das alterações humanas são consideradas os factores principais influenciando a vegetação nas colinas de Patharia. Os diferentes atributos fitosociológicos mostraram que a presença da *Acacia leucophloea, Diospyros melanoxylon* e *Butea monosperma* eram as espécies dominantes mostrando os valores IVI mais elevados (25.49 a 32.29); enquanto Misra e Joshi (1952), com base na elevada percentagem de frequência e dominância (coberto), deram notícia que a *Anogeissus latifolia* e *Diospyros melanoxylon* eram as espécies dominantes durante 1952. A maior parte das espécies arbóreas, arbustos e ervas mostraram uma distribuição contagiosa e a composição total da vegetação aparece ser heterogénea. Quer Durante os dois períodos de estudo as espécies arbóreas comuns, nas duas sub-estações, variaram entre as 7 e as 15 situando-se o índice de semelhança entre os 35.89 e os 57,69 %.

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Key words: Forest-complex, Patharia hills, successional changes, tropical dry deciduous forest.

Introduction

Tropical dry forests form a major biome in India accounting for about 46 % of the total forest cover of the county (Singh & Singh 1988). Central India harbours most of the tropical deciduous forests in the Indian subcontinent. Patharia hills of Sagar district are unique habitat and have been regarded as Patharia complex by earlier workers due to complexity of edaphic variations and occurrence of varied soil types within a small area (Misra & Joshi 1952; Bhatia 1958). Therefore, previous workers have studied this complex for variation in vegetation composition and put forth a possible successional trend. The forest of Sagar district can be broadly classified under the tropical dry deciduous type after Champion & Seth (1968). During the last 50 years, forests of Patharia complex have been under constant disturbance to a large extent due to increasing biotic disturbances, forest fire, livestock grazing, cutting of trees and increasing dryness in the area.

The present paper deals with the changing vegetation pattern of Patharia complex as earlier studies on this complex are available to make a comparison. Further, the paper also gives an insight as to what has happened to the vegetation after 50 years.

Study area

Sagar is situated on the northern boundary of Madhya Pradesh at 23° 50' N latitude and 78° 04' E longitude. The study was conducted in forests of Patharia hill situated near the University of Sagar. The hill rises up to 100 m elevation on the eastern side of Sagar town. The main ridge extends from north to south for 1.5 km and then curves towards the west for another 1.5 km before extending into a spur for about 3.15 km. The top forms a continuous plateau. The hills are formed by a series of lava flows (Wadia 1949). Basalt is laid horizontally, and between two successive flows shallow intertrapped lime beds seldom exceeding 1-2 m may occur. Highest altitude of the hill is 613 m and the range of altitude is from 540 to 600 m above mean sea level. Forested region in the southern end of the ridge is called "Rajababa"; the middle part "Gualipura" and in between a small flank extending to the east as "Saji Bhatar".

On the basis of variations within habitat, edaphic conditions, topography, local environmental variations and intensity of biotic factors, following six subsites were selected for present study :

(i) Rajababa to Saji Bhatar, (ii) South-east side of Saji Bhatar, (iii) Eastern slope of Saji Bhatar, (iv) South side of Saji Bhatar, (v) Top of the hill and (vi) Opposite to Gualipura. As far as possible, selection of sites was done in such a way that the sites are more or less similar to those selected by Misra & Joshi (1952) and Bhatia (1958).

The area enjoys a typical monsoonic climate with three well recognized seasons *viz*., rainy, winter and summer. The average annual rainfall is about 1220 mm, chiefly received during the rainy season from June to September. Winter rains are of common occurrence. Summer season from March to mid June is very hot with maximum temperatures touching 45 °C. Winter season is pleasant and dry except for the period of rains, with mean minimum temperature of 12.5 °C.

Soils in this area are the product of basic rock commonly known as Deccan trap or basalt. Round boulders are characteristic of the soil as these rocks exhibit a tendency to spheroidal weathering by exfoliation of roughly concentric shells (Wadia 1949). Bhatia (1958) has given detailed account of soils of Patharia hills and reported that the same parent rock gives rise to dissimilar products. In general, the derived products are red and black soils.

Anthropogenic influences like frequent and persistent exploitation of the forests for fuel and encroachment for habitation and agricultural land are the chief biotic influences that are continuously degrading the forest vegetation. Minor forest produce such as leaves of *Diospyros melanoxylon* are plucked in great quantities for making country cigarettes "Bidi". Further, as large trees of this species produce small sized leaves, they are generally cut to stump to produce bigger leaves. Similarly, leaves and roots of *Butea monosperma* are of common use for making country plates, rope and brushes. In general these forests are under great threat.

Materials and methods

Data on vegetation of each of the six subsites were obtained by 5, 10 and 20 randomly placed quadrats of 100, 25 and 1 sq.m. for trees, shrubs and herbs, respectively. Since the vegetation was not sufficiently dense, the quadrats for assessing quantitative characteristics for tree, were placed 20 m apart along the contours of the slopes. Further, the observations were taken from uniform stands on each subsite. Twenty line transects of 1 m length were considered for recording the cover area of herb species at each subsite. Circumference at the breast height (CBH) at 1.37 m above the ground of all woody/tree plants in each quadrat was measured and recorded individually.

The data were quantitatively analyzed for frequency, density and basal area (Curtis & McIntosh 1950). Relative values of frequency, density and dominance were determined following Misra (1968). The sum of all above relative values represented Importance Value Index (IVI). On the basis of IVI, dominant, co-dominant and main associate species were recognized (Muller-Dombois & Ellenberg 1974).

Misra & Joshi (1952) obtained the data for different phytosociological attributes taking line transect within a belt of about 10 feet. Frequency and dominance of different species were expressed by them in five classes as given by Braun-Blanquet (1932). Abundance (numerical abundance) and sociability were also expressed in five degrees. Different forest types at different subsites were recognized by high frequency and dominance (cover) of species. As far as possible, observations were taken from the same subsites as recognized by Misra & Joshi (1952). Since the vegetation has become less dense over the period of 50 years, size of the sample was increased three fold.

Nature of vegetation was assessed on the basis of frequency diagram for homo- and heterogeneity of vegetation (Raunkiaer 1934). The abundance to frequency ratio (A/F) for different species was determined for distribution pattern (Whitford 1949; Curtis & Cottom 1956).

Similarity index (community co-efficient) among different subsites was calculated following Sorenson (1948). Using similarity index, subsites were compared with each other as they existed in 1952 and in 2002. Further, comparison of subsites between 1952 and 2002 was also made.

Results

On the basis of highest values of IVI of tree species, following six forest communities, one for each subsite, have been recognized-

I. *Acacia leucophloea - Butea monosperma* type
II. *Lannea coromandelica - Tectona grandis* type
III. *Mitragyna parvifolia - Diospyros melanoxylon* type
IV. *Tectona grandis - Acacia leucophloea - Erythrina variegata* type
V. *Butea monosperma - Acacia leucophloea - Tectona grandis* type
VI. *Butea monosperma - Phoenix sylvestris - Bombax ceiba* type

I. *Acacia leucophloea - Butea monosperma* type

This type of forest community was found in the area from Raja Baba to Saji Bhatar. The vegetation was closed with a tree cover of 80-90 % in 1952 and 1958. *Tectona grandis* and *Anogeissus latifolia* were the dominant species in the past. However, the community has now been replaced by *Acacia leucophloea* and *Butea monosperma* community (Table 1), definitely showing the consequences of biotic disturbances like cutting, quarrying, and grazing leading to dryness in the area. Species like *Delonix regia* have also become part of the community due to immigration from nearby habitations.

Shrub layer has also changed. *Lantana camara* has now become the dominant shrub species in this area, while in 1952, the shrub layer was unevenly distributed and denser on slope which was inhabited by *Carissa spinarum, Mimosa rubicaulis* and *Helicteres isora*.

Distribution of herb layer depends chiefly upon the availability of sufficient light. This layer was found more or less similar with the past study and was dominated by *Cassia tora.*

II. *Lannea coromandelica - Tectona grandis* type

This forest community covers the slopes of the south-east side of Saji Bhatar. A total of 25 tree species was encountered during the sampling (Table 1) with 8 species common with the vegetation that occurred 50 years ago when *Anogeissus latifolia* and *Diospyros melanoxylon* were the dominant species. By then forest was mature and closed (70 % tree cover). About half or more of the standing crop appears to have been affected in one way or the other. Misra & Joshi (1952) reported increased grazing in the area and perhaps this was responsible for changing the composition. Bhatia

Table 1. Importance Value Indices (IVI) of tree species at different subsites and for total Patharia complex.

Sl. no.	Name of plant species	Subsite						Patharia Complex
		I	II	III	IV	V	VI	
1.	*Acacia catechu* Willd.				5.91	3.72		1.88
2.	*Acacia leucophloea* Willd.	69.49	25.18	28.51	29.11	39.42	20.95	32.29
3.	*Acacia nilotica* (Linn.) Del.				2.67			0.49
4.	*Aegle marmelos* Correa.	3.31	5.22	3.20	6.02	5.41	8.99	5.21
5.	*Ailanthus excelsa* Roxb.						4.09	0.49
6.	*Albizzia lebbeck* Benth.	5.56					19.76	6.02
7.	*Annona squamosa* Linn.		9.10	2.98		5.87	19.01	5.64
8.	*Anogeissus latifolia* Wall.		15.13	13.16	2.46	2.68		6.00
9.	*Azadirachta indica* A. Juss.	9.72				2.51		1.72
10.	*Bauhinia semla* Wund.		2.54		10.47		4.13	2.85
11.	*Bombax ceiba* Linn.	5.07					24.87	6.71
12.	*Bridelia retusa* Spreng.	3.63		3.77	2.47	17.07	20.10	10.09
13.	*Buchanania lanzan* Spreng				5.63	2.42	5.83	2.24
14.	*Butea monosperma* (Lamk.) Taub.	49.70	16.56	15.12	3.79	40.73	37.50	25.49
15.	*Cassia fistula* Linn.	7.98	11.62	11.08	8.42	9.68	4.37	9.04
16.	*Dalbergia lanceolaria* L.f.				2.47			0.46
17.	*Dalbergia paniculata* Roxb.				2.67		7.51	1.73
18.	*Delonix regia* Raf.	5.64						0.83
19.	*Diospyros melanoxylon* Roxb.	29.15	27.22	58.11	17.16	30.08	14.20	29.26
20.	*Ehretia leavis* Roxb.		7.87		2.46			1.84
21.	*Elaeodendron glaucum* Pers.	5.60	8.46		4.93	17.86	5.52	7.16
22.	*Emblica officinalis* Gaerth.				2.43			0.46
23.	*Erythrina variegata* L.				28.67			4.40
24.	*Ficus benghalensis* Linn.		6.31					1.01
25.	*Ficus racemosa* L.		7.81		2.88			1.78
26.	*Ficus virens* Aiton.						5.69	0.69
27.	*Flacourita indica* (Burm. F.)		10.70	11.14	2.64	11.08	8.40	7.48
28.	*Gardenia latifolia* Aiton	5.37	4.34		3.44	2.54		2.60
29.	*Garuga pinnata* Roxb.				3.89			0.70
30.	*Gmelina arborea* Roxb.	3.12						0.46
31.	*Holarrhena pubescens* (Buch. Ham.) Wall.				9.19	5.37		2.81
32.	*Holoptelea integrifolia* Planch.	4.37			2.77	21.53	17.33	7.92
33.	*Ixora parviflora* Vahl.	4.00		6.02				1.51
34.	*Lagerstroemia parviflora* Roxb.	10.78				20.10	4.21	5.80
35.	*Lannea coromandelica* (Houth.) Morr.	10.32	45.25	19.89	20.02			14.61
36.	*Madhuca indica* Gmel.			17.60		10.76		4.85
37.	*Miliusa tomentosa* (Roxb.) J. Sinclair.		5.33	3.70	24.03			5.68

Contd...

Table 1. Continued.

Sl. no.	Name of plant species	Subsite						Patharia Complex
		I	II	III	IV	V	VI	
38.	*Mitragyna parvifolia* Korth.	21.83	6.20	64.29	15.48	2.42	5.47	17.37
39.	*Morinda tinctoria* Roxb.		3.40					0.59
40.	*Phoenix sylvestris* Roxb.		14.28				27.49	9.16
41.	*Pongamia pinnata* (Linn.) Pierie					3.09		0.62
42.	*Santalum album* Linn.			3.11				0.47
43.	*Sapindus laurifolius* Vahl.		7.09					1.14
44.	*Schrebera swietenoides* Roxb.		7.93		2.47			1.36
45.	*Stereospermum suaveolans* DC.						14.49	2.59
46.	*Tectona grandis* Linn.	10.93	30.02	3.46	51.03	39.08		23.91
47.	*Terminalia belerica* (Gaearth.) Roxb.				4.55			0.70
48.	*Terminalia tomentosa* (DC.) W & A.	27.36	8.86	27.24	21.22	6.31	11.57	16.28
49.	*Wrightia tinctoria* Linn.	3.25	8.80				5.62	2.71
50.	*Ziziphus glabberrima* (Sedgw.) Santapau	3.57	4.42	3.19				2.33

(1958) reported that *Butea monosperma* showed low abundance but with high percentage of saplings. Result of the present study indicates this species as a co-dominant. As reported by Misra & Joshi (1952), saplings of *Anogeissus latifolia* were rarer, and hence, it ceased its dominance at present. *Lantana camara* again showed its dominance in shrub layer with other common species such as *Carissa spinarum* and *Zizyphus oenoplia.* Herb layer was composed of *Cassia tora* with 13 other common species.

III. *Mitragyna parvifolia - Diospyros melanoxylon* type

This forest community occurs on the eastern slopes of Saji Bhatar. A total of 18 species was encountered during sampling in place of 21 (during 1952), out of which seven were common (Table 1). *Terminalia tomentosa* remained a co-dominant species during both the study periods (1952 and present study).

Due to dense tree canopy, shrub layer was poor and represented by only two species, *Carissa spinarum* and *Ixora parviflora* (Misra & Joshi 1952). In the present study, due to high biotic interference forest cover was progressively reduced with many open areas, invaded by fast growing *Lantana camara* which contributes to the major part of shrub layer (Table 2). *Cassia tora* was recognized as dominating species in herb layer (Table 3).

IV. *Tectona grandis - Acacia leucophloea - Erythrina variegata* type

This forest community forms a small belt along the upper contours of the south face of Saji Bhatar. A total of 30 species was recorded during the present study in place of 18 as observed during 1952. Out of these, 12 species were found common. Misra & Joshi (1952) reported that regeneration of dominant trees including *Butea monosperma* was healthy due to more number of saplings, however, the dominant tree species of the past (*Aegle marmelos, Diospyros melanoxylon* and *Anogeissus latifolia*) now do not contribute much.

Like earlier the shrub layer, was dominated by *Lantana camara.* Other species of this layer like *Carissa spinarum* and *Woodfordia fruticosa* were common during both the study periods (Table 2). Herb layer showed dominance of *Cassia tora* and it appears that it has replaced *Justicia diffusa* which was frequent in 1952.

V. *Butea monosperma - Acacia leucophloea - Tectona grandis* type

This is an open forest community growing on most hill tops of the region. According to Misra & Joshi (1952), the status of this community is maintained by intense biotic factors under which most of the other tree saplings are eliminated. *Diospyros melanoxylon* and *Butea monosperma* were dominant tree species of the past and contributed 80 % to the total tree canopy. Due to low height of these trees browsing, lopping and picking of leaves were very common in the area (The leaves of *Diospyros melanoxylon* are used in the manufacturing of "Bidi"/country cigarettes and those of *Butea monosperma* are used as leaf plates for serving meals). As expected, *Butea monosperma* and *Acacia leucophloea* showed dominance in this area as both species thrive well in open habitat and calcium rich soil. A total of 22 tree species were observed during the present study, in place of 12 species reported in 1952 with 9 species as

Table 2. Importance Value Indices (IVI) of shrub species at different subsites and for total Patharia complex.

Sl. no.	Name of plant species	Subsite						Patharia Complex
		I	II	III	IV	V	VI	
1.	*Carissa spinarum* Linn.	44.12	20.81	65.35	70.65	83.28	62.70	63.47
2.	*Flacourtia indica* (Burm. F.) Merr.	18.43				6.66		3.86
3.	*Gymnosporia spinosa* Forsk.	41.42	35.34	17.02			15.57	14.40
4.	*Lantana camara* Linn.	166.15	168.1	128.53	132.14	157.36	195.30	155.59
5.	*Woodfordia fruticosa* Kurz.		11.84	30.38	39.00	43.19		23.75
6.	*Ziziphus oenoplia* Mill.	29.81	34.84	54.34	44.23	9.41	19.95	31.63
7.	*Ziziphus rotundifolia* Lamk.		29.00	4.03	13.89		6.42	7.19

Table 3. Importance Value Indices (IVI) of herb species at different subsites and for total Patharia complex.

Sl. no.	Name of plant species	Subsite						Patharia Complex
		I	II	III	IV	V	VI	
1.	*Acalypha indica* Linn.	18.43			1.53			2.73
2.	*Ageratum conyzoides* Linn.			1.61			9.83	1.45
3.	*Alysicarpus monilifer* DC.	15.85		15.91	7.06	14.87		10.06
4.	*Biophytum sensitivum* DC.	8.17	17.62	31.70	36.66	9.74		19.32
5.	*Blepharis boerhaaviaefolia* Pers.						12.67	1.26
6.	*Borreria stricta* Linn. f.	13.53	6.29			32.18	1.62	9.73
7.	*Brynoia laciniosa* Linn.				1.75			0.29
8.	*Cassia tora* Linn.	43.77	52.34	41.79	48.72	40.26	64.92	46.53
9.	*Corchorus actangulus* Lamk						25.03	2.89
10.	*Crotalaria prostrate* Roxb.						1.84	0.21
11.	*Cyperus aristatus* Rottb.					3.20		0.67
12.	*Desmodium triflorum* DC.	38.03	34.26	27.46	29.75	27.99	5.07	28.10
13.	*Elephantopus scaber* Linn.			1.23		1.20		0.51
14.	*Eragrostis interrupta* Hook.f.					7.70		1.61
15.	*Eragrostis pilosa* (Linn.) P. Beaur.		13.96					2.03
16.	*Eragrostis tenella* Linn.	34.62	33.45	36.51	32.78	38.27		31.78
17.	*Euphorbia geniculata* Orteg.	9.16	17.44	5.71	5.81	6.52	4.85	7.88
18.	*Euphorbia hirta* Linn.	20.29	13.33	10.91	11.81	16.48	29.95	15.72
19.	*Euphorbia hypericifolia* Linn.		11.76	7.90	13.61	2.23		6.30
20.	Indigofera cordifolia Heyne.			8.96	4.91			2.89
21.	*Indigofera glandulosa* Willd.	25.57	29.34	7.52	20.50			13.02
22.	*Indigofera trifoliata* Linn.				7.37			1.26
23.	*Iseilema anthephoroides* Hack						7.19	0.70
24.	*Justicia simplex* Don.						4.96	0.53
25.	*Malvastrum tricuspidatum* A. Grey					2.57	14.24	2.05
26.	*Merremia emarginata* (Burm.f.) Hall. f.	17.05	8.56	8.38	13.84			7.81
27.	*Oplismemus burmannii* (Retz.) P.Beauv.						11.74	1.22
28.	*Phyllanthus deblis* Ham.	4.51			2.98	4.27		2.00
29.	*Phyllanthus simplex* Retz.	32.51	42.94	46.85	41.93	34.72		36.20

Contd...

Table 3. Continued.

Sl. no.	Name of plant species	Subsite						Patharia Complex
		I	II	III	IV	V	VI	
30.	*Phyllanthus urinaria* Linn.						5.75	0.67
31.	*Setaria glauca* P. Beauv.			25.27	2.22	6.27		7.60
32.	*Sida rhombifolia* Linn.			11.33	5.97	19.48		7.75
33.	*Sida veranicaefolia* Lamk					2.43	42.75	5.13
34.	*Sporobolus diander* (Retz.) P. Beauv.					3.47		0.72
35.	*Tephrosia purpurea* Pers.						2.17	0.25
36.	*Tridax procumbens* Linn.	16.27	10.36	10.71	8.98	7.49	34.35	12.96
37.	*Xanthium strumarium* Linn.				1.50		20.89	2.63
38.	*Zornia diphylla* (Linn.) Pers.		8.13			18.29		5.00

common. Shrub layer again showed abundance of *Lantana camara* during the present study in place of *Crissa spinarum* and *Flacourtia indica* reported earlier.

Ground layer consisted of 21 herb species in which *Cassia tora* and *Eragrostis tenella* were dominant. According to Misra & Joshi (1952), on burning the thorny thicket, a good grassland may grow in course of time consisting of *Dicanthium annulatum, Bothriochloa pertusa, Iseilema anthophoroides, Aristida cyanantha* and *Heteropogon contortus,* etc. They described variability in the herb layer and observed different species in different microhabitats.

VI. *Butea monosperma - Phoenix sylvestris - Bombax ceiba* type

This is a small patch of open community found in a valley opposite to Gualipura. A total of 23 tree species was observed (Table 1). Misra & Joshi (1952) reported a good percentage of *Boswellia serrata* found in valley growing on steep slopes (50-70°). Interestingly, in the present study no traces of *Boswellia serrata* were seen. Absence of this species could be due to its requirement for paper and match industries in the state. Due to excessive exploitation of this species, complete disappearance of the species might have occurred. Increasing of open area due to biotic disturbances and excessive exploitation changed the forest community. Other dominating species of the past (*Anogeissus latifolia*) also disappeared from this community.

Discussion

As far as dominance of tree species is concerned, each vegetation community of the Path-aria complex showed dominance of more than one species. However, only two communities (V and VI) were found dominated by *Butea monosperma* while others showed the dominance of *Acacia leucophloea* (community I); *Lannea coromandelica* (community II); *Mitragyna parvifloia* (community III) and *Tectona grandis* (community IV). Interestingly, *Diospyros melanoxylon* was found consistently associated with the dominants in all communities as indicated by its importance values which lies just next to the dominant species making it as co-dominant species. It is evident from Table 1 that *A. leucophloea, B. monosperma, D. melanoxylon, T. grandis* and *M. parvifolia* were the most common dominants in the entire Patharia complex. Their dominance can further be visualized on the basis of their synthetic attributes.

Species composition of shrub layer of Patharia complex did not conform to the trend of composition of tree layer. The whole complex as well as the communities were found dominated by *Lantana camara*. The growth and distribution of *L. camara* was such that it has IVI more than 150 in general and nearing to about 200 at some of the communities. The total number of species in the shrub layer was small (only seven). It is also important to mention that almost similar composition of species was found in all the communities in the present study. The shrub layer shows less heterogeneity in composition as compared to the tree layer (Table 2).

Unlike shrub layer, a large number of species of herbs were found; as many as 38 different species were observed (Table 3). However, on the different subsites the number of species ranged from 14 to 21. It is presumed that more species could have been recorded from Patharia but in the present study only those species were considered

that fell within the sampling units. By and large, *Cassia tora* invariably dominated the herb layer in all the communities as well as in Patharia-complex as a whole (Table 3). Other co-dominant species of herb layer were *Phyllanthus simplex, Desmodium triflorum, Eragrostis tenella,* etc. The herb layer also showed heterogeneous nature for the entire Patharia-complex.

Bhatia (1958) also worked on Patharia forest and his study revealed four types of forests :

1. *Butea monosperma - Diospyros melanoxylon* type
2. *Anogeissus latifolia - Terminalia tomentosa - Diospyros melanoxylon* type
3. Mixed teak (*Tectona grandis*) type
4. Riverine type

   Riverine type is not included in the present study.

These types were sub-divided into eleven sub types on the basis of co-dominant species that increase in abundance within defined area.

Studies of Misra & Johsi (1952) were confined to highly disturbed area where biotic pressure has resulted in elimination of some species and preponderance of certain other species like *Butea monosperma* and *Diospyros melanoxylon*, while Bhatia (1958) selected more closed and less disturbed part of Patharia forest to study the distribution of the associate species of teak (*Tectona grandis*). He found that dominant species maintained their present status due to either biotic disturbances, edaphic or physiographic influence or may be constituting long persistent seral stages. Presently, forest-complex of Patharia hill is under the stress of biotic pressure leading to dominance of *Acacia leucophloea, D. melanoxylon* and *B. monosperma*. These species generally gain abundance in areas that have been disturbed and increase significantly with increasing forest degradation.

Total vegetation of Patharia complex appears to be heterogeneous in its composition as indicated by frequency diagram (Fig. 1). More than 70 % of the species belong to frequency class A showing greater heterogeneity of the total complex.

Contagious distribution is the most common pattern exhibited by trees, shrubs and herb layers (Table 4). Although, Misra & Joshi (1952) and Bhatia (1958) did not include A/F ratio in their vegetation analysis, our results are in agreement with others as they also come out with the conclusion that contagious distribution is the most common type of pattern found in most of the communities. Occurrence of contagious distribution in natural vegetation has been reported by a number of workers (Kershaw 1973; Khatri 2000; Kunhikannan 1999; Odum 1971; Singh & Yadava 1974; Singhal & Sharma 1989; Singhal *et al*. 1986; Thakur 2003; Verma 2000).

In both the study periods, common tree species in different communities ranged from 7 to 15 and similarity index lies between 35.89 to 57.69 % (Table 5). In general, the results envisage that the similarities among three communities during 1952 were more as compared to the present study. Further, it is evident from the data (Table 5) that one to one comparison of same community tended towards dissimilarity rather than similarity. Results showed that species composition has been changed during the last 50 years. Misra & Joshi (1952) reported that 18 % tree species were common to first five stands, while in the present study 14 % tree species were common to all six stands.

Table 4. Distribution pattern (%) of trees, shrubs and herbs species at different forest types of Patharia.

Sl. no.	Subsites	Trees			Shrubs			Herbs		
		R	r	C	R	r	C	R	r	C
1.	I	18.18	4.54	77.27	-	40.00	60.00	-	28.57	71.42
2.	II	32.00	12.00	56.00	-	50.00	50.00	-	-	100.00
3.	III	5.55	33.33	61.11	-	33.33	66.66	-	-	100.00
4.	IV	3.33	30.00	66.66	-	60.00	40.00	-	-	100.00
5.	V	9.99	27.27	63.63	-	40.00	60.00	-	-	100.00
6.	VI	17.39	13.04	69.56	-	20.00	80.00	-	11.11	88.88
	Patharia Complex	-	12.0	88.00	-	14.28	85.71	-	-	100.00

R = Regular, r = Random, C = Contagious.

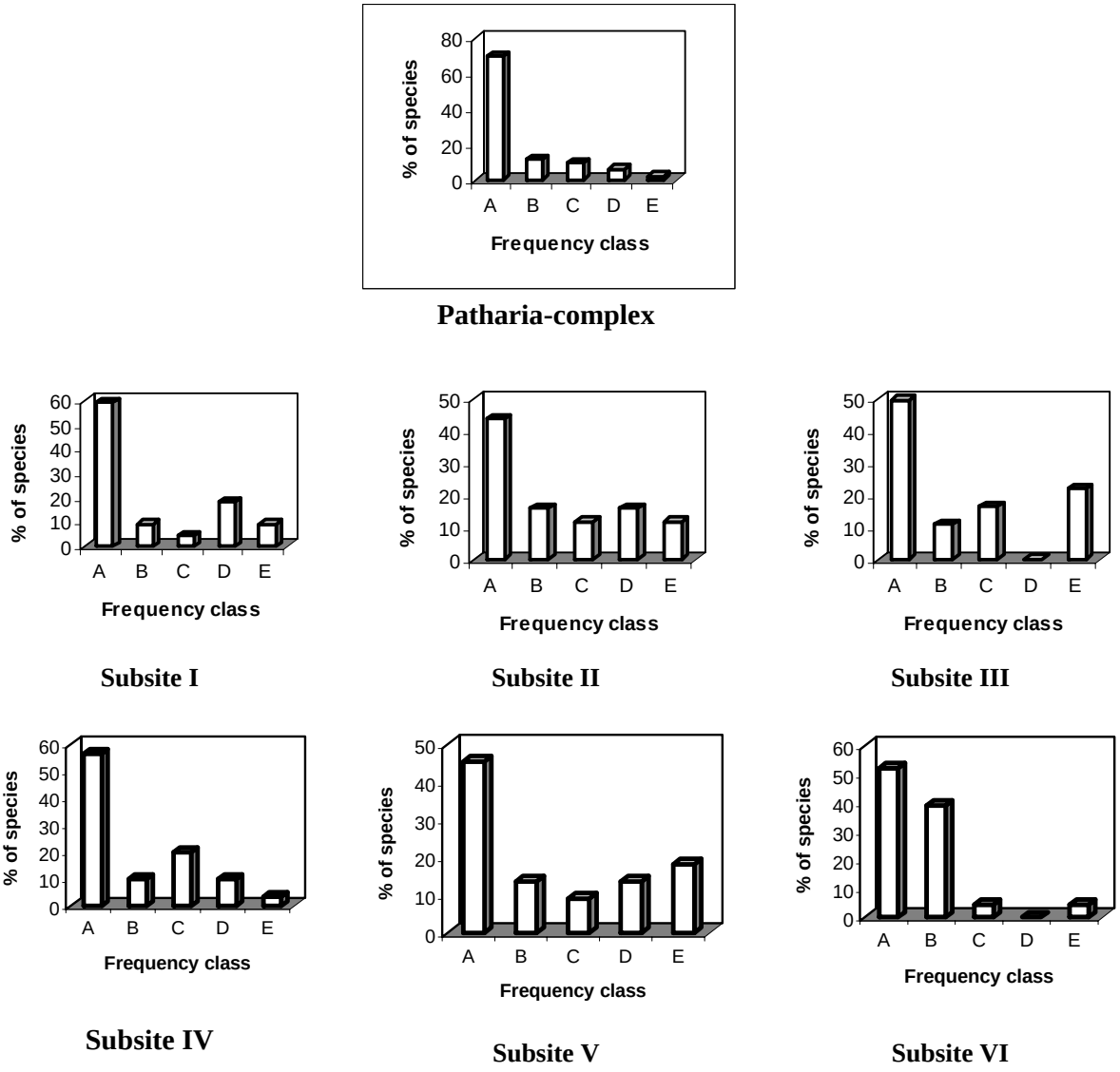

Fig. 1. Frequency diagram of tree communities at Patharia hills and its different subsites.

Table 5a. Similarity matrix of different forest communities of Patharia hills (Sagar) in 2002.

↓ Subsites →	I	II	III	IV	V	VI
I	+					
II	55.31	+				
III	60.00	65.11	+			
IV	50.00	65.45	54.16	+		
V	63.63	55.31	65.00	61.53	+	
VI	62.22	54.16	48.78	52.83	62.22	+

Table 5b. Similarity matrix of different forest communities during 1952 (Misra & Joshi 1952).

↓ Subsites →	I	II	III	IV	V
I	+				
II	63.82	+			
III	70.58	73.68	+		
IV	70.83	62.85	82.05	+	
V	52.38	62.06	48.48	46.66	+

Table 5c. Comparison of forest communities during 1952 and 2002.

2002 \ 1952	I	II	III	IV	V
I	57.69				
II		38.90			
III			35.89		
IV				52.00	
V					52.94

The succession diagram of Patharia forest complex was prepared following Misra & Joshi (1952) and Bhatia (1958) and evidences derived from soil, vegetation and regeneration (Fig. 2). Misra & Joshi (1952) considered *Butea monosperma* to be the chief component of the climax and post climax communities because of its high abundance in all the types. Presently also this species occured as a chief component of climax and post climax communities, indicating high biotic disturbances in the area. Bhatia (1958) considered *Tectona grandis* as a main component of climax community, but in the present study it was found dominant only in some of the types. Biotic and edaphic factors strongly influenced the composition of seral communities. Due to increasing biotic intensity, calcium content in soil and dryness, *Acacia leucophloea* has become the dominant species in the area.

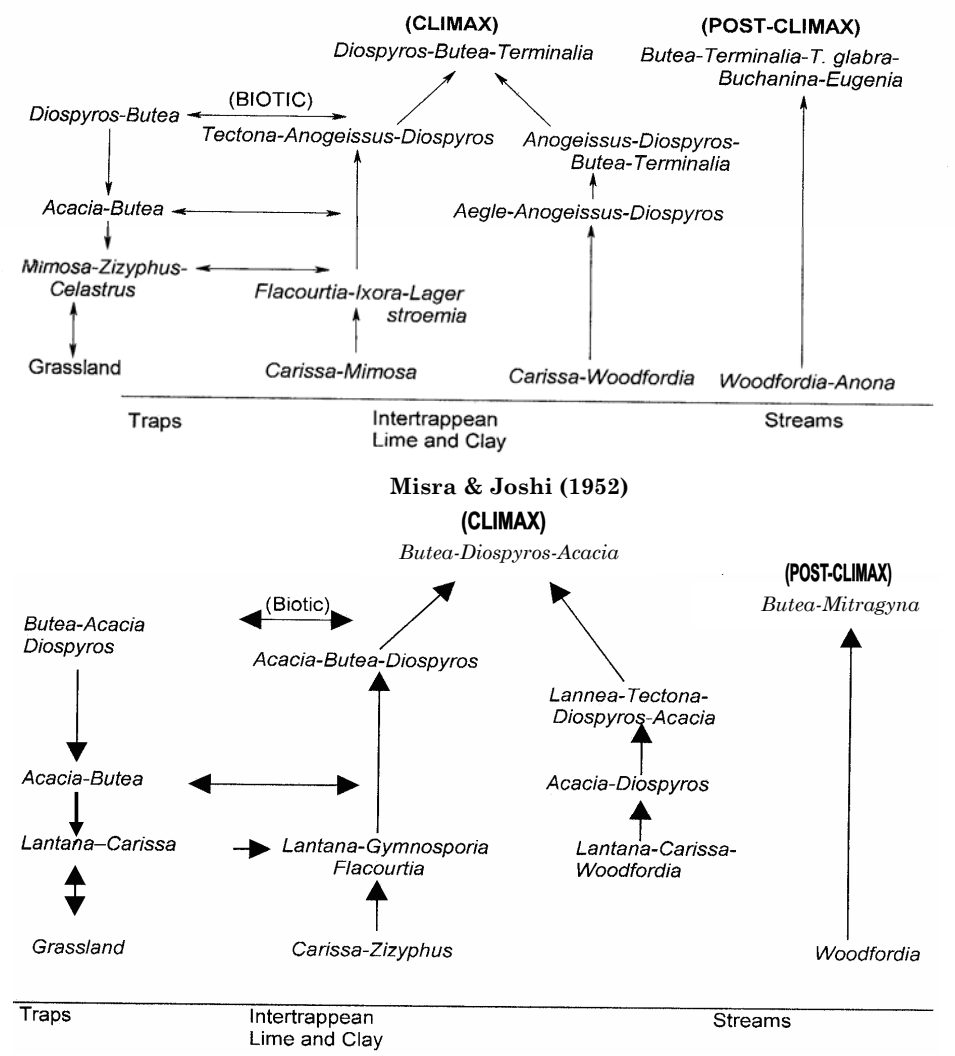

Fig. 2. Succession diagram of Patharia Forest-complex.

The early stages of succession were characterized by the presence of thorny shrubs like *Carissa spinarum, Zizyphus oenoplia* and *Flacourtia indica,* etc. These species not only stabilize the substratum but also provide effective shelter to tree saplings against grazing. But due to denudation and increase in open area, fast growing shrub *Lantana camara* became dominant and replaced the other shrubs to a large extent.

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