ISSN (E): 2320-3862
ISSN (P): 2394-0530
https://www.plantsjournal.com
JMPS 2023; 11(1): 29-33

Received: 13-10-2022
Accepted: 16-12-2022

Shivnandan Patel
Research Scholar, Department Botany, S.G.S. Govt. P.G. College, Sidhi, Madhya Pradesh, India

M Salim
Professor, Department of Botany, S.G.S. Govt. P.G. College, Sidhi, Madhya Pradesh, India

Corresponding Author:
Shivnandan Patel
Research Scholar, Department Botany, S.G.S. Govt. P.G. College, Sidhi, Madhya Pradesh, India

Vegetation structure and species diversity in Kusumi forest, Sidhi (M.P.) India

Shivnandan Patel and M Salim

Abstract
Vegetation structure of different strata (tree, shrub and herb,) were analysed in Kusumi forest, Sidhi (M.P.). Total 738 woody individuals belonging to 14 species were recorded from random quadrats covering 0.25 ha area. The highest stem density and IVI was obtained by *Shorea robusta*. All the species had clumped distribution. The trees occupied a basal area of 20.39 m^2 ha^{-1}. Species richness and diversity of shrubs and herbs were greater than trees. Presence of various anthropogenic disturbances warrants immediate conservation efforts.

Keywords: Lateritic zone, forest, species diversity, vegetation structure

Introduction
Biodiversity is essential for human survival and economic well being and for the ecosystem function and stability (Singh, 2002) [47]. Sacred forests are patches of native vegetation traditionally managed as part of local cultural tradition and functionally link social life and forest management system of a region (Boraiah *et al*., 2003) [4]. The practice of sacred groves dates back to the nomadic hunter-gatherer age of human history (Gadgil and Vartak 2004) [11]. At certain places in India such traditional forest management has sustained over the years by native communities (Kushalappa *et al*., 2001) [18]. Sacred groves are believed as treasure house of medicinal and rare plants, as refugia for regional relic flora, and as centres of seed dispersal (Chandran *et al*., 1998) [8] and are therefore relevant for in-situ biodiversity conservation (Upadhaya *et al*., 2003) [50]. Commonly it is believed that sacred forests are better protected and managed owing to their religious significance and harbour richer plant diversity than other forests. However, several sacred forests are experiencing failure of legal protection in guaranteeing their integrity and conservation (Rawat *et al*., 2011) [35].
Description of forest vegetation by determining essential measurable properties, such as species richness and biomass, and documenting quantitative relationships among them is a desirable goal of plant ecology (Keddy, 2005) [15]. Many studies have documented the community structure, species diversity and regeneration of sacred forests in India. Rao *et al*. (2011) [33] higher species richness, diversity and density in sacred forest stands compared with reserve forests in the Eastern Ghats. Sunitha (2002) [48] studied plant biodiversity in the 14 sacred groves of Andhra Pradesh. Higher number of medicinal plants as well as higher success of species regeneration compared to reserve forests has been reported Himachal Pradesh and Western Ghats, respectively (Singh *et al*., 1998; Boraiah *et al*., 2003) [43, 4].
The dry tropical forest accounts for 38.2% of the total forest cover of India (MoEF, 1999) [23]. Kusumi forest forms an important part of the tropical dry deciduous forests of the lateritic zone. Lateritic zone in West Bengal comprising Purulia district and western portions of Birbhum, Burdwan, Midnapore and Bankura districts harbor floristically important Northern Tropical Dry Deciduous forests (Champion and Seth, 1968) [7]. Lateritic soils are characterized by acidic pH, low NPK content and high iron as reported by many studies (Raychaudhuri, 1980; Chakraborty *et al*., 2002) [6]. Many plants of this region are having immense importance due to their medicinal and dye yielding properties. The minor forest products of the region include lac, sal seeds and leaves, mohua flowers, fibres and flosses, grasses, barks, gums and resins (Mukherjee, 1995) [24]. Sacred forests of Kusumi are very old natural forest and dedicated to goddess Durga. Forest studies conducted so far in the entire lateritic zone concentrated on floristic and ethnobotanical aspects (Rahaman *et al*., 2000, 2008; Bhattacharya and Mukherjee, 2006; Bouri and Mukherjee, 2011) [2, 5, 31-32].

Reconstruction of modern vegetation changes using pollen analysis was attempted by Bhattacharya *et al.* (2003) [3] while Gupta Joshi (2012) [13] made a preliminary quantitative analysis of vegetation structure covering a few sites in the lateritic zone. Kushwaha and Nandy (2012) [19] compared species diversity and community structure of sal forests under different rainfall regimes. Pandit (2011) [28] documented about sacred groves of West Medinipur district. No reports are available on vegetation analysis of Kusumi forests.

The objective of the present study is to analyze the vegetation structure and species diversity pattern of a sacred forest from lateritic zone which in turn will help to control the forest structure by plantation and better management of the forest flora.

Material and Methods

The vegetation was sampled randomly by laying 25 quadrats of 10m x 10m each, covering 0.25 ha area, during February 2021 to March 2022 covering all the seasons. In each quadrat all the trees (dbh>1cm) were identified and their number and diameter at breast height (dbh) were recorded with the help of a slide caliper. Where dbh measurement was not possible, girth at breast height (gbh) was measured using a meter tape. The shrubs, climbers and tree saplings (< 1cm dbh, height >30 cm) were sampled in two 5m x 5m quadrats, and herbs including tree seedlings (< 1cm dbh, height.

Data analysis

Phytosociological characters like frequency, density, basal area and importance value index (IVI) were calculated for each tree species according to Misra (1968) [22]. Family importance value (FIV) was estimated as the sum of relative density, relative diversity and relative dominance of a family (Ganesh *et al*., 1996) [10]. Dispersion of species was calculated as ratio of abundance to frequency (A/F) (Curtis and Cottam, 1956).

Population structure of tree species was studied by determining the number of individuals in different diameter classes starting from 1–5cm to 50-55cm. Species diversity was calculated separately for various vegetation strata – trees, shrubs and herbs. Various diversity measures were estimated like Shannon - Wiener index (H′), Simpson’s index (Cd), evenness (E) and Margalef’s index of species richness (M) (Shannon and Weaver, 1949; Simpson, 1949; Pielou, 1966; Margalef, 1968) [43, 45, 30, 21].

$$H' = -\sum_{i=1}^{s} pi\ In\ pi$$

$$Cd = \sum (Pi)^2$$

$E = H'/H^{max}$; $H^{max} = \ln(S)$

$M = (S-1)/\text{In } N$

Where, s=total no of species, pi= ni/N, ni= total no of individual of “i” species, N= total no of individual of all species, ln= natural log

Results and Discussion

Species Composition and Vegetation Structure

A total of 738 woody individuals (≥1cm dbh) of 14 species from 12 families were recorded in the study area (Table 1). The number of individuals of various species varied from 1 to 468. The family Dipterocarpaceae had the greatest number of individuals (468) of single species. The family Ebenaceae was represented by single species having single individual. The number of species ranged from 2 to 5 per quadrat and individuals from 8 to 72 per quadrat. Total stem density in the area studied was 2952 N ha^{-1}. However the total density of stems with dbh ≥ 10 cm was 744 N ha^{-1} (Table 2). Mean stem density per quadrat was 29.52 and 11 out of 25 quadrats had stem density more than the mean value.

Table 1: Phytosociological characteristics of tree species in Kusumi forest district Sidhi (M.P.)

Species	Family	Total No.	Density ± sd (N ha^{-1})	Frequency (%)	Basal area (m^2 ha^{-1})	IVI
Shorea robusta Gaertn. F.	Dipterocarpaceae	468	1872±1095.51	84	11.72	145.90
Madhuca indica Gmelin	Sapotaceae	76	304±180.69	68	1.63	38.51
Acacia nilotica (L.) Willd. Ex Del.	Mimosaceae	9	36±264.58	12	0.033	4.95
Buchanania lanzan Spreng.	Anacardiaceae	109	436±583.57	72	1.37	42.89
Semecarpus anacardium L.f.	Anacardiaceae	7	28±70.71	8	0.016	3.41
Tectona grandis L.f.	Verbenaceae	21	84±275.38	16	0.88	11.91
Haldina cordifolia (Roxb.) Ridsdale	Rubiaceae	7	28±57.74	12	1.05	9.67
Pterocarpus marsupium Roxb.	Fabaceae	8	32±54.77	20	0.48	9.39
Schleichera oleosa (Lour.) Oken	Sapindaceae	10	40±321.46	12	0.41	6.93
Spondias pinnata (L.f.) Kurz	Anacardiaceae	13	52±577.35	12	2.12	15.75
Alangium lamarckii Thw.	Alangiaceae	3	12±70.71	8	0.009	2.83
Bombax ceiba L.	Bombacaceae	2	8	4	0.60	4.42
Diospyros melanoxylon Roxb.	Ebenaceae	1	4	4	0.003	1.34
Aegle marmelos (L.) Corr.	Rutaceae	4	16	4	0.07	2.09

Table 2: The proportion of tree species, stem density and basal area in different diameter classes

S. No.	dbh class (cm)	Species	Stems ha^{-1}	% of stems	Basal area (m^2)	% of basal area
1	1 to 5	3	1264	42.82	0.028	0.14
2	>5 to 10	2	944	31.98	0.11	0.52
3	>10 to 15	0	452	15.31	0	0
4	>15 to 20	1	172	5.83	1.63	7.97
5	>20 to 25	2	80	2.71	1.29	6.30
6	>25 to 30	3	24	0.81	13.56	66.54
7	>30 to 35	1	8	0.27	0.60	2.96
8	>35 to 40	0	0	0	0	0

9	>40 to 45	0	0	0	0	0
10	>45 to 50	2	8	0.27	3.17	15.57
11	>50 to 55	0	0	0	0	0
	total	14	2952	100	20.39	100

Based on their density, species were categorized into five classes:

Predominant species (≥ 200 individuals): *Shorea robusta* with highest density (1872 N ha^{-1}) contributing 63.41% of the total density.

Dominant species (100 to 199 individuals): *Buchanania lanzan* with 109 individuals contributing 14.76% of total density belong to this group.

Common species (25 to 99 individuals): *Madhuca indica* represented this group accounting for 10.29% of total density (76 individuals).

Rare species (5 to 24 individuals): seven species contributing 10.16% of total density (75 individuals) formed this group – *Acacia nilotica, Semecarpus anacardium, Tectona grandis, Haldina cordifolia, Pterocarpus marsupium, Schleichera oleosa, Spondias pinnata*.

Very rare species (< 5 individuals): four species with total 10 individuals (1.35% of total density) belonged to this category. These four species were *Alangium lamarckii* (3 individuals), *Bombax ceiba* (2 individuals), *Diospyros melanoxylon* (single individual) and *Aegle marmelos* (4 individuals).

The total basal area occupied by the tree species was 20.39 m² ha^{-1}. However considering the stems with dbh ≥ 10 cm, total basal area was 20.25 m² ha^{-1}. Species-wise basal area ranged from 0.0003 m² ha^{-1} to 11.719 m² ha^{-1}. Largest basal area was occupied by *Shorea robusta* (11.719 m² ha^{-1}) followed by *Spondias pinnata* (2.1239 m^2 ha^{-1}). Dipterocarpaceae was the dominant family based on basal area. Quadrat wise basal area varied from 0.09 to 0.42 m² with a mean of 0.203 m²; in 10 quadrats the basal area exceeded the mean value.

The highest IVI was exhibited by *Shorea robusta* (145.904) followed by *Buchanania lanzan* (42.89). *Diospyros melanoxylon* had the lowest IVI (1.34). Based on family importance value (FIV), Dipterocarpaceae ranked highest among all families followed by Anacardiaceae (Table 3).

Table 3: Family Importance Value (FIV) based on number of species, density and basal area under different families

Family	Species	Trees	Basal area (m² ha⁻¹)	Relative Density	Relative Diversity	Relative Dominance	FIV
Anacardiaceae	3	129	3.51	17.48	21.43	17.19	56.10
Alangiaceae	1	3	0.01	0.41	7.14	0.05	7.59
Bombacaceae	1	2	0.60	0.27	7.14	2.96	10.38
Dipterocarpaceae	1	468	11.72	63.42	7.14	57.49	128.05
Ebenaceae	1	1	0.003	0.14	7.14	0.02	7.29
Fabaceae	1	8	0.48	1.08	7.14	2.36	10.58
Mimosaceae	1	9	0.03	1.22	7.14	0.16	8.52
Rubiaceae	1	7	1.05	0.95	7.14	5.15	13.24
Rutaceae	1	4	0.07	0.54	7.14	0.35	8.04
Sapindaceae	1	10	0.41	1.36	7.14	2.00	10.50
Sapotaceae	1	76	1.63	10.30	7.14	7.97	25.42
Verbenaceae	1	21	0.88	2.85	7.14	4.30	14.29
Total 12	14	738	20.39	100	100	100	300

The maximum diameter recorded was 49.31cm (for *Spondias pinnata*). The most preferred diameter class was 1-5 cm with density ranging from 4 to 748 stems ha^{-1}. However based on basal area, the 10-15 cm dbh class had the highest basal area of 5.04 m² ha^{-1}. Figure 2 shows the diameter density distribution of tree species. Almost all the species exhibited a reverse 'J' pattern with stems restricted below 40cm dbh, except *Spondias pnnata* and *Haldina cordifolia*.

The shrub layer had 608 individuals belonging to 17 species including 5 climbers and a creeper species having 278 individuals. The highest frequency is exhibited by *Erycibe paniculata*. 30 herbs with 1639 individuals composed the ground flora. Distribution pattern for all the species in the area studied was of clumped type (>0.5).

Species Diversity

For tree species Shannon-Wiener Index or heterogeneity (H´) was 1.88 (Table 4). Evenness was low resulting in higher concentration of dominance. Species richness was high leading to high heterogeneity value. Shrub layer had higher species richness and evenness than trees leading to heterogeneity value of 3.42. Species richness and heterogeneity were highest in the herb layer and evenness was highest in the shrub layer.

Table 4: Diversity values of tree, shrub and herb layer in Kusumi forest.

Vegetation stratum	H'	E	Cd	M
Tree	1.88	0.71	0.44	1.97
Shrub	3.42	1.21	0.12	2.50
Herb	3.62	1.06	0.13	3.92

Discussion

No two forest communities could be closely identical with respect to vegetation composition and structure (Murphy and Lugo, 1986) [25]. The presence of 738 woody individuals belonging to 14 species in 0.25 ha area of Kusumi forest dry deciduous forest is relatively a good number. Among these, only *Aegle mermelos* is evergreen to semi deciduous. Higher number of species including medicinal plants has been reported from other conserved as well as disturbed sacred groves involving areas ranging from 1 ha to 50 ha - 146-156 in Karnataka (Boriah *et al*., 2003), 239 in Uttarakhand (Rawat *et al*., 2011) [35], 158 tree species in southern Eastern Ghats (Rao *et al*., 2011) [33], 83 tree species form 14 sacred groves in Kurnool district of Andhra Pradesh (Sunitha, 2002) [48], and 139 species form 25 sacred groves in West Medinipur, West Bengal (Pandit, 2011) [28].

Mean stem density in this study ranged from 4 to 1872 N ha^{-1}, with mean 210.85 N ha^{-1} and only one species representing 63.41% of the total tree population. Density range of 929-

1018 N ha^{-1} has been reported from sacred dry deciduous forest stands in Eastern Ghats (Rao *et al*., 2011) [33]. Reported values of mean stem density from other deciduous forests of India are 35 – 419 ha-1 (Sagar and Singh, 2006) [39], 591 ha^{-1} (Sahu *et al*., 2007) & 315-494 ha^{-1} (Pandey and Shukla, 2001). Mean tree density of 276 - 980 stems ha^{-1} has been reported in some other tropical dry forests with preferred diameter classes ranging from 20-50 cm (Bhadra *et al*., 2010; Krishnamurthy *et al.,* 2010; Kumar *et al.,* 2010) [1, 16, 17].

The highest stem density and IVI was obtained by *Shorea robusta*, which showed similarity with the previous study in similar adjacent forests showing dominance of *Shorea robusta* (Gupta Joshi, 2012) [13]. The total basal area occupied by the tree species of sampled plot (0.25 ha) was 20.39 m^2 ha^{-1} which showed almost similar range when compared to the earlier studies including 1.31 to 13.78 m^2 ha^{-1} (Sagar and Singh, 2006) [39]; 7 - 23 m^2 ha^{-1} from certain dry forest communities in India (Jha and Singh, 1990) [14], 10.79 - 20.44 m^2 ha^{-1} for a tropical dry evergreen forest of southern India (Parthasarathy and Sethi, 1997) [29]. However comparatively higher range of basal area (16.6 m^2 ha^{-1} to 31.7 m^2 ha^{-1}) is reported from sacred forest sites (Rao *et al*., 2011) [33].

Almost all the species exhibited reverse J shaped diameter density distribution suggesting a young or regenerating population. Only two species exceeded 40cm diameter class – *Spondias pinnata* and *Haldina cordifolia*. In the present study all the species showed clumped distribution which is very common in nature (Odum, 1971) [26] due to patchy distribution and coppice forming (Roy and Singh, 1994) [42], insufficient mode of seed dispersal or gap formation encouraging recruitment and growth of numerous saplings (Richards, 1996) [37] or vegetative reproduction by suckers (Lieberman, 1979) [20].

The values of Shannon-Wiener diversity index (1.88) and Simpson's dominance index (0.43) in the present study are within the reported range for tropical forests. Diversity (H’) range of 0.83 - 4.1 has been reported by earlier workers for Sal forests (Rasingam and Parthasarathy, 2009; Shukla, 2009; Tripathi and Singh, 2009; Krishnamurthy *et al*., 2010; Sahu *et al*., 2012) [29, 16, 49] and the concentration of dominance (Cd) ranged 0.10-1 for tropical dry forests by other workers (Visalakshi, 1995; Kumar *et al*., 2010; Sahu *et al*., 2012) [41, 51, 17]. However, the Shannon’s diversity value of 1.8 is much lower when compared with Shannon’s diversity index value of 3.34 reported from a scared tropical dry deciduous forest (Rao *et al*. 2011) [33]. The species diversity as well as richness (H′ and M) increased as we moved from the trees to the herbs. Concentration of dominance was highest for trees indicating dominance by a few species. Increased diversity of shrubs and herbs also indicate an open canopy forest and presence of disturbance.

Conclusion

The results of present study indicated a young or regenerating population of tree species. Future work will compare the vegetation structure of this sacred forest with adjacent forests under different management regimes. It is generally believed and supported by published reports that sacred forests are better protected and managed owing to their religious significance and harbour richer plant diversity than other forests. However, comparison with results from other sacred forests indicated lower species richness, diversity as well as basal area in the Kusumi forests. The health of Kusumi forests is deteriorating due to various anthropogenic disturbances such as grazing, extraction of fuel wood, collection of various NTFP, etc. apart from the periodic man made fires. Therefore further conservation efforts are immediately needed to curb the anthropogenic disturbances.

Acknowledgements

The authors are thankful to authority of forest deptt of Sidhi district to carryout this work.

References

1. Bhadra AK, Dhal NK, Rout NC, Reddy VR. Phytosociology of the tree community of Gandhamardan hill ranges. The Indian Forester. 2010;136(5):610-620.
2. Bhattacharya A, Mukherjee A. A preliminary forest survey in Garhjangal: Durgapur, West Bengal. Indian Journal of Applied and Pure Biology. 2006;21(2):293-298.
3. Bhattacharya K, Yousuf S, Gupta Bhattacharya S. Pollen analysis in reconstructing modern vegetation changes in lateritic zones of West Bengal. In: Late Quaternary Environment Change: Emerging Issues (Ed. Anupama K and Achyuthan H), French Institute, Pondicherry, 2003, p. 157-160.
4. Boraiah KT, Vasudeva R, Bhagwat SA, Kushalappa CG. Do informally managed sacred groves have higher richness and regeneration of medicinal plants than state-managed reserve forests? Current Science. 2003;84(6):804-808.
5. Bouri T, Mukherjee A. Biological spectrum of Bankati forest areas in Burdwan district, West Bengal. Indian Journal of Science and Research. 2011;2(4):57-60.
6. Chakraborty T, Ghosh GK, Laha P. Fertility status and phosphorus fractionations in lateritic soils under different agroecosystems of West Bengal. Journal of Agricultural Sciences. 2002;72(1):42-44.
7. Champion HG, Seth SK. A Revised Survey of the Forest Types of India. New Delhi, India: Government of India Publication, 1968.
8. Chandran MDS, Gatgil M, Hughes JD. in Conserving the Sacred for Biodiversity Management (eds Ramkrishnan, P.S., Saxena, H.G. and Chandrashekhera, U.M.), Oxford and IBH, New Delhi, 1998, p, 211-231.
9. Curtis JT, Cottom G. Plant Ecology Workbook: Laboratory Field Reference Manual. Burgess Publishing Co., Minnesota, 1956, p. 193.
10. Ganesh T, Ganesan R, Soubadradevi M, Davidar P, Bawa KS. Assessment of plant biodiversity at mid-elevation evergreen forest of Kalakad- Mundanthurai Tiger Reserve, Western Ghats, India. Current Science. 1996;71(5):379-392.
11. Gatgil M, Vartak VD. Groves dedicated to the gods. In: Focus on Sacred Groves and Ethnobotany. (eds V. Ghate, H. sane and S.S. Ranade) Prism Publication, Mumbai, 2004, p. 1-5.
12. Guha Bkshi DN. Flora of Murshidabad District, West Bengal, India. Scientific Publishers, Jodhpur, India, 1990.
13. Gupta Joshi H. Vegetation structure, floristic composition and soil nutrient status in three sites of tropical dry deciduous forest of West Bengal. Indian journal of fundamental and applied Life Sciences. 2012;2(2):355-364.
14. Jha CS, Singh JS. Composition and dynamics of dry tropical forest in relation to soil texture. Journal of Vegetation Science. 1990;1:609–614.
15. Keddy P. Putting the plants back into plant ecology: six pragmatic models for understanding and conserving plant

diversity. Annals of Botany, 2005, 96: 177–189.
16. Krishnamurthy YL, Prakasha HM, Nanda A, Krishnappa M, Dattaraja HS. Vegetation structure and floristic composition of a tropical dry deciduous forest in Bhadra Wildlife Sanctuary, Karnataka, India. Tropical Ecology. 2010;51(2) 235-246.
17. Kumar JIN, Kumar RN, Bhoi RK, Sajish PR. Tree species diversity and soil nutrient status in three sites of tropical dry deciduous forest of western India. Tropical Ecology. 2010;51(2):273-279.
18. Kushalappa CG, Bhagwat SA. in Tropical Ecosystems: Structure, Diversity and Human Welfare (eds Ganeshaiah, K.N. Uma Shaanker, R. and Bawa, K.S.), Oxford and IBH, New Delhi, 2001, p. 21-29.
19. Kushwaha SPS, Nandy S. Species diversity and community structure in sal (Shorea robusta) forests of two different rainfall regimes in West Bengal, India. Biodiversity Conservation. 2012;21:1215-1228
20. Lieberman D. Dynamics of forest and thicket vegetation on the Accra plains, Ghana. Ph.D. Thesis. University of Ghana, Legon. 1979.
21. Margalef R. Perspectives in Ecological Theory. Chicago, IL, USA: University of Chicago Press, 1968.
22. Misra R. Ecology work book. Oxford and IBH publishing Co. New Delhi, 1968.
23. MoEF, National Policy and Macrolevel Action Strategy on Biodiversity. Ministry of Environment and Forest, Government of India, New Delhi.
24. Mukherjee AR. Forest resources conservation and regeneration – A study of West Bengal plateau. Concept Publishing Company, New Delhi, 1995.
25. Murphy PG, Lugo AE. Ecology of tropical dry forest. Annual Review of Ecology and Systematics. 1986;17: 67–88.
26. Odum EP. Fundamentals of Ecology, Philadelphia, PA, USA: W.B. Saunders & Co. 1971.
27. Pandey SK, Shukla RP. Regeneration strategy and plant diversity status in degraded sal forests. Current Science. 2001;81:95-102.
28. Pandit PK. Conservation and cultural dimensions of sacred groves in Paschim Medinipur District, West Bengal, India. Indian Forester. 2011;137(5):571-588.
29. Parthasarathy N, Sethi P. Trees and liana species diversity and population structure in a tropical dry evergreen forest in south India. Tropical Ecology. 1997;38:19–30.
30. Pielou EC. Species diversity and pattern diversity in the study of ecological succession. Journal of Thereotical Biology. 1966;10:370–383.
31. Rahaman CH, Ghosh A, Mandal S. Studies on ethnomedicinal uses of plants by the tribals of Birbhum district, West Bengal. Indian Journal of Environment and Ecoplanning. 2008;15(1-2):71-78.
32. Rahaman CH, Mondal S, Mandal S. Study of host ranges of some phanerogamic parasites of Birbhum district, West Bengal. Asian Journal of Microbiology, Biotechnology and Environmental Science. 2000;2(3-4):141-144.
33. Rao BRP, Suresh Babu MV, Reddy MS, Reddy AM, Rao VS, Sunitha S. Sacred groves in southern eastern ghats, India: Are they better managed than forest reserves? Tropical Ecology. 2011;52(1):79-90.
34. Rasingam L, Parthasarthy N. Tree species diversity and population structure across major forest formations and disturbance categories in Little Andaman Island, India. Tropical Ecology. 2009;50(1):89-102.
35. Rawat M, Vasistha HB, Manhas RK, Negi M. Sacred forest of Kunjapuri Siddhapeeth, Uttarakhand, India. Tropical Ecology. 2011;52(2):219-221.
36. Raychaudhury SP. The occurrence, distribution, classification and management of laterite and lateritic soil. Cah. ORSTOM, series Pedology. 1980;18(3-4):249-252.
37. Richards PW. The Tropical Rainforest, 2nd ed. Cambridge University Press, Cambridge, 1996.
38. Roy S, Singh JS. Consequences of habitat heterogeneity for availability of nutrients in a dry tropical forest. Journal of Ecology. 1994;82:503–509.
39. Sagar R, Singh JS. Tree density, basal area and species diversity in a disturbed dry tropical forest of northern India: implication for conservation. Environmental conservation. 2006;33(3):256-262.
40. Sahu SC, Dhal NK, Reddy CS, Pattanaik C, Brahmam M. Phytosociological study of tropical dry deciduous forest of Boudh district, Orissa, India. Research Journal of Forestry. 2007;1:66-72.
41. Sahu SC, Dhal NK, Mohanty RC. Tree species diversity, distribution and population structure in a tropical dry deciduous forest of Malygiri hill ranges, Eastern India. Tropical Ecology. 2012;53(2):163-168.
42. Sanyal MN. Flora of Bankura District. Bishen Singh Mahindra Pal Singh, Dehradun, 1994, p. 555.
43. Shannon CE, Weaver W. The Mathematical Theory of Communication. University of Illinois Press, Urbana, USA, 1949.
44. Shukla RP. Patterns of plant species diversity across Terai landscape in north-eastern Uttar-Pradesh, India. Tropical Ecology. 2009;50(1):111-123.
45. Simpson EH. Measurement of diversity. Nature. 1949;163:688.
46. Singh GS, Rao KS, Saxena KG. In Conserving the Sacred for Biodiversity Management (eds Ramakrishnan, P.S., Saxena H. G. and Chandrasekhara, U.M.), Oxford and IBH, New Delhi, 1998, p. 301-314.
47. Singh JS. The biodiversity crisis: A multifaceted review. Current Science. 2002;82:632-647.
48. Sunitha S. Plant Biodiversity of the Sacred Groves of Kurnool District, A.P. Ph.D. Thesis, Sri Krishnadevaraya University, Ananatapur, 2002.
49. Tripathi KP, Singh B. Species diversity and vegetation structure across various strata in natural and plantation forests in Katerniaghat Wildlife Sanctuary, North India. Tropical Ecology. 2009;50(1):191-200.
50. Upadhaya K, Pandey HN, Law PS, Tripathi RS. Tree diversity in sacred groves of the Jaintia hills in Meghalaya Northeast India. Biodiversity and Conservation. 2003;12:583-597.
51. Visalakshi N. Vegetation analysis of two tropical dry evergreen forests in southern India. Tropical Ecology. 1995;36(1):117-127.
52. Wikitravel. Durgapur Travel Guide. 2015. http://www.wikitravel.org/en/Durgapur (Assessed on July 11, 2016)