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Plant Diversity in Sacred Groves of Dapoli: A Comparative Study of Four Life Forms

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A B S T R A C T

The biodiversity-rich sacred groves are of immense ecological significance. They also play an important role in the conservation of flora and fauna. Besides, several rare and threatened species are found only in sacred groves, which are, perhaps, the last refuge for these vulnerable species. In Dapoli Taluka sacred groves have immense potential as ecosystem service providing habitats. There have been gaps in their documentation. So a comparative study four life forms was initiated in 11 sacred grove of Dapoli Taluka. For the present investigation, 11 Sacred groves were selected on the basis of size class viz. 0-5, 5-10, and 10< (Ha). Field surveys and mapping were conducted in selected sacred groves during October 2016 to January 2017 for gathering information on the status, extent, floral elements etc. A total of 171 species representing 145 genera and 66 families were recorded in the 11 sacred groves and associated outside plots. The maximum were trees (92) followed by shrubs (33), herbs (27), and climbers (18) and one orchid species. Among the families, Fabaceae was most dominant comprising 12 species and 10 genera, followed by Acanthaceae representing 10 species and 8 genera. In present study we recorded total 10 rare and threatened plants and 29 endemic plants from the 11 sacred groves of Dapoli taluka.

Introduction

Sacred groves are outstanding and excellent examples of the collective attitudes and beliefs of a rural society. They are the aesthetic symbols of the interaction of man with nature, a rich blend of natural and cultural values. These are believed to be the sites where the ancestors and forefathers lived and the abode of natural spirits or deities. Isolation of such forests has resulted in the conservation of many rare, endangered and endemic species. Their plant wealth and conservation potential were impressive enough to acknowledge them as mini biosphere reserves (Gadgil and Vartak, 1975). The forests associated with these sacred groves are typically different in their vegetation structure and species composition (Chandrashekhar and Shankar 1998).

Biodiversity keeps the ecological processes in a balanced state, which is necessary for human survival. Therefore, the biodiversity-rich sacred groves are of immense ecological significance. They also play an important role

in the conservation of flora and fauna. Besides, several rare and threatened species are found only in sacred groves, which are, perhaps, the last refuge for these vulnerable species. The importance of sacred groves in the conservation of biological diversity has been well recognized. Vartak (1976) found a grove in the Koloba district of Maharashtra harboring a solitary specimen of the liana *Entadaphaseoloides*.

Sacred groves are the good source of a variety of medicinal plants, fruits, fodder, fuel wood, spices, etc. Some interesting ethno-botanical studies were conducted by Gadgiland Vartak(1976) in the sacred groves of Maharashtra. Despite their small size, they are important sources of ecosystem services including biodiversity conservation (Ray and Ramachandra 2010).

But in recent times the traditional values appear to be on the gradual decline due to the advent of modernization and various developmental activities. Various anthropogenic activities have altered the structure and function of different ecosystems all over the world. One of the most conspicuous effects of ecosystem perturbation has been the depletion of biodiversity. Disappearance of species due to habitat alteration, overexploitation, pollution, global climate change and invasion of exotic species is so fast that many valuable taxa may vanish even before they are identified and their scientific value is discovered.

In Dapoli taluka sacred groves have immense potential as ecosystem service providing habitats. There have been gaps in their documentation. It is also necessary to bring them in a geographic perspective wherein their information could be useful in taking landscape level decisions. They also need to be conserved and conservation cannot be targeted at abstract entities. They need to be identified, located and mapped. An effort has been made towards this by Patil (2016). However, it needs to be taken further by associating attributes of sacred groves to the mapped land parcels. These attributes could be used as conservation parameters both in ethical and utilitarian approaches.

Therefore, there is an urgent need to study the structure and functions of sacred groves before initiating the conservation strategies to protect them.

Materials and Methods

This study was carried out in Dapoli Taluka (17°34' to 17°56'; 73°03' to 73°20') of Ratnagiri district. Total geographical area of Dapoli is 846 km^2. The landscape of Dapoli is dominated by forests, plateaus, agricultural patches and fruit orchards.

In Dapoli tehsil 110 sacred groves are present as per the records of the revenue department (Patil 2016). They range in size from 0.05 to 40 ha. They are known as *Dev-rahati* meaning the abode of the deity. For the present investigation, 11 Sacred groves were selected on the basis of size class viz. 0-5, 5-10, and 10< (Ha). Field surveys and mapping were conducted in selected sacred groves during October 2016 to January 2017 for gathering information on the status, extent, floral elements etc.

We marked plots in the sacred groves so as to cover core, buffer edge area of each sacred grove. One additional plot was marked in the nearby forest area (hereinafter referred to as vicinity plots). Each plot was sampled using quadrats of different dimensions for different life forms. For trees it was 10m x 10m, for shrubs it was 5m x 5m, for herbs and climbers it was 1m x 1m. These quadrats were nested as within each other.

Data analysis

The software program Estimates (Colwell 1997) was used to estimate species richness and associated parameters. Species accumulation curves were generated after 100 randomizations. The non-parametric estimator Jackknife-1 was used as a robust estimator of species richness in each sacred grove (Heltshe and Forrester 1983) and for the pooled data. Jackknife-1gives an estimate of absolute number of species in an assemblage based on number of rare species (species that occur only in one sample; (Magurran 2004). But values of other estimators are also presented in the results and compared for their efficacy and for calculating the completeness of surveys percentage. Completeness of surveys is the number of species discovered in the surveys as a proportion of actual number of species as estimated by the non-parametric estimators. This programme also gave values of diversity indices namely Shannon index and Simpson index.

Program Nestedness (Ulrich, 2006) was used to quantify nestedness of species by site matrix. The program provides nestedness scores in form of 'temperature-T', the values of which range between0 (perfect order) and 100 (perfect disorder). The significance of the observed temperature was judged from the 95% CI after 100 randomizations.

The beta diversity using Whittaker's β and inverse of Jaccard's index of similarity were calculated as measures of species turnover because of their advantages over other indices was calculated (Wilson and Shmida, 1984).

Species-area relationship was explored using scatter plots and modeling curves in the software PAST. The parameters of power function were estimated for the observed curves. Similarly, logistic regression was fitted to the data to test asymptotic nature of the species-area relationship.

Results and Discussion

Flora of sacred grove

Present study aimed at recording maximum number of plant species in the sacred groves and their vicinity through systematic sampling and *ad lib* recording. In this way, a total of 171 species representing 145 genera and 66 families were recorded in the 11 sacred groves and associated outside plots. The flora recorded exclusively in sacred groves included 127 species, whereas only nine species were recorded exclusively in the vicinity plots. Thirty five species could be recorded in both the areas. The species not recorded in sacred groves included *Abrusprecatorius*, *Anacardium occidentale*, *Lantana camara*, *Morinda tinctoria*, *Semecarpusanacardium*, *Senna tora*, *Tectonagrandis*, *Terminalia chebula*, and *Woodfordia fruticosa*. Some of these species may be present in sacred groves but in very rare numbers. Hence, they were not recorded in sampling effort.

The maximum were trees (92) followed by shrubs (33), herbs (27), climbers (18) and one orchid species (Fig. 1). Among the families, Fabaceae was most dominant comprising 12 species and 10 genera, followed by Acanthaceae representing 10 species and 8 genera.

Species richness

A total of 65 species of trees, 25 species of shrubs, 9 species of herbs and 12 species of climbers were recorded in the 43 plots laid in 11 sacred groves and 11 plots in the vicinity of scared groves. Out of these, 60 species of trees, 22 species of shrubs, 9 species of herbs and 11 species of climbers were recorded exclusively in sacred groves and 19 species of trees, 13 species of shrubs, 3 species of herb and 6 species of climbers were recorded exclusively in the vicinity plots. For the

purpose of statistical treatment, only this data of observed species richness is used henceforth.

The species are grouped into different life forms as per the sampling strategy. Maximum number of tree species was recorded in Sadavali followed by Dhankoli, Douli and Kudavale. In case of shrubs, maximum number of species were recorded in Sadavali and Douli followed by Sakhloli and Shivnari. It can be seen that the number of individuals and species recorded for herbs and climbers were relatively very less. It is because most of the ephemeral herbs and climbers could not be recorded in the designated survey season. Therefore, although interpretations based on herbs and climber's data are presented here, they may not carry the robustness. The study carried by the Page *et al.*, (2009) in fragmented scared grove of western Ghat also reported 122 species of trees, 29 species of lianas, 60 spices of shrub and 66 epiphtes in 11 fragmented sacred grove.

Estimated species richness

Estimates gave values of estimated species richness using several estimators. However, the Jacknife1 is the most reliable estimator (Patil 2016).

Results indicate that estimated species richness of trees was considerably higher than observed species richness in all sacred groves. Whereas for other life forms it was not so different. Only in case of Douli and Dhankoli, the estimated species richness of shrubs was also considerably higher than observed species richness (Fig. 2 and 3).

It was observed that most of the vicinity plots had less number of observed species richness across all sacred groves and across all life forms. Similarly, it was found that estimate Jacknife1 species richness values were significantly greater in case of larger sacred groves and particularly in case of trees and shrubs.

Completeness of survey

As can be seen from above results, the sampling effort has yielded a lesser number of species than that could be recorded using sampling plus other methods. Thus, sampling usually presents a problem of incomplete survey of species diversity.

It could be seen that minimum completeness recorded in herb (47-97%) whereas the other three life forms recorded relatively high per cent completeness (56-91%).

It is very interesting to note that despite recording 60 species of trees in sacred groves, the maximum completeness is 72 per cent. On the other hand, in the vicinity plots, only 19 tree species were recorded yet there was completeness to the tune of 92 per cent. This clearly indicates that, despite a greater sampling effort (n=43) failed to record all maximum possible tree species. And this is a clear proof that sacred groves support a rich flora compared with adjacent forest patches.

It can be seen that in general completeness is higher in smaller sacred groves because the sampling effort was almost adequate to record the maximum possible species in smaller areas. However, the smaller values of completeness in case of larger sacred groves provide guideline to increase the sampling effort so as to make it adequate.

Species accumulation curve

Species accumulation curves for different life-forms for pooled data of sacred groves are shown in Figure 4. These curves buttress the results of completeness analysis. It can be clearly seen that the curve for trees is not

showing any sign of reaching an asymptote even after 43 samples. On the other hand, other life forms have stabilized after a few samples. However, it must be noted that the herbs data in the present study is not sufficient as the season in which survey was conducted had very little presence of ephemeral herbaceous plant species.

Species-area relationship

Species-area relationship investigation of the life forms across the sacred groves under study was done. The only significant and positive correlation was found in case of trees where species richness increased with area of the sacred grove patch. For other life forms, there was no conclusive relationship. Even the logistic regressions indicate the only asymptotic relationship in case of trees (Fig. 5). For shrubs, it comes closer to an asymptotic relationship, but the initial part of the curve does not fit. Given the high number of trees recorded in this study compared to shrubs, climbers and herbs, this kind of result was expected. A positive species-area relationship, as indicated that species richness was a function of patch area, highlighting once again the importance of species richness in fragmented habitat. isolation plays an important role in colonization process and is one of the important predictors of the species diversity (Page *et al.,* 2009)

Diversity indices

The Shannon index (H') that is considered true indicator of diversity of an assemblage and the Simpson's index (D) which is an indicator of dominance within the community were also worked out for all sacred groves based on tree and shrub assemblages.

Dhankoli sacred groves possessed the most diverse tree assemblage as illustrated by values of both H′ and D. On the other hand, Douli sacred grove possessed the most diverse shrub assemblage. Vanzloli sacred grove where only one shrub species was recorded showed the extreme values of both the indices clearly indicating the academic fact that there was least diversity and highest dominance of a single species (Fig. 6 and 7).

Rank abundance

Comparison of trees is shown for three size categories, In small size sacred groves *Memecylon umbellatum* species was most dominant, followed by *Nathapodytes nimmoniana*, But in medium size class *Terminalia bellerica* most abundant species. *Mammea suriga* was second most abundant species in medium size class. In small size class*Ixora brachiata* species was dominant and second was *Saraca asoca.*

For shrubs *Carrisa congesta* was most dominant species in small size class and also second-most dominant species in medium size class of sacred groves. *Leea indica* was most dominant species in medium size class and also second-most in large size class of sacred groves. *Justicia adathoda* was most dominant in large size class.

Similarly, *Eranthemum roseum* was most dominant herb in all size class of 11 sacred groves of Dapoli, and also *Curcuma pseudomontana* was second-most dominant species was found. In case of climber species *Jasminun malabericum* was most dominant species followed by *Cyclea pelteta* in small size class.

But most dominant in medium size class *Ipomoea campanulata* was second-most dominant in medium and large size class and also *Dalbergia horrida* was most dominant in large size class.

Spatial turnover

Spatial turnover is a measure of beta diversity. Spatial turnover at species level was assessed by calculating the Whittaker's ß index. The index gives an idea about compositional dissimilarity between two sets of taxon assemblages. The sacred groves were arranged by their size and sequential values. A Whitteker's β were calculated for entire assemblage. Similarly it was calculated for tree and shrub separately. The same is shown graphically in figure 5 illustrate with observed species richness in each groves. It was found that there was highest turnover between Karde-Shivnari (0.91) followed by that in Shirkhal–Vanzloli (0.85). The lowest turnover was recorded between pairs of Douli-Sadavali (0.70) and Shivnari–kadivali (0.72).

In case of trees species, it was found that the maximum turnover of species happened between Karde-Shivnari (0.94) followed by Sakhloli-Shirkhal (0.90). The lowest turnover was species between Gavtale-Sakhloli (0.70).

For the shrubs highest turnover of species between Kadivali-Gavtale,Shirkhal-Vanzloli (0.85) followed by Vanzloli-Dhankoli, but lowest turnover in Douli-Sadvali, Sakhloli-Shirkhal (0.36, 0.63). Overall, there was no trend in the turnover rate for either the entire assemblage or for trees or shrubs separately (Fig. 8).

Figure.1 Distribution of plant species recorded in this study in various life forms

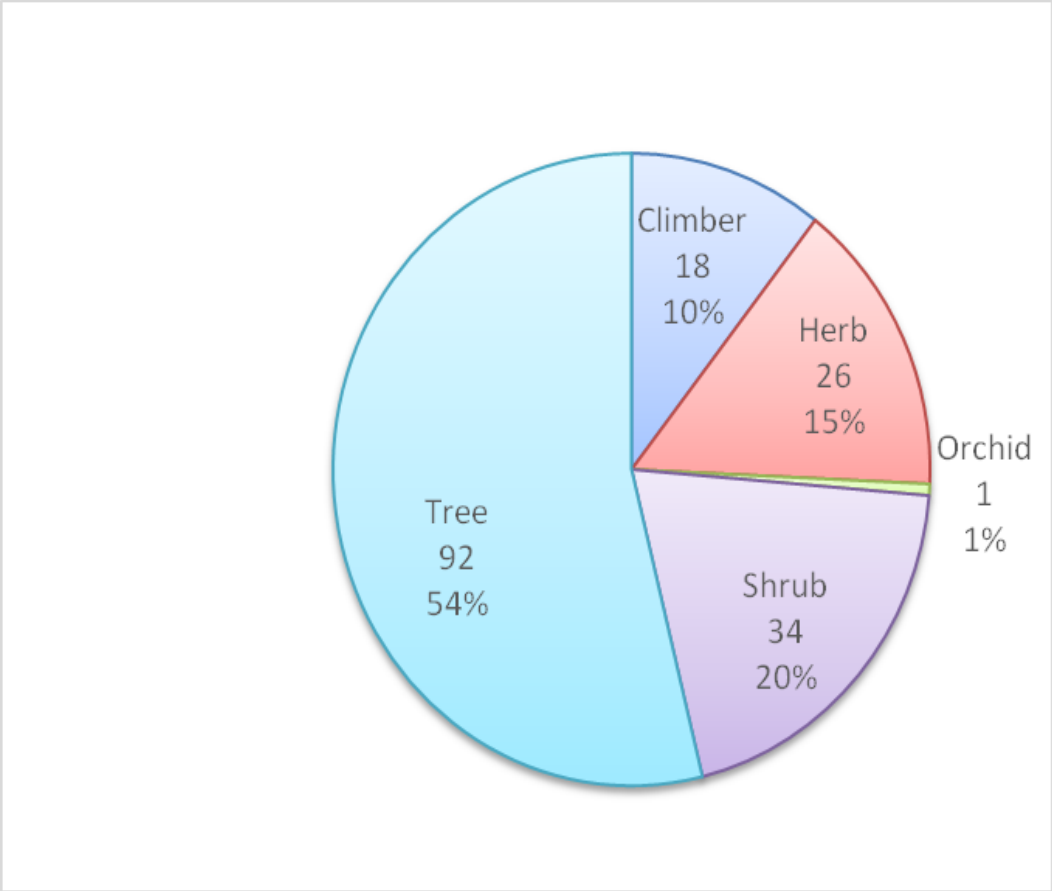


Figure.2 Comparison of observed (diamonds) and estimated Jacknife1 (squares) species richness for different study sites for different life forms

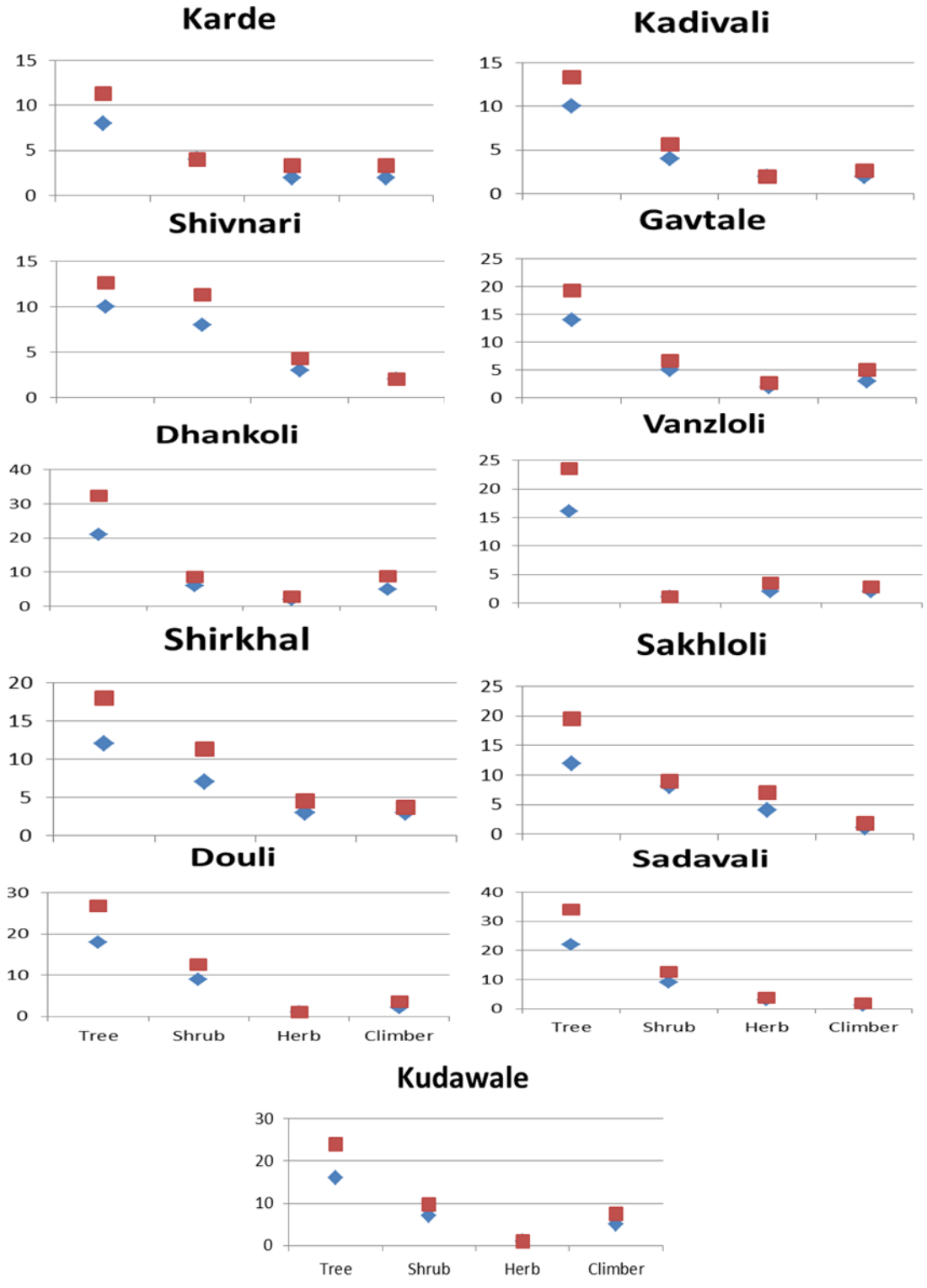


Figure.3 Comparison of observed (diamonds) and estimated Jacknife1 (squares) species richness for in sacred groves and observed species richness (triangles) in vicinity plots

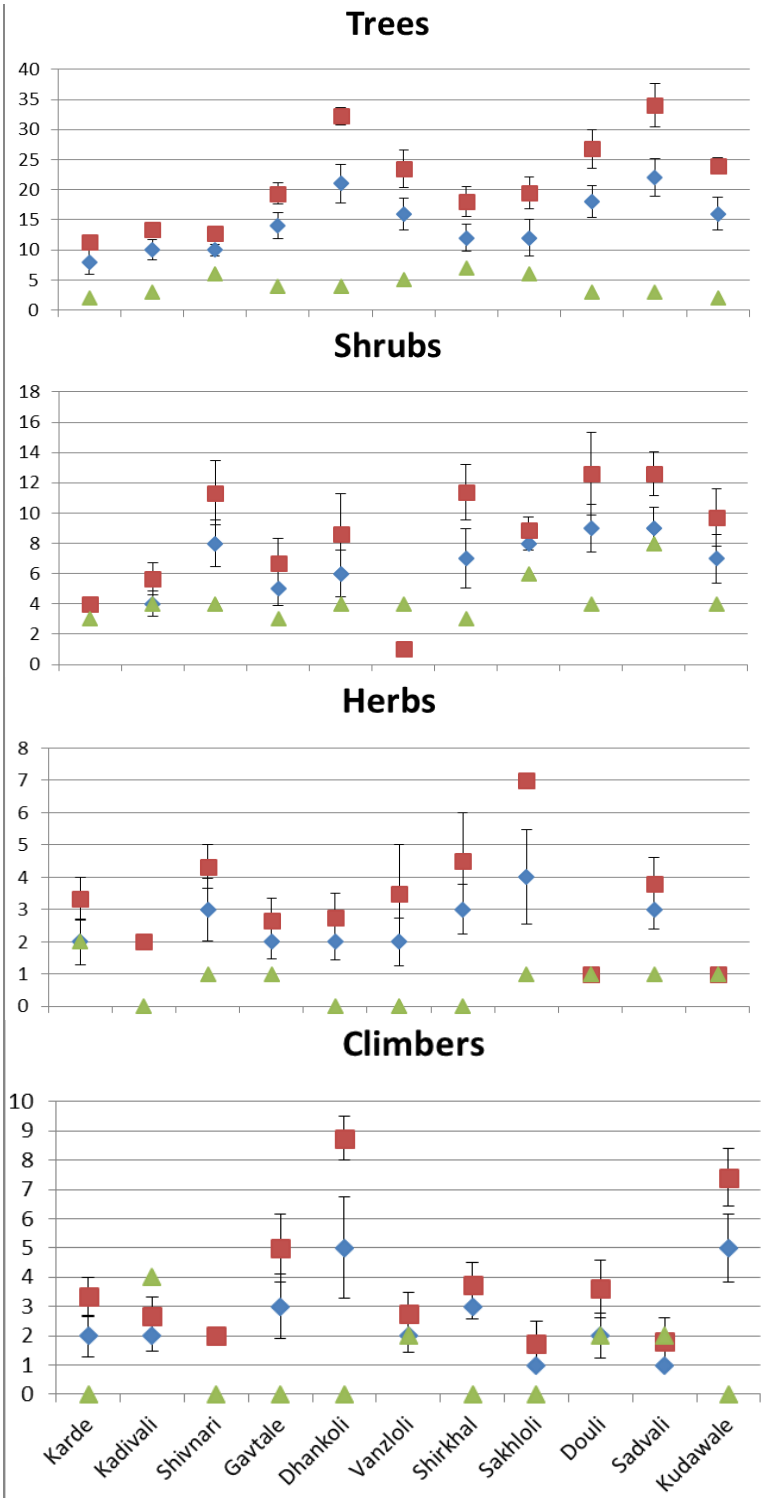


Figure.4 Species accumulation curve of all form with no of quadrant in all sacred groves.

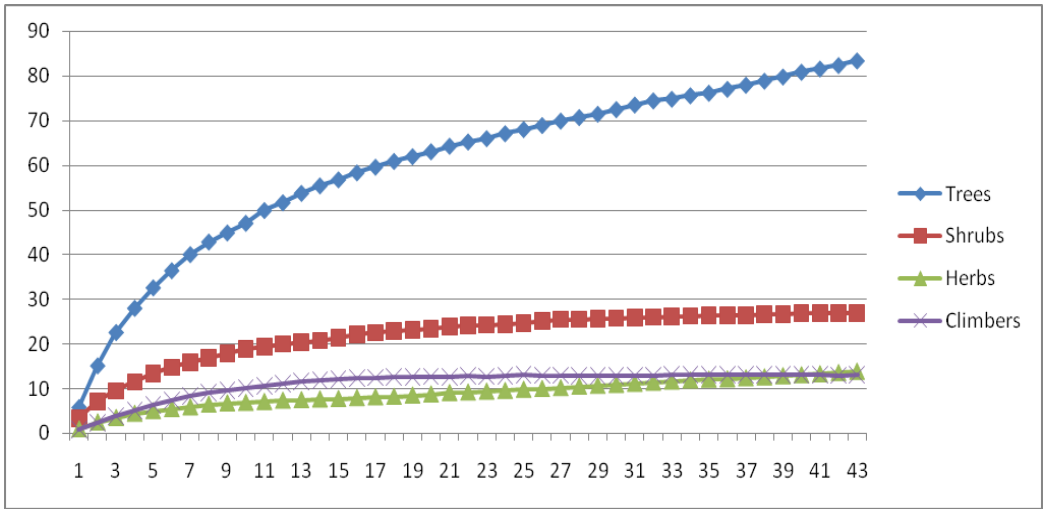


Figure.5 Logistic regression fitted to the species-area relationship of different life-forms across the study sites

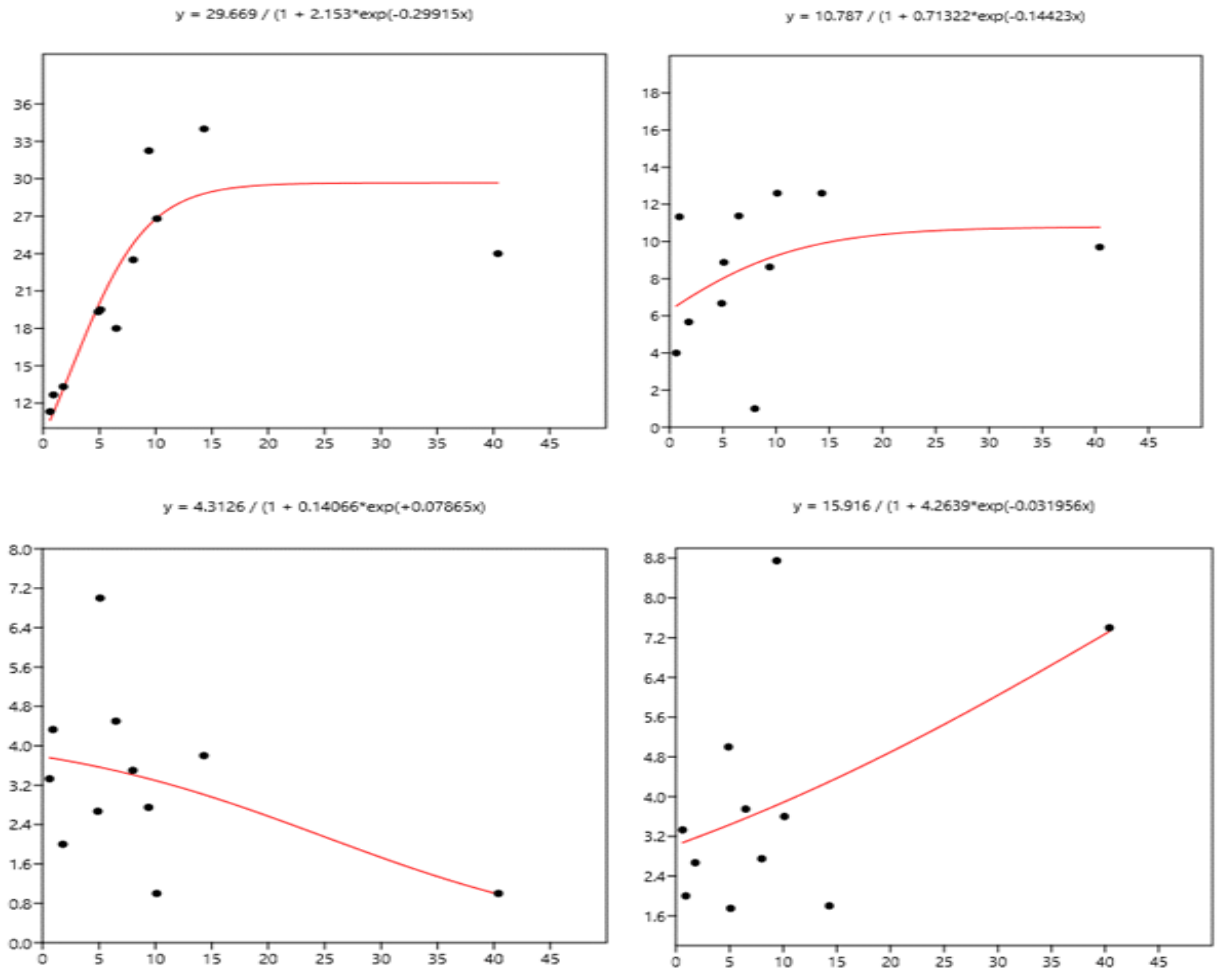


Figure.6 Shannon and Simpson diversity indices based on tree assemblage

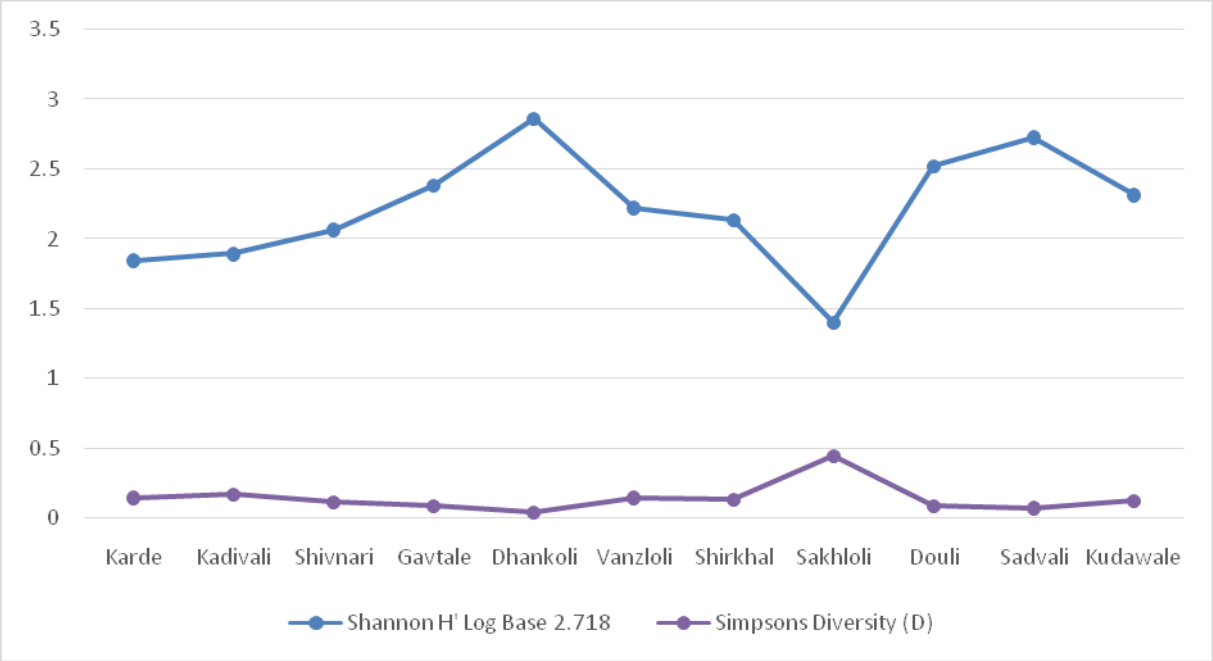


Figure.7 Shannon and Simpson diversity indices based on shrub assemblage

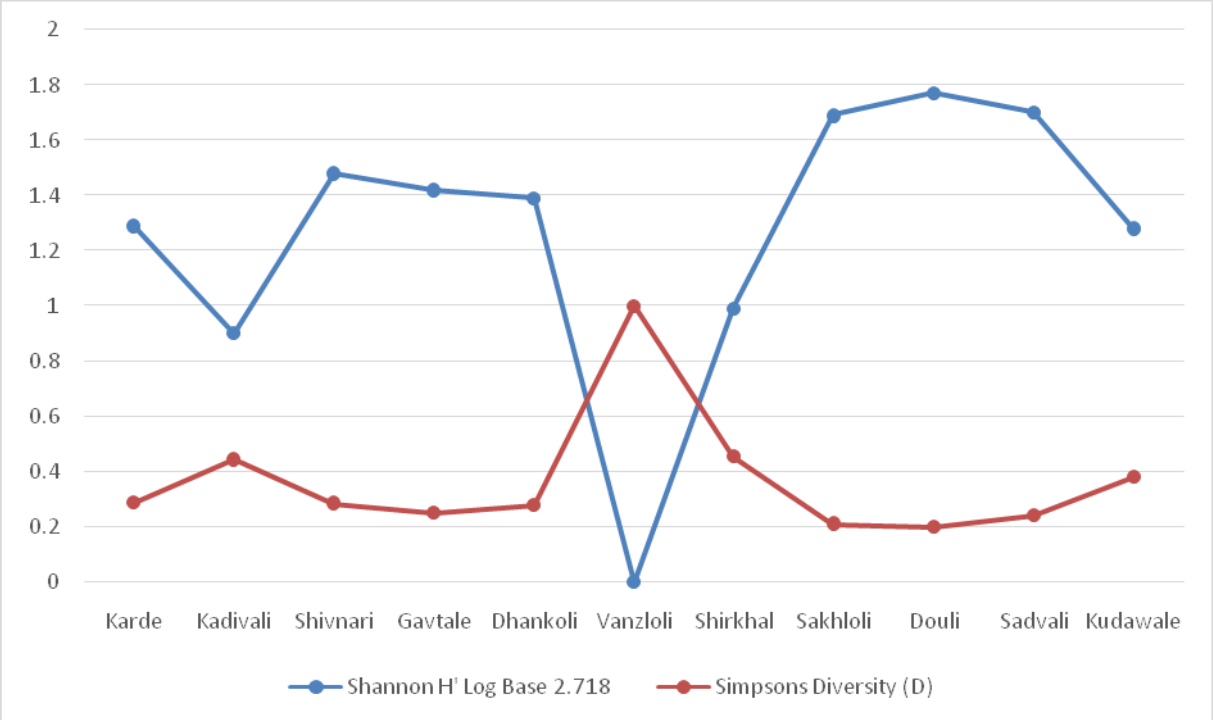
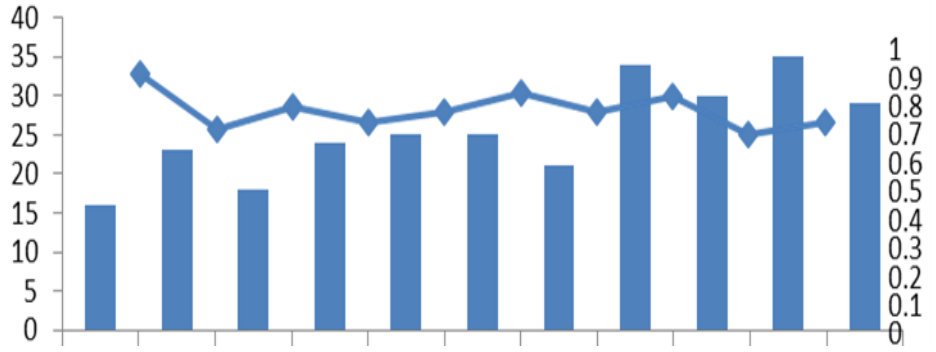
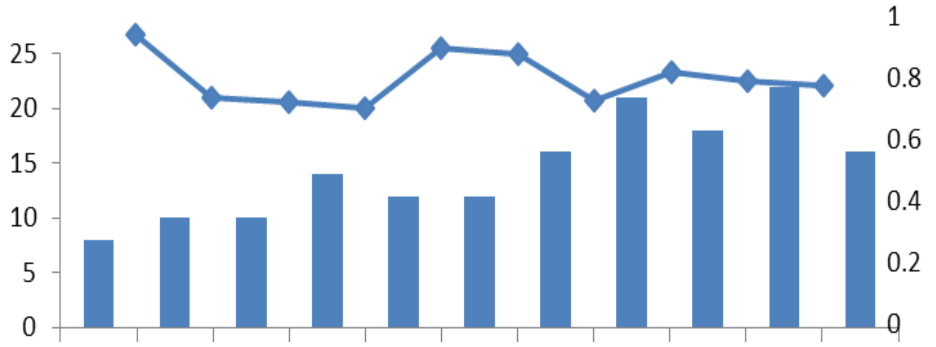


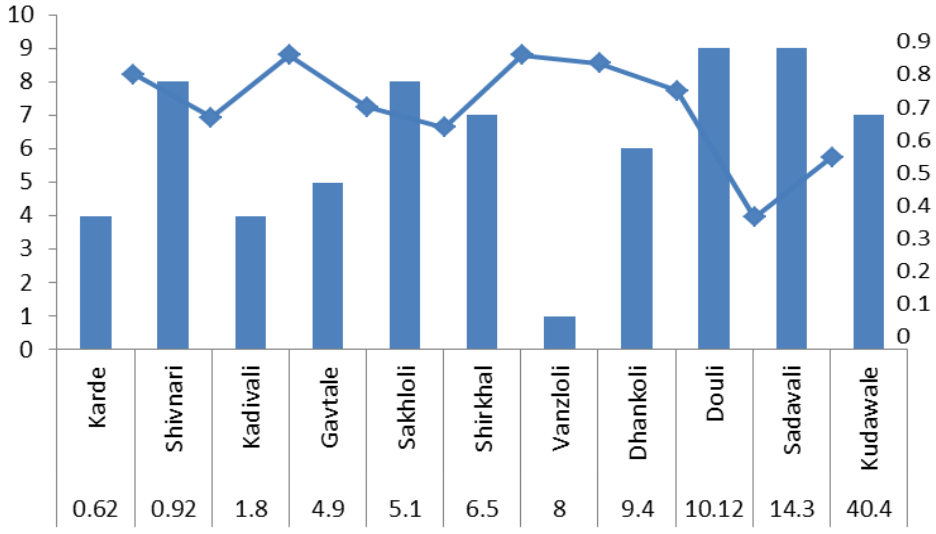
Figure.8 Spatial turnovers of beta diversity a) All Life form species, b) Tree species, c) Shrubs species



a)



b)



c)

Figure.9 Clustering of sacred groves using Bray-Curtis similarity distance based on their species composition of trees (A) and shrubs (B)

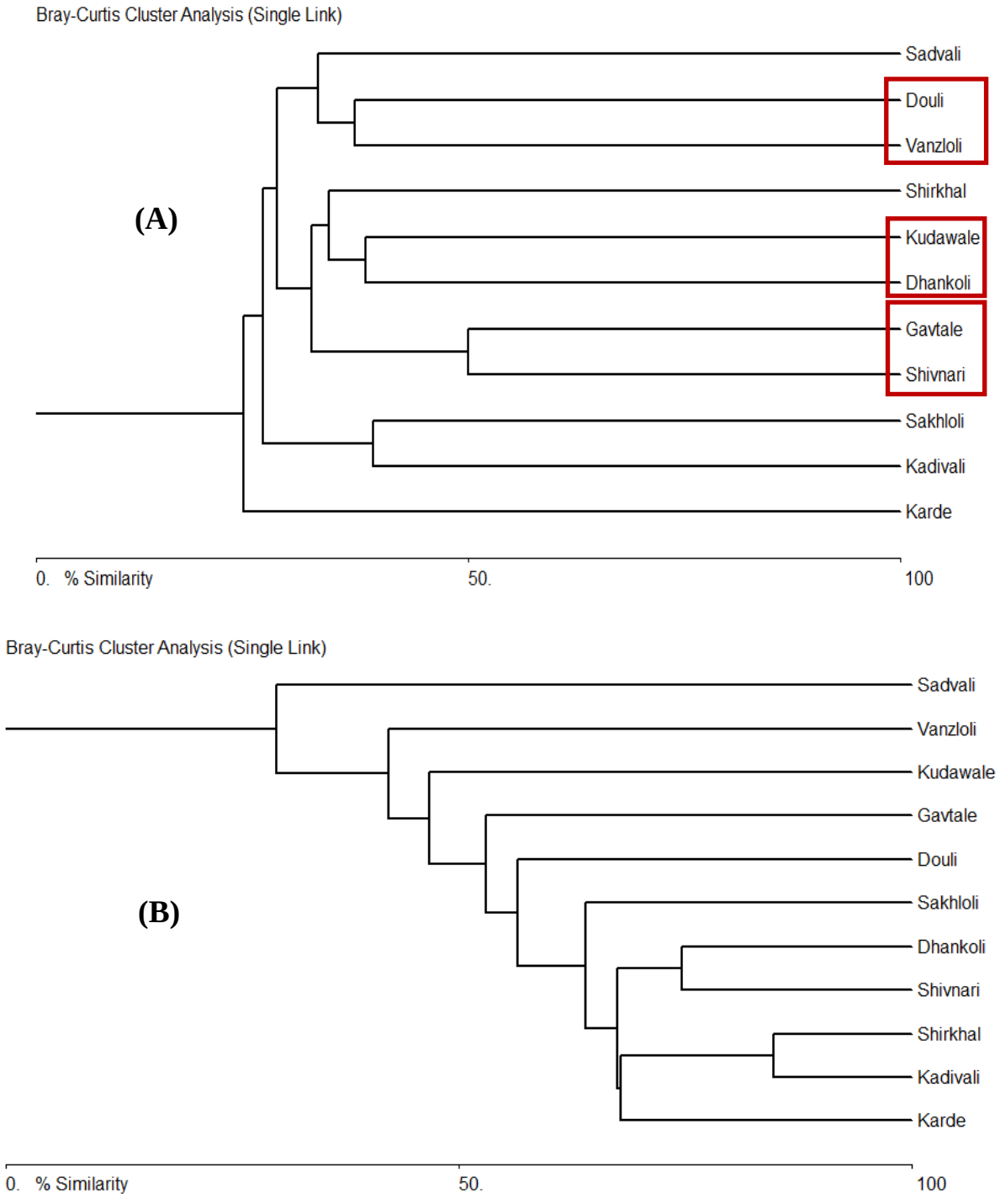


Table.1 Checklist of plants recorded in sacred groves and their vicinity in Dapoli, Maharashtra

Sl. No.	Scientific name	Family	Common name	Occurrence
Trees				
1	*Acacia auriculiformis*	Mimosaceae	Australian Babhul	Sacred groves
2	*Acacia catechu*	Mimosaceae	Khair	Sacred groves & Vicinity
3	*Acacia mangium*	Mimosaceae	Australian teak	Sacred groves
4	*Aegle marmelos*	Rutaceae	Bel	Sacred groves
5	*Albizialebbeck*	Mimosaceae	Shirish	Sacred groves
6	*Alseodaphnesemicarpifolia*	Lauraceae	Phudgus	Sacred groves
7	*Anacardiumoccidentale*	Anacardeceae	Kaju	Vicinity
8	*Anodendronpaniculatum*	Apocynaceae	Kavali	Sacred groves
9	*Antiaristoxicaria*	Moraceae	Chandfal	Sacred groves
10	*Aphanamixispolystachya*	Meliaceae	Raktrohida	Sacred groves
11	*Aporosacardiosperma*	Phyllantaceae	Lindley's Aporosa	Sacred groves
12	*Artocarpusheterophyllus*	Moraceae	Jackfruit	Sacred groves
13	*Azadirchtaindica*	Meliaceae	Neem	Sacred groves
14	*Bauhinia racemosa*	Caesalpiniaceae	Apta	Sacred groves &Vicinity
15	*Bixaorellana*	Bixaceae	Shendri	Sacred groves
16	*Bombax ceiba*	Bombacaceae	Kate sawar	Sacred groves & Vicinity
17	*Brideliaretusa*	Euphorbiaceae	Asana	Sacred groves & Vicinity
18	*Butea monosperma*	Fabaceae	Palas	Sacred groves
19	*Callicarpa tomentosa*	Verbenaceae	Kaarivaati	Sacred groves
20	*Calophylluminophyllum*	Clusiaceae	Undi	Sacred groves
21	*Caralliabrachiata*	Rhizophoraceae	Phanshi	Sacred groves
22	*Careyaarborea*	Lecyhidaceae	Kumbha	Sacred groves & Vicinity
23	*Caryotaurens*	Arecaceae	Bherlimad	Sacred groves
24	*Casuarina equisetifolia*	Casuarinaceae	Suru	Sacred groves
25	*Catunaregamspinosa*	Rubiaceae	Madanphal	Sacred groves
26	*Chukrasiatabularis*	Meliaceae	Chukrasia	Sacred groves
27	*Dilleniaindica*	Dilleniaceae	Karmal	Sacred groves
28	*Dimorphocalyxglabellus*	Euphorbiaceae	Jodpakli	Sacred groves
29	*Diospyros montana*	Ebenaceae	Lohari	Sacred groves
30	*Erinocarpusnimmonii*	Tiliaceae	Cher	Sacred groves
31	*Erythrina variegata*	Fabaceae	Pangara	Sacred groves & Vicinity
32	*Ficusbenghalensis*	Moraceae	Vad	Sacred groves
33	*Ficushispida*	Moraceae	Kala umbar	Sacred groves
34	*Ficusracemosa*	Moraceae	Umber	Sacred groves

35	*Ficusreligiosa*	Moraceae	Pimpal	Sacred groves
36	*Ficustinctoria*	Moraceae	Datir	Sacred groves
37	*Ficusvirens*	Moraceae	Basari	Sacred groves
38	*Firmianacolorata*	Sterculiaceae	Koushi	Sacred groves
39	*Flacourtiamontana*	Flacourtiaceae	Ataki	Sacred groves
40	*Garcinia indica*	Clusiaceae	Kokam	Sacred groves
41	*Garugapinnata*	Burseraceae	Kakad	Sacred groves
42	*Glochidionellipticum*	Phyllanthaceae	Bhoma	Sacred groves
43	*Gmelina arborea*	Verbenaceae	Shivan	Sacred groves & Vicinity
44	*Grewiaserrulata*	Tiliaceae	Kawri	Sacred groves
45	*Grewiatilifolia*	Tiliaceae	Dhaman	Sacred groves
46	*Haldinacordifolia*	Rubiaceae	Haladu	Sacred groves
47	*Heterophragmaquadriloculare*	Bignoniaceae	Varas	Sacred groves
48	*Holarrhenapubescens*	Apocynaceae	Kuda	Sacred groves
49	*Holigarnagrahamii*	Anacardiaceae	Biboi	Sacred groves
50	*Holopteleaintegrifolia*	Urticaceae	Wavala	Sacred groves
51	*Hydnocarpuspentandrus*	Flacourtiaceae	Kadu kawath	Sacred groves
52	*Ixora brachiata*	Rubiaceae	Lokhandi	Sacred groves
53	*Lagerstroemia microcarpa*	Lythraceae	Nana	Sacred groves
54	*Lagerstroemia speciosa*	Lythraceae	Tamhan	Sacred groves
55	*Leucaena leucocephala*	Mimosaceae	Subabhul	Sacred groves
56	*Macaranga peltata*	Euphorbiaceae	Chandvad	Sacred groves
57	*Mallotusphilippensis*	Euphorbiaceae	Kunkufal	Sacred groves
58	*Mammeasuriga*	Clusiaceae	Surangi	Sacred groves
59	*Mangiferaindica*	Anacardiaceae	Mango	Sacred groves & Vicinity
60	*Memecylonumbellatum*	Melastomataceae	Anjan	Sacred groves & Vicinity
61	*Microcospaniculata*	Tiliaceae	Shirali	Sacred groves
62	*Mimusopselengi*	Sapotaceae	Bakul	Sacred groves
63	*Morindatinctoria*	Rubiaceae	Bartondi	Vicinity
64	*Murrayapaniculata*	Rutaceae	Kamini	Sacred groves
65	*Neolamarckiacadamba*	Rubiaceae	Kadamb	Sacred groves
66	*Nothapodytesnimmoniana*	Icacinaceae	Narkya	Sacred groves
67	*Oroxylumindicum*	Bignoniaceae	Tetoo	Sacred groves
68	*Peltophorumpterocarpum*	Caesalpiniaceae	Piwalagulmohar	Sacred groves
69	*Perceamacarantha*	Lauraceae	Gulaamba	Sacred groves
70	*Phyllanthus emblica*	Phyllanthaceae	Amala	Sacred groves
71	*Plumeria rubra*	Apocynaceae	Pandharachafa	Sacred groves
72	*Pongamiapinnata*	Fabaceae	Karanj	Sacred groves
73	*Sageraealaurifolia*	Annonaceae	Harkinjal	Sacred groves
74	*Saracaasoca*	Caesalpiniaceae	Seetaashok	Sacred groves

75	*Semecarpusanacardium*	Anacardiaceae	Bibba	Vicinity
76	*Sterculiaguttata*	Sterculiaceae	Kukar	Sacred groves
77	*Sterculiaurens*	Sterculiaceae	Kandol	Sacred groves
78	*Stereospermumcolais*	Bignoniaceae	Padal	Sacred groves
79	*syzygiumcumini*	Myrtaceae	Jambhul	Sacred groves & Vicinity
80	*Tabernamontanaheyneana*	Apocynaceae	Nag kuda	Sacred groves
81	*Tectonagrandis*	Verbenaceae	Saag	Vicinity
82	*Terminalia bellirica*	Combretaceae	Behada	Sacred groves & Vicinity
83	*Terminalia chebula*	Combretaceae	Harda	Vicinity
84	*Terminalia cuneata*	Combretaceae	Arjun	Sacred groves
85	*Terminalia elliptica*	Combretaceae	Ain	Sacred groves & Vicinity
86	*Terminalia paniculata*	Combretaceae	Kinjal	Sacred groves & Vicinity
87	*Tremaorientalis*	*Cannabaceae*	Ghol	Sacred groves
88	*Vitex altissima*	Verbenaceae	Balage	Sacred groves
89	*Xantolistomentosa*	Sapotaceae	Kumbal	Sacred groves
90	*Xyliaxylocarpa*	Mimosaceae	Yerul	Sacred groves
91	*Zanthoxylumrhetsa*	Rutaceae	Tisal	Sacred groves & Vicinity
92	*Ziziphusjujuba*	Rhamnaceae	Bor	Sacred groves
Shrubs				
93	*Abelmoschus ficulneus*	Malvaceae	Ran bhendi	Sacred groves
94	*Atalantiamonophylla*	Rutaceae	Makadlimbu	Sacred groves
95	*Barleriacristata*	Acanthaceae	Koranti	Sacred groves
96	*Barleriaprattensis*	Acanthaceae	Gulabikoranti	Sacred groves
97	*Breyniaretusa*	Phyllanthaceae	Dalfodi	Sacred groves & Vicinity
98	*Butea superba*	Fabeaceae	Lata palas	Sacred groves
99	*Carissa congesta*	Apocynaceae	Karvand	Sacred groves & Vicinity
100	*Clerodendrumserratum*	Verbenaceae	Bharangi	Sacred groves & Vicinity
101	*Costusspeciosus*	Zingiberaceae	Pev	Sacred groves & Vicinity
102	*Decaschistiatrilobata*	Malvaceae	Mysore mallow	Sacred groves
103	*Derris scandens*	Fabaceae	Garudvel	Sacred groves
104	*Embeliatsjeriam-cottam*	Primulaceae	Ambati,Wavding	Sacred groves
105	*Eugenia phillyraeoides*	Myrtaceae	Ran jambhul	Sacred groves
106	*Euphorbia neriifolia*	Euphorbiaceae	Neya-dungra	Sacred groves
107	*Gardenia gummifera*	Rubiaceae	Dikemali	Sacred groves
108	*Helicteresisora*	Sterculiaceae	Murud sheng	Sacred groves
109	*Hemidesmus indicus*	Apocynaceae	Anantmul	Sacred groves
110	*Hygrophilaauriculata*	Acanthaceae	Talimkhana	Sacred groves
111	*Ixora coccinea*	Rubiaceae	Devhara	Sacred groves
112	*Justicia adhatoda*	Acanthaceae	Adulasa	Sacred groves
113	*Lantana camara*	Verbenaceae	Ghaneri	Vicinity

114	*Leeaindica*	Vitaceae	Dinda	Sacred groves & Vicinity
115	*Meynalaxiflora*	Rubiaceae	Alu	Sacred groves & Vicinity
116	*Plumbago indica*	Plumbaginaceae	Lal chitrak	Sacred groves
117	*Plumbago zeylanica*	Plumbaginaceae	Chitrak	Sacred groves
118	*Rotula aquatica*	Boraginaceae	Machim	Sacred groves
119	*Senna tora*	Caesalpiniaceae	Takala	Vicinity
120	*Solanum anguivi*	Solanaceae	Amb-keli	Sacred groves
121	*Thespesia lampas*	Malvaceae	Ran bhendi	Sacred groves & Vicinity
122	*Triumfettarhomboidea*	Tiliaceae	Jhinjhardi	Sacred groves
123	*Vitex negundo*	Verbenaceae	Nirgudi	Sacred groves & Vicinity
124	*Woodfordiafruticosa*	Lythraceae	Dhayati	Vicinity
125	*Ziziphusoenoplia*	Rhamnaceae	Burgi	Sacred groves & Vicinity
126	*Ziziphus rugosa*	Rhamnaceae	Toran	Sacred groves & Vicinity
Climbers				
127	*AbrusPrecatorius*	Fabaceae	Gunj	Vicinity
128	*Asparagus racemosus*	Asparagaceae	Shatavari	Sacred groves
129	*Cycleapeltata*	Menispermaceae	Thoralipadwal	Sacred groves & Vicinity
130	*Dalbergiahorrida*	Fabaceae	Pendgul	Sacred groves
131	*Dregeavolubilis*	Asclepiadaceae	Harandodi	Sacred groves
132	*Embeliaribes*	Primulaceae	Wavding	Sacred groves
133	*Entadarheedei*	Mimosaceae	Garambi	Sacred groves
134	*Getonia floribunda*	Combretaceae	Ukshi	Sacred groves & Vicinity
135	*Gloriosa superba*	Liliaceae	Kallavi	Sacred groves
136	*Gnetumedule*	Gnetaceae	Umbali	Sacred groves
137	*Ipomoea campanulata*	Convolvulaceae	Tamber vel	Sacred groves & Vicinity
138	*Jasminum malabericum*	Oleaceae	Jasminum	Sacred groves
139	*Moullavaspicata*	Caesalpiniaceae	Waghati	Sacred groves
140	*Mucunamonosperma*	Fabaceae	Pandharikhajkuiri	Sacred groves
141	*Mucunapruriens*	Fabaceae	Khajkhujali	Sacred groves & Vicinity
142	*Piper longum*	Piperaceae	Pimpali	Sacred groves
143	*Smilax ovalifolia*	Smilacaceae	Ghotvel	Sacred groves & Vicinity
144	*Tinosporacordifolia*	Menispermaceae	Gulvel	Sacred groves
Herbs				
145	*Adenoonindicum*	Asteraceae	Sonaki	Sacred groves
146	*Amorphophalluscommutatus*	Araceae	Mogarikand	Sacred groves
147	*Begonia concanensis*	Begoniaceae	Gajkarnika	Sacred groves
148	*Biophytumsensitivum*	Oxalidaceae	Jhajera	Sacred groves & Vicinity
149	*Celosia argentea*	Amaranthaceae	Kurdu	Sacred groves & Vicinity
150	*Ceryptocorynecognata*	Araceae	Water trumpet	Sacred groves

151	*Canscoradiffusa*	Gentianaceae	Kilvar	Sacred groves & Vicinity
152	*Crotalaria filipes*	Fabaceae	Phatphati	Sacred groves
153	*Curcuma amada*	Zingiberaceae	Ranhalad	Sacred groves
154	*Curcuma pseudomontana*	Zingiberaceae	Ran halad	Sacred groves & Vicinity
155	*Cyathoclinepurpurea*	Asteraceae	Gangotra	Sacred groves
156	*Cynarospermumasperrimum*	Acanthaceae	Dikana	Sacred groves & Vicinity
157	*Desmodiumgangeticum*	Fabaceae	Salvan	Sacred groves
158	*Ensetesuperbum*	Musaceae	Ran Kel / Chavai	Sacred groves
159	*Eranthemumroseum*	Acanthaceae	Ranaboli	Sacred groves
160	*Eriocauloneurypeplon*	Eriocaulaceae	Gend	Sacred groves
161	*Haplanthodestentaculatus*	Acanthaceae	Nilajakara	Sacred groves
162	*Haplanthodesverticillatus*	Acanthaceae	Jhankara	Sacred groves
163	*Hemigraphislatebrosa*	Acanthaceae	Morpankhi	Sacred groves
164	*Hygrophilaserpyllum*	Acanthaceae	Ran tevan	Sacred groves
165	*Impatiens minor*	Balsaminaceae	Terada	Sacred groves
166	*Pentanemaindicum*	Asteraceae	Sonkadi	Sacred groves
167	*Phyllocephalumscabridum*	Asteraceae	Parnagumphi	Sacred groves
168	*Pogostemondeccanensis*	Lamiaceae	JambhliManjiri	Sacred groves
169	*Polygonum glabrum*	polygonaceae	Marsh buckwheat	Sacred groves
170	*Smithiasalsuginea*	Fabaceae	Brackish Smithia	Sacred groves
171	*Aeridesringens*	*Orchidaceae*	Ringaniriamri	Sacred groves & Vicinity

Cluster analysis

Sacred groves were clustered on the basis of tree species composition using Bray-Curtis distance in programme Biodiversity Pro (McAleece *et al.,* 1997). It can be seen that the pairs of sacred groves similar in tree composition are also the pairs without much inter-patch distance. For example, Gavtale and Shivnari are separated by the smallest distance (1.78 km), Kudawale and Dhankoli (2.10 km), Douli and Vanzloli (3.57). This comes into perspective when it is noted that the maximum inter-patch distance is 28.02 km (Gavtale and Vanzloli). However, it must also be noted that Sakhloli and Kadivali which are relatively far apart also grouped together. A look at the raw data reveals that presence of Terminalia bellirica in relatively large numbers in these two sacred groves was a reason behind clustering them together.

On the other hand, clustering based on shrub species composition revealed no such groupings which could be correlated with the physical distance between the sacred grove. This goes on to show that while trees give peculiarity to sacred groves, shrubs are well distributed throughout the study area and cannot be used for making distinctions between sacred groves.

From both the clustering, however, it seems that Karde has a very distinct species composition which is true and owes its distinctness, perhaps, to its closeness to the coast. In Boyina *et al.,* (2011), the clustering of sacred groves and reference forest stands was attempted and it was found that the sacred groves except one clustered together. Ambinakudige and Sathish (2008) in their study of species evenness measurements indicated that all the three habitats differing in

land tenures had similar evenness. Redeemed and unredeemed coffee plots were similar in species richness abundance but were different compared to sacred groves (Fig. 9).

Rare and endemic plants

In present study we recorded total 10 rare and threatened plants and 29 endemic plants from the 11 sacred groves of Dapoli taluka (Table 1). The status of plant species as per IUCN Red List is also provided (www.iucnredlist.org). From the observations it is clear that sacred groves of Dapoli hold rich biodiversity of rare, threatened and endemic plant species. Sacred groves of Dapoli Taluka have been reported to hold important and rare floristic elements like *Entada scandens, Antiaristoxicaria, Saracaasoca* (locally rare) and also threatened species like *Cryptocoryne cognate* (Ghalme 2013, Patil 2016). Ghalame (2013)carried out an inventory for ethno-medico-botanical explorations in sacred groves of Dapoli tehsil. During his inventory he recorded 281 plant species of which there were 19 threatened and 36 endemic plant species.

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