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Macrolichen Diversity Associated with a Regenerating Sacred Grove: A Case Study From Futsil Sacred Grove, Gangolihat, Pithoragarh, Uttarakhand, India

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ABSTRACT

The present study is based on a devoted sacred site of Gangolihat, Pithoragarh which is located in Futsil village and is dominated by *Quercus leucotrichophora* trees. Since sacred sites play an important role in biodiversity conservation through socio-cultural practices and taboos, the present site was extensively surveyed for macrolichen diversity because this grove which was earlier destroyed by villagers and is now under the phase of regeneration has no data about lichens which are pioneer colonizers and best bioindicators of a given forest. A total of 38 macrolichen species belonging to16 genera and 5 families were reported from the study area. Family Parmeliaceae was the dominating family with 18 species, followed by Physciaceae (11), Collemataceae (6), Ramalinaceae (2) and Cladoniaceae (1). The baseline data generated during the present study is likely to contribute the future climate change studies by comparing the present data sets *viz*. diversity of lichens and other climatic parameters such as temperature and moisture with that of the sacred sites when it will reach its climax condition in future.

Key Words: Biodiversity; Macrolichens; Sacred Grove; Socio-cultural Activities; Taboo

INTRODUCTION

Conservation and management of biodiversity is one of the most burning issues of present time and in order to conserve biodiversity of a particular area or geographical landscape, several strategies have been developed from time to time. One of the traditional strategies by which villagers conserve and manage biodiversity through cultural and religious beliefs and taboos, is by devoting a small or larger part of forest to local deities or spiritual ancestors for a certain period of time and declaring it as *sacred grove.*

Sacred groves not only preserve the genetic diversity of the common trees (Nair et al. 1997) but are important reservoirs of indigenous plant species, particularly medicinal, aromatic and other ecologically and economically important plants (Gadgil and Vartak 1975, Hughes and Chandran 1998, Rawat 2014) and refugee for threatened and rare species (Joshi and Gadgil 1991).

Though numerous studies on various aspects of sacred groves are known from India, there are only a few from Uttarakhand (Sinha and Maikhuri 1998, Adhikari and Adhikari 2007, Bisht and Gildiyal 2007, Agnihotri et al. 2010, 2012, Anthwal et al. 2010, Negi 2010, Singh et al. 2010a,b, 2011a, 2012, 2013, Gokhale et al. 2011, Pala et al. 2012, Joshi et al. 2016) of which most were confined to higher plants. Besides these higher plants, microflora such as algae, bryophytes, lichens, pteridophytes are also a part of total biodiversity and play a significant role in forest ecosystem functioning and also needs to be assessed and conserved.

Lichens which play a very important role in ecosystem functioning, such as, forage, nesting/habitat material for animals, insects and microbes (Pike 1978, Boucher et al. 1990, Knops et al. 1991, Esseen et al. 1996); indicators of environmental pollution and ecosystem health (Upreti and Pandev 1994, Mistry 1998); traditional medicines (Upreti 1994, Gonzalez-Tejero et al. 1995); staple diet of the Himalayan musk deer (Negi 1996), have been well worked out in India, but studies pertaining with lichen diversity associated with sacred groves of India are so far limited (Nayaka and Upreti 2004, Singh et al. 2010b, Mishra and Saini 2012, Singh et al. 2012, Sen 2014, Joshi et al. 2016).

Uttarakhand well known for its several natural and sacred sites (forests and groves) (Sinha and Maikhuri 1998, Negi 2005, Anthwal et al. 2006, Agnihotri et al. 2009, 2010, Singh et al. 2010a, Gokhale and Pala 2011, Singh et al. 2011b, 2013, Negi 2014), is not well explored in context of lichen diversity associated with sacred groves (Singh et al. 2010b, 2012, Joshi et al. 2016). Hence this led authors to undertake the present study in Futsil sacred grove which is located in Pithoragarh district of Uttarakhand in order to generate the baseline data which in near future can likely contribute in assessing climate change studies by comparing the present data sets when the sacred grove will reach climax condition.

STUDY AREA

In 2014 one of the authors (SU) got the chance to visit the Futsil sacred forest site situated at Gangolihat (a small religious town situated in Pithoragarh district, Uttara-khand, about 75 km from Pithoragarh district head-quarter and 5 km from Gangolihat town). The forest which lies between 029˚40.619´ to 029˚40.682´N latitude & 80˚02.62´ to 80˚02.582´E longitude (Table 1), was lopped and ruined by the villagers for collecting fuel and fodder during 2013-2014 without any prior information to the van panchayat of the Futsil village. Hence in order to protect the forest, the village community of Futsil village decided to devote that forest to the goddess of justice 'Maa Kotgarhi' and in 2014 the forest was declared sacred by the Sarpanch and for the next five years fuel and fodder collection and grazing practices were completely banned in the forest. The forest will reopen for the Futsil village community after five years and some particular rules will be framed out for utilizing the forest resources so that the forest will sustain for a longer period of time and will continuously provide ecosystem services to the village community.

METHODS

Semi-structured questionnaire and interview-based methods were used to collect the information about Futsil sacred grove and the taboos which are prevalent in that sacred grove.

Lichen Sample Collection

Some of us (SU, KB and PJ) visited the Futsil Sacred site for lichen sampling in the month of May 2015 with prior permission from village representatives to know whether the lichens have started appearing in the forest. Three sites each of 50 × 50 m (2500 m^2) were selected and trees, soil and rock falling within the sites were selected as substrate/hosts for macrolichen sampling. Thirty 5 × 10 cm (50 cm^2) quadrats were laid in each of the four corners and 30 in the centre of the plot on tree trunk of the host trees, on soil and on rocks. A total of 450 quadrats were laid in the three study sites. All the individuals of macrolichens falling in quadrats were collected. Circumference at breast height of host trees was measured at 1.37 m above the ground level to assess their impact on macrolichen diversity. The collected samples were packed in poly bags and brought to the laboratory where they were air dried. The geo-coordinates of the area were recorded with a hand-held GPS (Garmin eTrex30).

Lichen sample identification

Lichens were identified on the basis of morphological characters of the thallus, reproductive structures, colour, size and shape under stereo-zoom dissecting microscope (SZ2-ILST OLYMPUS). Anatomy of the thallus and fruiting bodies was studied by cutting thin sections under stereo-zoom dissecting micro-scope and examining under compound microscope (B -150 DB OPTIKA). Spot tests were performed with the help of standard reagents: K (10% KOH solution), C (aqueous solution of sodium or calcium hypochlorite) and Pd (para-phenylenediamine). Thin Layer Chromatography of samples followed Orange et al. (2001). Lichen samples were identified with the help of published literature (Divakar and Upreti 2005, Awasthi 2007, Singh and Sinha 2010). The samples were deposited in the personal herbarium of Yogesh Joshi.

Statistical Analysis

Macrolichen assemblages were quantitatively analysed for density, frequency and abundance (Curtis and McIntosh 1950, Pinokiyo et al. 2008). The Importance Value Index (IVI) for the macrolichens was determined as the sum of the relatiusilve frequency and relative density. Relative frequency and relative density were determined following Phillips (1959). The ratio of abundance and frequency was used to interpret the distribution pattern of the species (Whitford 1949). If the value comes below 0.025 then it indicates regular distribution, falls between 0.025-0.05 then randomly distributed and if >0.05 then contagiously distributed (Curtis and Cottam 1956). Alpha diversity (H′) was estimated as the Shannon-Weiner index (Shannon and Weaver 1949) for the establishment of alternative estimates of species diversity in three sites of Futsil sacred grove. Cluster analysis between all the recorded macrolichen species were performed on the basis of their importance value index and number of individuals by using PAST software (Hammer et al. 2001).

RESULTS AND DISCUSSION

During this study 317 specimens from 450 laid quadrats were reported, which showed the occurrence of 38 species of macrolichens belonging to 16 genera and 5 families in three sites of Futsil sacred grove. Family Parmeliaceae was the dominating family with 18 species, followed by Physciaceae (11), Collemataceae (6), Ramalinaceae (2) and Cladoniaceae (1) [Table 2]. Site second showed the maximum alpha diversity (0.158; 19 species) but the maximum species richness of macrolichens was shown by first site which had the second highest alpha diversity (0.157; 29 species) followed by site third (0.148; 19 species; Table 1). All the sites have equal importance value index of macrolichens (Table 1).

The first site had the maximum number of individuals (137) followed by second (104) and third (76). *Parmotrema reticulatum* had the maximum importance value and number of individuals (35.9 and 45, respectively) followed by *Heterodermia diademata* (33.8 and 48, respectively), *P. hababianum* (22.4 and 31, respectively) and others (Table 2). Minimum importance value and number of individuals were shown by *Collema auriforme, Heterodermia albidiflava, H. obscurata, P. austrosinense, P. indicum, Phaeophyscia endococcina, Punctelia rudecta* and *Usnea himalayana* (1.27 and 1, respectively).

On the basis of number of individuals and their importance value index, all the species were grouped into three clusters (Figure 1). The first cluster represents two species i.e. *H. diademata* & *P. reticulatum*, and the cluster II represent 31 macrolichen species, while the cluster III represents remaining five macrolichen species (Figure 1).

Thirty-four species of macrolichens were contagiously distributed and the other 4 species were randomly distributed (Table 2). However, no species was found with regular distribution in the studied sacred grove.

Since the extent of biodiversity conservation through sacred sites is least practiced in India and this very few number of macrolichens from a very small recently declared sacred forest (approx. 3 ha) led us to think that, this number could be different if the forest had remained intact and this number will definitely rise as the forest is being declared a sacred site and is protected from anthropogenic activities.

The sacred sites in Uttarakhand are smaller in size but larger in number; hence, they can contribute a big role in biodiversity conservation. By conserving sacred sites we can directly conserve biodiversity in small parts throughout the world. With the help of biosphere reserves, wild life sanctuaries, national parks we can conserve biodiversity in state or national level, but sacred sites act directly at the grass root level i.e. at regional levels by involving local peoples and is also a cost effective management practice. What all we need to do is just declare a small part of forest as sacred and leave it undisturbed, and let the nature nourish and protect it her own way. The same was witnessed by us in the case of Futsil village; a forest that has been trespassed earlier has now started regenerating bearing the primary colonizers of the earth i.e. lichens, after being declared as sacred. Since lichens are considered the best indicators of climate change and forest health, by monitoring lichen diversity in this sacred forest can tell a lot about the changing climatic conditions and forest health. At this time the forest is in juvenile state, after passes of time when it will achieve its climax state, the diversity of lichens may get changed, this can led to climate change studies in future.

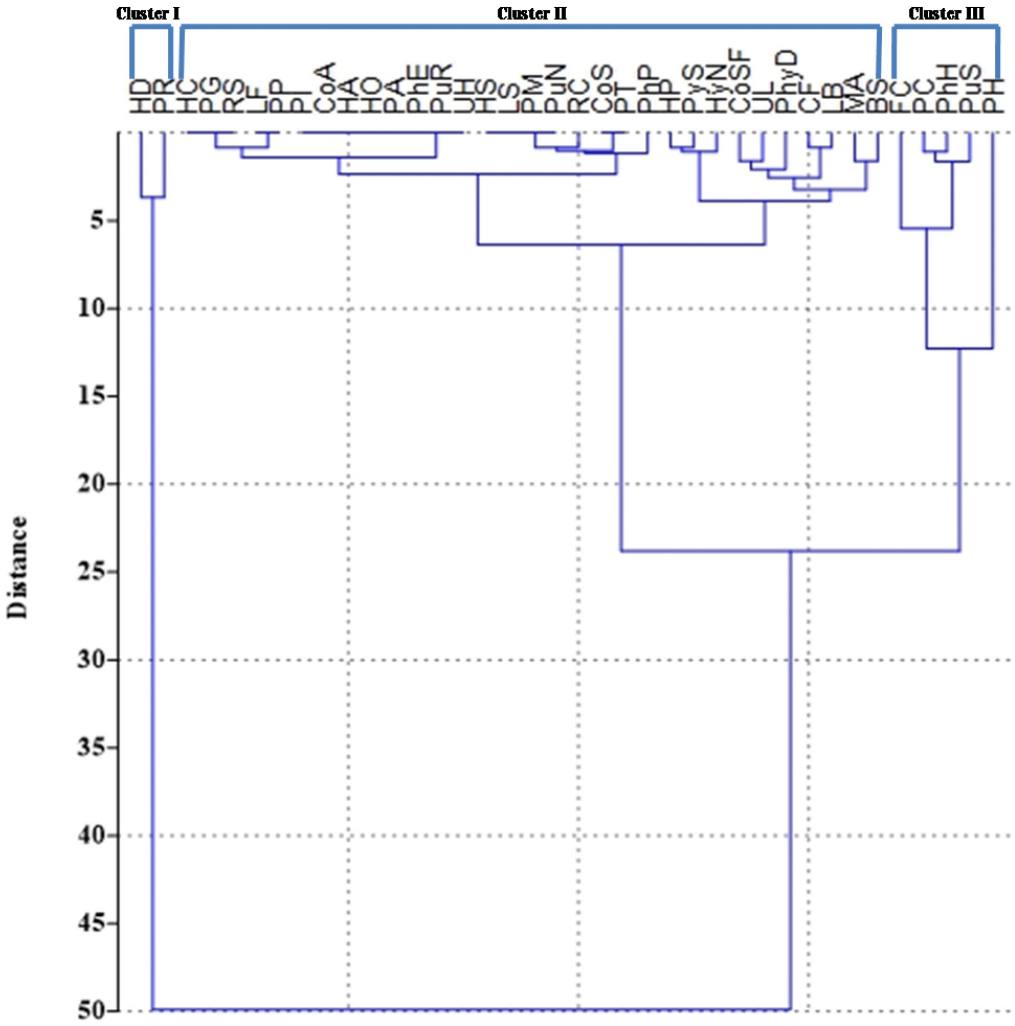

Figure 1. Hierarchal clustering between the macrolichen species with respect to their importance value index and number of individuals. (Note: HD- *Heterodermia diademata*, PR- *Parmotrema reticulatum*, HC- *Heterodermia comosa*, PG- *Parmotrema grayanum*, RS- *Ramalina sinensis*, LF- *Leptogium fallax*, PP- *Parmotrema praesorediosum*, PI- *Parmotrema indicum*, CoA- *Collema aureforme*, HA- *Heterodermia albidiflava*, HO- *Heterodermia obscurata*, PA- *Parmotrema austrosinense*, PhE- *Phaeophyscia endococcina*, PuR- *Punctelia rudecta*, UH- *Usnea himalayana*, HS- *Heterodermia speciosa*, LS- *Leptogium* sp., PM- *Parmotrema melanothrix*, PuN- *Punctelia neutralis*, RC- *Ramalina conduplicans*, CoS- *Collema* sp., PT- *Parmotrema tinctorum*,PhP- *Phaeophyscia pyrrhophora*, HP- *Heterodermia podocarpa*, PyS- *Pyxine sorediata*, HyN- *Hypotrachyna nepalensis*, CoSF- *Collema subflaccidum*, UL- *Dolichousnea longissima*, PhyD- *Physcia dilatata*, CF- *Cladonia fimbriata*, LB- *Leptogium burnetiae*, MA- *Myelochroa aurulenta*, BS- *Bulbothrix setschwanensis*, FC- *Flavoparmelia caperata*, PC- *Parmotrema crinitum*, PhH- *Phaeophyscia hispidula*, PuS- *Punctelia subrudecta*, PH- *Parmotrema hababianum*)

Table 1. Qualitative and quantitative characters of Futsil sacred grove of Kumaun Himalaya

Sites	Altitude (m)	Latitude (N)	Longitude (E)	Slope	Aspect	SR	NI	H'	RIVI
1	1707	80°02.62'	029°40.619'	35°	East	29	137	0.157	100
2	1746	80°02.720'	029°40.614'	40°	East-North	19	104	0.158	100
3	1818	80°02.582'	029°40.682'	35°	East-South	19	76	0.148	100

Note: SR- Species richness (number of species), NI- Number of individuals, H'- Alpha diversity, RIVI- Relative Importance value index.

Table 2. Diversity and distribution pattern of macrolichens with their quantitative characters in all the studied sites of Futsil Sacred grove of Kumaun Himalaya

SN	Species	Abbrev	Family	Ni	D	F	A	A/F	DP	H'	IVI
1	*Bulbothrix setschwanensis* (Zahlbr.) Hale	BS	Parmeliaceae	7	0.23	20	1.17	0.06	C	0.084	8.03
2	*Cladonia fimbriata* (L.) Fr.	CF	Cladoniaceae	9	0.3	10	3	0.3	C	0.101	6.33
3	*Collema auriforme* (With.) Coppins & J.R. Laundon	CoA	Collemataceae	1	0.03	3.33	1	0.3	C	0.018	1.27
4	*Collema* sp.	CoS	Collemataceae	3	0.1	10	1	0.1	C	0.044	3.81
5	*C. subflaccidum* Degel.	CoSF	Collemataceae	7	0.23	3.33	7	2.1	C	0.084	3.79
6	*Dolichousnea longissima* (Ach.) Articus	UL	Parmeliaceae	8	0.27	6.67	4	0.6	C	0.093	5.06
7	*Flavoparmelia caperata* (L.) Hale	FC	Parmeliaceae	24	0.8	20	4	0.2	C	0.195	15.2
8	*Heterodermia albidiflava* (Kurok.) D.D.Awasthi	HA	Physciaceae	1	0.03	3.33	1	0.3	C	0.018	1.27
9	*H. comosa* (Eschw.) Follmann & Redón	HC	Physciaceae	2	0.07	6.67	1	0.15	C	0.032	2.54
10	*H. diademata* (Taylor) D.D. Awasthi	HD	Physciaceae	48	1.6	53.3	3	0.06	C	0.286	33.8
11	*H. obscurata* (Nyl.) Trevis.	HO	Physciaceae	1	0.03	3.33	1	0.3	C	0.018	1.27
12	*H. podocarpa* (Bél.) D.D. Awasthi	HP	Physciaceae	5	0.17	13.3	1.25	0.09	C	0.065	5.5
13	*H. speciosa* (Wulfen) Trevis.	HS	Physciaceae	3	0.1	6.67	1.5	0.23	C	0.044	2.96
14	*Hypotrachyna nepalensis* (Taylor) Divakar, A. Crespo, Sipman, Elix & Lumbsch	HyN	Parmeliaceae	4	0.13	13.3	1	0.08	C	0.055	5.08
15	*Leptogium burnetiae* C.W. Dodge	LB	Collemataceae	9	0.3	13.3	2.25	0.17	C	0.101	7.18
16	*L. fallax* Müll. Arg.	LF	Collemataceae	2	0.07	3.33	2	0.6	C	0.032	1.69
17	*Leptogium* sp.	LS	Collemataceae	3	0.1	6.67	1.5	0.23	C	0.044	2.96
18	*Myelochroa aurulenta* (Tuck.) Elix & Hale	MA	Parmeliaceae	8	0.27	23.3	1.14	0.05	B	0.093	9.3
19	*Parmotrema austrosinense* (Zahlbr.) Hale	PA	Parmeliaceae	1	0.03	3.33	1	0.3	C	0.018	1.27
20	*P. crinitum* (Ach.) M. Choisy	PC	Parmeliaceae	20	0.67	33.3	2	0.06	C	0.174	16.9
21	*P. grayanum* (Hue) Hale	PG	Parmeliaceae	2	0.07	6.67	1	0.15	C	0.032	2.54
22	*P. hababianum* (Gyeln.) Hale	PH	Parmeliaceae	31	1.03	36.7	2.82	0.08	C	0.227	22.4
23	*P. indicum* Hale	PI	Parmeliaceae	1	0.03	3.33	1	0.3	C	0.018	1.27
24	*P. melanothrix* (Mont.) Hale	PM	Parmeliaceae	3	0.1	6.67	1.5	0.23	C	0.044	2.96
25	*P. praesorediosum* (Nyl.) Hale	PP	Parmeliaceae	2	0.07	3.33	2	0.6	C	0.032	1.69
26	*P. reticulatum* (Taylor) M. Choisy	PR	Parmeliaceae	45	1.5	66.7	2.25	0.03	B	0.277	35.9
27	*P. tinctorum* (Despr. ex Nyl.) Hale	PT	Parmeliaceae	3	0.1	10	1	0.1	C	0.044	3.81
28	*Phaeophyscia endococcina* (Körb.) Moberg	PhE	Physciaceae	1	0.03	3.33	1	0.3	C	0.018	1.27
29	*P. hispidula* (Ach.) Essl.	PhH	Physciaceae	19	0.63	36.7	1.73	0.05	B	0.169	17.3
30	*P. pyrrhophora* (Poelt) D.Awasthi & M.Joshi	PhP	Physciaceae	4	0.13	6.67	2	0.3	C	0.055	3.38
31	*Physcia dilatata* Nyl.	PhD	Physciaceae	7	0.23	13.3	1.75	0.13	C	0.084	6.34
32	*Punctelia neutralis* (Hale) Krog	PuN	Parmeliaceae	3	0.1	6.67	1.5	0.23	C	0.044	2.96
33	*P. rudecta* (Ach.) Krog	PuR	Parmeliaceae	1	0.03	3.33	1	0.3	C	0.018	1.27
34	*P. subrudecta* (Nyl.) Krog	PuS	Parmeliaceae	18	0.6	40	1.5	0.04	B	0.163	17.7
35	*Pyxine sorediata* (Ach.) Mont.	PyS	Physciaceae	5	0.17	10	1.67	0.17	C	0.065	4.65
36	*Ramalina conduplicans* Vain.	RC	Ramalinaceae	3	0.1	3.33	3	0.9	C	0.044	2.11
37	*R. sinensis* Jatta	RS	Ramalinaceae	2	0.07	6.67	1	0.15	C	0.032	2.54
38	*Usnea himalayana* C. Bab.	UH	Parmeliaceae	1	0.03	3.33	1	0.3	C	0.018	1.27

Note: Ni- number of individuals, D- density, F- frequency, A/F- Abundance & Frequency ratio, DP- distribution pattern, A- regular (<0.025), B- random (0.025 to 0.05), C- contagious (>0.05), IVI- Importance value index.

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