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DIVERSITY, DISTRIBUTION AND ABUNDANCE OF LICHEN IN SIMILIPAL BIOSPHERE RESERVE, ODISHA

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ABSTRACT

Lichens are organized symbionts that have their importance due to a potential indicator of the forest ecosystem. The lichen diversity of Odisha is not well explored as compared to the other phytogeographical region of India. Though the earlier study reported the occurrence of 252 lichen species from different parts of the state, it was limited to the northeast part of the Similipal Biosphere Reserve (SBR). The objective of the present study was to survey some unexplored areas of SBR, which revealed the occurrence of 84 species of lichens belonging to 38 families and 18 genera. Most of the lichens were found growing as phorophytes on the matured bark of the trees. The western part of the SBR is rich in lichen diversity as compared to the eastern part. Species frequency was found to be highest in the southwest part of the SBR, while the density and abundance were more or less similar within all the study sites. The correlation between frequency and density was found to be significant and insignificant between frequency and abundance.

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1 Introduction

Lichens are the example of the symbiotic association between one fungus (ascomycetes or basidiomycetes) and one alga or cyanobacterium leading to the formation of self-sustaining life forms. The fungal hyphae absorb the required nutrients from the substratum while the algal cells synthesize food through photosynthesis (Weerakoon & Aptroot, 2016). The world lichen biota is represented by more than 20,000 species (Galloway, 2008) out of which 2714 species are reported from India (Sinha et al., 2018). Indian phytogeographical regions have been divided into 8 categories (Figure 1), among which Eastern Himalayas recorded for 1286 species which is highest as compared to other phytogeographic regions (Shukla et al., 2014). Odisha is coming under central India and the Eastern Ghats. However, the diversity-related to lichen of Odisha is scantily available. According to the work compiled by Nayak et al. (2016), the lichen flora of Odisha is represented by 252 species belonging to 81 genera under 35 families. The study of lichen diversity has been done in different districts of Odisha including Jharsuguda (Upreti, 1996; Das et al., 2018), Khurdha (Satapathy et al., 2016; Pradhan et al., 2020), Kendrapara (Panda et al., 2017), Gajapati (Swarnalatha, 2017), Puri (Nayak et al., 2017; Majhi & Pradhan, 2020), Jajpur (Nayak et al., 2018), Angul (Mishra et al., 2020) and Dhenkanal (Nayak et al., 2015). Mayurbhanj is the largest district of Odisha according to the land area, mostly covered with the forest canopy. The Similipal Biosphere Reserve covers almost half of the geographical area of the Mayurbhanj district and is spread over an area of 5569 km^2, which comprises dense forested hills and valleys with dry deciduous vegetation (Pradhan et al., 2021). On average, the area receives 1800mm annual rainfall with a temperature variation of a minimum of 3°C to a maximum of 38°C during winter and summer respectively. The areas near streams with low elevation have trees such as *Syzygium cumini*, *Pongamia pinnata*, *Diospyros peregrina*, *Saraca asoca*, and *Terminalia arjuna*. The elevated and moist areas are covered with *Bombax ceiba*, *Alstonia scholaris*, *Madhuca indica*, and *Dalbergia sissoo*. However, *Shorea robusta* was observed to be the dominant tree species in both lowlands and tiny hillocks. The earlier report indicated the occurrence of 141 species from the northwest part of the Similipal Biosphere Reserve (Singh & Kamal, 2012; Sahoo & Pradhan, 2020; Pradhan & Satapathy, 2020). The community forest area of Udala, which is situated outside of SBR reported the occurrence of 22 lichen species (Pradhan et al., 2018). In the present study, different unexplored localities of Similipal Biosphere Reserve have been surveyed for the determination of their lichen diversity.

2 Materials and Methods

2.1 Study area

Similipal Biosphere Reserve lies between 21°28' and 22°08' N latitudes and 86°04' to 86°37' E longitudes in Mayurbhanj district of Odisha. Brundeiposi, Kaliani, Talabandh, Devkund, and Karkatbeda area of Similipal Biosphere Reserve were systematically surveyed and samplings were done (Figure 2).

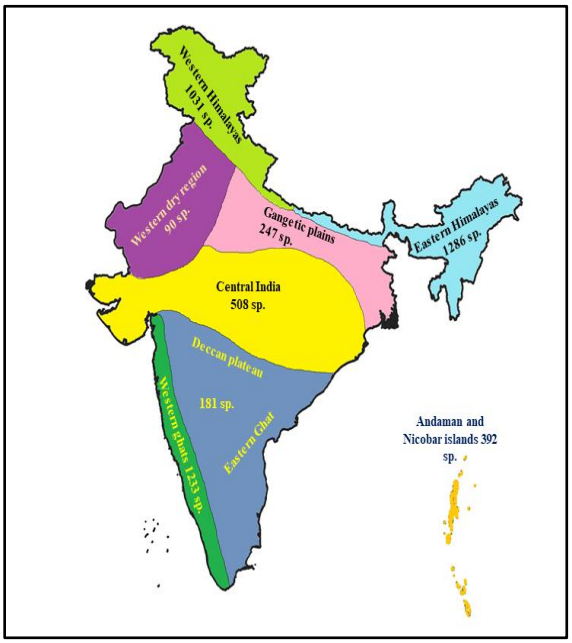

Figure 1 Number of lichen species recorded from different phytogeographical regions of India

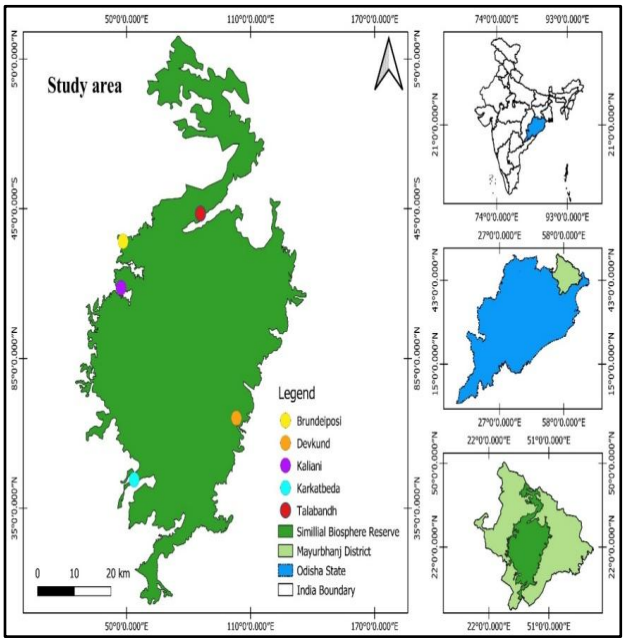

Figure 2 Map with survey sites situated within the Similipal Biosphere Reserve

Table1 Lichen diversity of Similipal Biosphere Reserve (SBR) in Mayurbhanj district of Odisha

Sl. No.	Lichen taxa	G.F.	S	Survey Sites					Herbarium (LWG)
				BS	KN	KD	TD	DK	
	Arthoniaceae								
1.	*Arthothelium abnorme* (Ach.) Müll. Arg.	C	B	-	-	-	+	-	45332
2.	*Arthothelium confertum* (A.L. Sm.) Makhija & Patw.	C	B	-	+	-	-	-	48622
3.	*Coniocarpon cinnabarinum* DC	C	B	+	-	+	+	+	45046
4.	*Cryptothecia effusa* (Müll. Arg.) R. Sant.	C	B	+	+	-	-	-	48589
5.	*Cryptothecia lunulata* (Zahlbr.) Makhija & Patw.	C	B	-	+	-	-	-	45371
6.	*Cryptothecia multipunctata* Jagad. Ram, G.P. Sinha & Kr.P. Singh	C	B	-	+	+	-	-	45316
7.	*Cryptothecia striata* G.Thor	C	B	-	-	+	-	-	45134
8.	*Cryptothecia subtecta* Stirt.	C	B	+	+	-	-	-	48587
9.	*Herpothallon isidiatum* Jagad. Ram & G.P. Sinha	C	B	+	+	+	-	-	45203
10.	*Herpothallon philippinum* (Vain.) Aptroot & Lücking	C	B	+	+	+	-	-	45208
	Caliciaceae								
11.	*Amandinea montana* (H. Magn.) Marbach	C	B	+	+	-	-	-	44953
12.	*Cratiria obscurior* (Stirt.) Marbach & Kalb	C	R	+	+	+	-	-	45074
13.	*Dirinaria aegialita* (Afzel. ex Ach.) B.J. Moore	F	B	+	+	+	+	-	45069
14.	*Dirinaria applanata* (Fée) D.D. Awasthi	F	B	-	+	-	+	-	45140
15.	*Dirinaria consimilis* (Stirt.) D.D. Awasthi	F	B	+	-	-	-	-	45368
16.	*Pyxine coccifera* (Fée) Nyl.	F	B	-	-	+	-	-	45249
17.	*Pyxine cocois* (Sw.) Nyl.	F	B	-	+	-	-	-	45157
18.	*Pyxine consocians* Vain.	F	R	+	-	-	-	-	45248
19.	*Pyxine reticulata* (Vain.) Vain.	F	B	-	+	+	-	-	50078
	Chrysotrichaceae								
20.	*Chrysothrix candelaris* (L.) J.R. Laundon	C	B	-	-	-	-	+	45005
	Collemataceae								
21.	*Leptogium austroamericanum* (Malme) C.W. Dodge	F	B	-	-	-	+	-	45336
	Graphidaceae								
22.	*Diorygma hieroglyphicum* (Pers.) Staiger & Kalb	C	B	+	+	+	-	-	45182
23.	*Diorygma junghuhnii* (Mont. & Bosch) Kalb, Staiger & Elix	C	B	+	+	+	+	-	45177
24.	*Diorygma rufosporum* (Patw. & C.R. Kulk.) B.O. Sharma & Makhija	C	B	+	+	+	-	-	45167
25.	*Diorygma soozanum* (Zahlbr.) M. Nakan. & Kashiw.	C	B	+	+	-	-	+	45180
26.	*Dyplolabia afzelii* (Ach.) A. Massal.	C	B	+	-	-	-	-	44913
27.	*Fissurina comparimuralis* Staiger	C	B	-	+	-	-	-	48621
28.	*Glyphis cicatricosa* Ach.	C	B	-	-	-	-	+	44911
29.	*Graphis ajarekarii* Patw. & C.R. Kulk.	C	B	-	-	+	+	-	48562

Sl. No.	Lichen taxa	G.F.	S	Survey Sites					Herbarium (LWG)
				BS	KN	KD	TD	DK	
30.	*Graphis albidofarinacea* Adaw. & Makhija	C	B	-	+	-	-	-	45075
31.	*Graphis caesiella* Vain.	C	B	+	-	-	-	-	45387
32.	*Graphis capillacea* Stirt.	C	B	-	+	-	-	-	48566
33.	*Graphis chlorotica* A. Massal.	C	B	-	-	+	-	-	45315
34.	*Graphis elegans* (Borrer ex Sm.) Ach.	C	B	-	-	+	-	-	44964
35.	*Graphis furcata* Fée	C	B	-	-	-	-	+	48612
36.	*Graphis glaucescens* Fée	C	B	-	+	-	-	-	48618
37.	*Graphis lineola* Ach.	C	B	-	-	+	-	-	50083
38.	*Graphis proserpens* Vain.	C	B	-	-	-	+	-	48613
39.	*Graphis scripta* (L.) Ach.	C	B	-	+	+	-	-	45011
40.	*Phaeographis endophaeiza* (Stirt.) Zahlbr.	C	B	+	+	+	+	+	45033
41.	*Sarcographa labyrinthica* (Ach.) Müll. Arg.	C	B	-	-	+	-	-	44912
	Haematommataceae								
42.	*Haematomma puniceum* (Ach.) A. Massal.	C	B	-	+	-	-	-	45130
	Lecanoraceae								
43.	*Lecanora achroa* Nyl.	C	B	+	+	+	-	+	44914
44.	*Lecanora helva* Stizenb.	C	B	-	+	+	-	-	44947
45.	*Lecanora interjecta* Müll. Arg.	C	B	-	-	-	+	-	48629
46.	*Lecanora perplexa* Brodo	C	B	+	+	+	+	-	48582
47.	*Lecanora tropica* Zahlbr.	C	B	-	+	-	-	-	44951
48.	*Lecidella enteroleucella* (Nyl.) Hertel	C	R	+	+	-	+	+	45231
	Letrouitiaceae								
49.	*Letrouitia leprolyta* (Nyl.) Hafellner	C	B	-	+	+	-	-	44943
50.	*Letrouitia transgressa* (Malme) Hafellner & Bellem.	C	B	+	+	+	+	+	45262
	Parmeliaceae								
51.	*Bulbothrix isidiza* (Nyl.) Hale	F	B	+	+	+	+	-	45050
52.	*Parmotrema praesorediosum* (Nyl.) Hale	F	R	+	+	+	+	-	45084
53.	*Parmotrema reticulatum* (Taylor) M. Choisy	F	B	+	-	-	-	-	45191
54.	*Parmotrema saccatilobum* (Taylor) Hale	F	B	+	+	+	-	-	45338
55.	*Parmotrema tinctorum* (Despr. ex Nyl.) Hale	F	B	+	+	+	-	+	45103
	Pertusariaceae								
56.	*Lepra leucosora* (Nyl.) Hafellner	C	B	-	+	-	-	-	45152
57.	*Pertusaria cinchonae* Müll. Arg.	C	B	+	-	+	-	-	48554
58.	*Pertusaria concinna* Erichsen	C	B	+	-	-	-	-	45281
59.	*Pertusaria indica* Preeti Srivast. & D.D. Awasthi	C	B	-	-	-	+	-	48554

Sl. No.	Lichen taxa	G.F.	S	Survey Sites					Herbarium (LWG)
				BS	KN	KD	TD	DK	
60.	*Pertusaria leioplacella* Nyl.	C	B	-	+	-	-	-	45399
61.	*Pertusaria leucostoma* (Ach.) A. Massal.	C	B	+	+	+	+	+	48552
62.	*Pertusaria punctata* Nyl.	C	B	-	+	+	-	-	45396
63.	*Pertusaria quassiae* (Fée) Nyl.	C	B	+	+	-	-	-	45290
	Petulaceae								
64.	*Peltula euploca* (Ach.) Poelt	C	R	+	-	-	-	-	45339
	Physciaceae								
65.	*Heterodermia diademata* (Taylor) D.D. Awasthi	F	B	-	+	-	-	-	45078
66.	*Heterodermia obscurata* (Nyl.) Trevis.	F	B	+	-	-	-	-	45125
67.	*Heterodermia speciosa* (Wulfen) Trevis.	F	B	-	+	-	-	-	45077
68.	*Physcia caesia* (Hoffm.) Fürnr.	F	B	+	+	-	-	-	45016
69.	*Physcia sorediosa* (Vain.) Lynge	F	B	-	+	+	-	-	45322
70.	*Rinodina oxydata* (A. Massal.) A. Massal.	C	R	-	+	-	-	+	45337
	Pyrenulaceae								
71.	*Pyrenula leucotrypa* (Nyl.) Upreti	C	B	+	-	-	-	-	45019
72.	*Pyrenula nitida* (Weigel) Ach.	C	B	-	-	+	-	-	45347
	Ramalinaceae								
73.	*Bacidia alutacea* (Kremp.) Zahlbr.	C	B	-	-	+	-	+	44978
74.	*Bacidia convexula* (Müll. Arg.) Zahlbr.	C	B	-	+	-	-	-	48617
75.	*Bacidia millegrana* (Taylor) Mill. Zahlbr.	C	B	+	-	-	-	-	44983
76.	*Bacidia submedialis* (Nyl.) Zahlbr	C	B	-	+	-	-	+	44982
77.	*Bacidina medialis* (Tuck. ex Nyl.) Kistenich, Timdal, Bendiksby & S. Ekman	C	B	-	+	-	-	-	48611
	Ramboldiaceae								
78.	*Ramboldia russula* (Ach.) Kalb, Lumbsch & Elix	C	B	+	-	-	-	-	45333
	Stereocaulaceae								
79.	*Lepraria incana* (L.) Ach.	C	B	+	-	-	-	-	48631
	Teloschistaceae								
80.	*Caloplaca bassiae* (Ach.) Zahlbr.	C	B	-	-	+	-	-	45331
81.	*Caloplaca orissensis* (Räsänen) D.D. Awasthi	C	R	-	-	-	-	+	50057
	Trypetheliaceae								
82.	*Marcelaria benguelensis* (Müll. Arg.) Aptroot, Nelsen & Parnmen	C	B	+	+	+	-	-	44905
83.	*Nigrovothelium tropicum* (Ach.) Lucking, M.P. Nelsen & Aptroot	C	B	+	+	+	-	+	44904
84.	*Trypethelium eluteriae* Spreng.	C	B	-	+	-	-	+	44902

BS - Brundeipoisi, KN - Kaliani, KD - Karkatbeda,TD - Talabandh, DK - Devkund; S- Substratum, B - Bark, R - Rock; G.F. - Growth form, C- Crustose, F - Foliose; + Present, - Absent

2.2 Methodology

The survey was conducted during the period from July 2019 to June 2020. The sample plot was 10×10 m^2 according to the access of undulating terrain of the field condition. From each site, 10 quadrates plots were placed for the collection and documentation of lichen samples. The epiphytic and epilithic species were collected by using a chisel and hammer from the bark and rocks and documented properly for future reference. The samples were kept in polythene zipper bags and transported to the lab for analysis. The specimens were identified morphologically using a stereo-zoom microscope at 40X (Leica S8APO), anatomically under a compound microscope at 100X (Leica DM2500), and chemically following the available literature (Awasthi, 1991, 2000, 2007; Divakar & Upreti, 2005; Joshi, 2008). Secondary metabolites were detected through thin layer chromatography (TLC) in solvent system C (Orange et al., 2001).

2.3 Statistical analysis

The statistical analysis for frequency, density, and abundance of species at different study sites was done by using MS-Excel (2010) and the correlation was done by PAST software. The calculation of frequency (%) was carried out by the following formula (Sharma, 2005; Basistha et al., 2010).

$$\text{Frequency (F)} = \frac{\text{Number of quadrats in which a species occurs}}{\text{Total number of quadrats sample}} \times 100$$

The density and abundance were carried out by the following formulae:

$$\text{Density (D)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$$

$$\text{Abundance (A)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which species occured}}$$

$$\text{Jaccard's similarity index } (C_j) = \frac{a}{a+b+c}$$

Where a - Number of species common to both sites, b - Number of species present in site B but not in A, c - Number of species present in site A but not in B.

3 Results and Discussion

A total of 84 species of lichens were found in the present study (Table 1) which belong to 38 genera and 18 families. The family Graphidaceae was found to be most dominant represented by 20 species followed by Arthoniaceaere presented by 10 numbers of species (Figure 3), which is similar to studies conducted in Western Ghats of India (Nayaka & Upreti, 2005), Peru (Plata & Lücking, 2013) and amazon rain forest of Brazil (Caceres et al., 2014). Based on genera, *Graphis* is found to be the most dominant followed by *Pertusaria* represented by 11 and 7 numbers of species respectively similar to the studies in northern Assam (Rout et al., 2010) and Mexico (Córdova-Chávez et al., 2014). Epiphytic species dominated the study area, growing on barks of matured as well as young trees represented by 77 numbers of species followed by epilithic species represented by only 7 numbers of species. The area was found to be dominated by a crustose form of lichens followed by foliose lichens which are represented by 66 and 18 numbers of species respectively. Based on growth form Kaliani (KN) which is situated in the north-west region of the SBR, found to be enriched with both crustose and foliose lichens represented by 39 and 12 species respectively, while Devkund (DK) which is present in the south-east part of SBR registered the least diversity both for crustose and foliose forms represented by 16 and 1 species respectively (Figure 4).

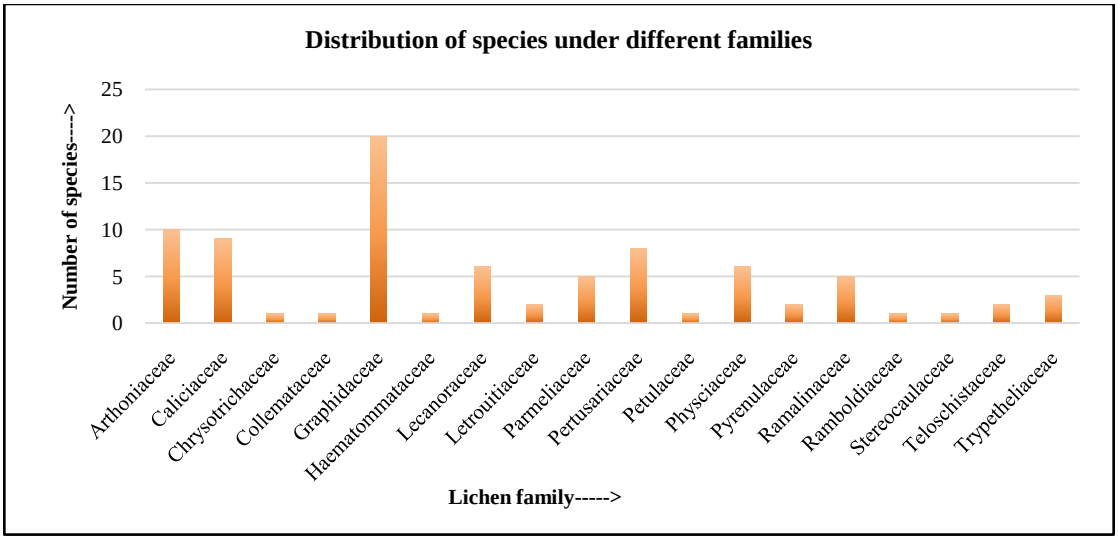

Figure 3 Lichen distributions under different families

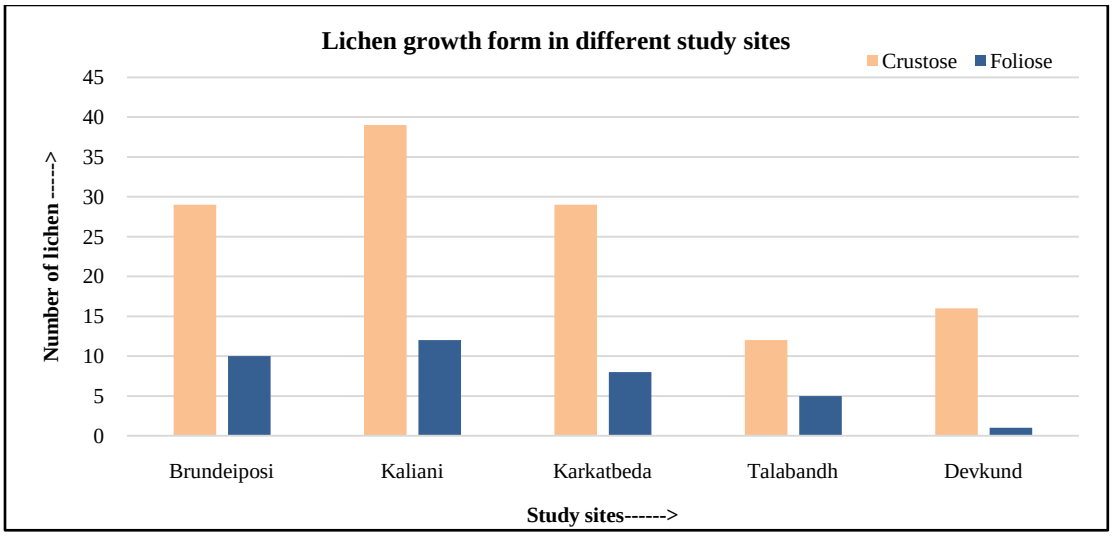

Figure 4 Growth of lichen forms in different study sites

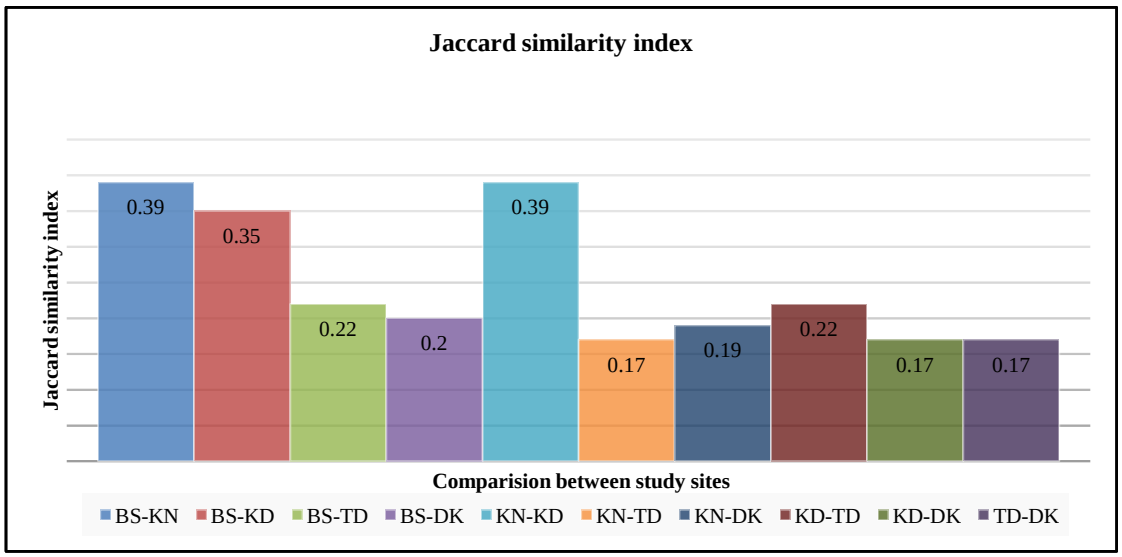

Figure 5 Jaccard's similarity index of recordedlichen species collected from different localities of Similipal Biosphere Reserve

The Jaccard's similarity index (C_j) indicated that the study sites which are situated in the western part of SBR are more similar to each other's species distribution, as the similarity index was found to be 0.39 both for BS-KN and KN-KD (Figure 5). However, it (C_j) was found least, similar between the study sites of KN-TD, KD-DK, and TD-DK. The values of the similarity index indicated that the western part of the SBR is having more or less similar species composition due to similar ecological structure (Mishra et al., 2008; Leinster & Cobbold, 2012; Suárez-Mota et al., 2015; Oluyinka Christopher, 2020; Hidasi-Neto et al., 2020). The statistical analysis result shows the maximum frequency and density of lichens observed at Karkatbeda (KD) and least observed in Talabandh (TD) (Figure 6), which could be due to the dense forest canopy at the south-west part of the Similipal Biosphere Reserve as compared to the north-east, as suggested by the earlier studies (Pipp, 1998; Dymytrova et al., 2014; Wolseley et al., 2017). The density of lichens revealed a very minute difference in all the study sites selected, while abundance showed that the sites are more or less similar to each other. The diversity of lichen species is more in Brundeiposi, Kaliani, and Karkatbeda, as compared to Devkund and Talabandh, which can be correlated to the anthropogenic disturbances due to high tourist pressure in the eastern part of the Similipal Biosphere Reserve (Stevens, 1979; Shukla et al., 2014). The correlation between frequency and density was found to be significant, while it was insignificant between frequency and abundance at the level $p > 0.05$ (Figure 7).

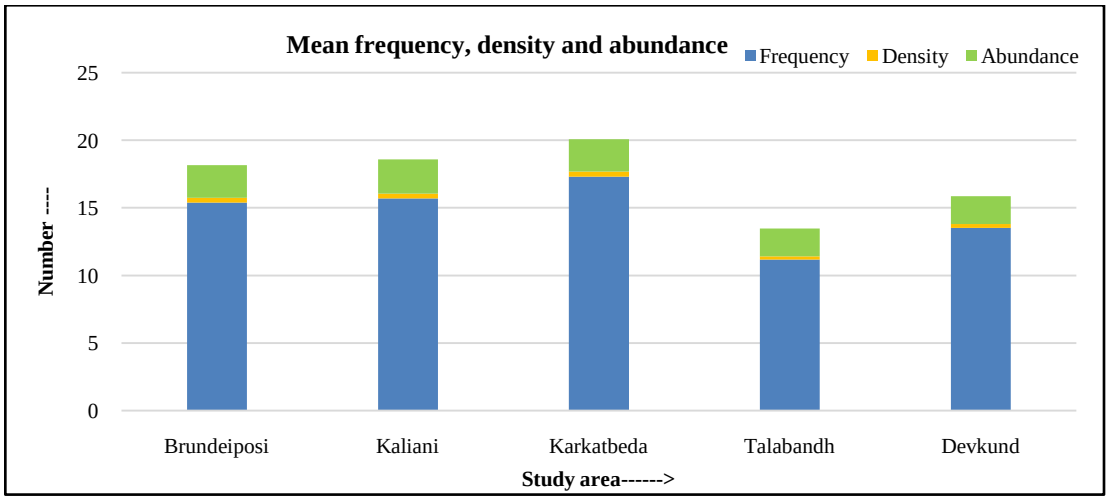

Figure 6 Species distribution pattern at different localities surveyed in Similipal Biosphere Reserve

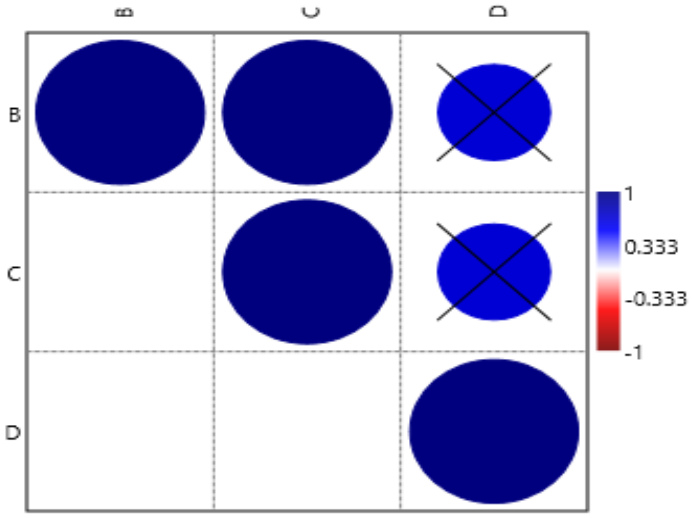

Figure 7 Correlation between frequency (B), density (C) and abundance (D) of lichen from different study sites

Conclusion

The present survey though revealed the lichen richness of the Similipal Biosphere Reserve, more intensive study in other unexplored areas will add a greater number of species to state and national biota.

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Conflict of interest

All authors have read the Journal's policy on authorship agreement and disclosure of potential conflicts of interest. They have none to declare

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Authors' contributions

SP had conceptualized the idea, worked and prepared the data and results along with the draft manuscript, DKU and KBS have edited the final draft manuscript. All authors have written, reviewed, and edited the manuscript.

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