



Preliminary studies on the lichens growing in FEEDS campus and SB garden in Manipur, India

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Abstract

In our continuous effort to explore the lichens in new and interesting areas FEEDS campus and SBG garden located in Manipur, a north-eastern state of India are surveyed. The study resulted in 47 species in FEEDS campus and 80 species in SB garden respectively, while both areas shared 22 species in common. The crustose lichens were more dominant in the area represented by Graphidaceae (16 spp.) and Pyrenulaceae (15 spp.). The species composition in both the sites represented photophilic communities such as graphidaceous, physcioid and parmelioid lichens. FEEDS campus had open areas with cultivated plants where as SBG garden had semi-evergreen forest at its initial stage of succession. The study also added 55 lichen species as new distributional records to Manipur.

Key words – Biodiversity – Lichenized fungi – Mycobiota – North-east India – Taxonomy

Introduction

North-east India consisting of eight states is undoubtedly a biodiversity hotspot in the country. Presence of Himalaya and its foothills make the region ecologically interesting with varied climate, edaphic and altitudinal gradients. The region hosts 50% of the flowering plants (ca. 8000 species), of which 2526 species are endemic (Tripathi et al. 2016). Likewise, the north-eastern region also has high diversity of lichens hosting approximately 1600 species, which is more than half of the known 2902 lichen species from the country (Sinha & Jagadeesh Ram 2020). Among the north-eastern states Arunachal Pradesh, Assam and Sikkim are probably most extensively explored states for lichens, Manipur, Nagaland and Meghalaya are moderately explored, while Mizoram and Tripura are least explored states (Shukla et al. 2014). There has been a steady lichenological exploration in north-east region in the recent days and several novel or previously unreported species are being reported (Upreti et al. 2014, Singh et al. 2015, Singh & Singh 2016, Logesh et al. 2017, Sinha & Pooja 2017, Gogoi et al. 2019).

Lichens from Manipur were explored as early as 1880s. Dr. G. Watt, a European botanist collected lichens from Manipur during 1881-82 which were identified by Müller Argoviensis (1892) who reported 101 species including 29 new ones. Singh & Sinha (2010) listed 292 species for Manipur in their book 'Indian lichens: An annotated checklist' from all the studies carried out in the state till then. Devi et al. (2013, 2015) documented 140 lichen species belonging to 50 genera

and 23 families from various localities in Manipur. Singh & Singh (2015) reported 11 species of Graphidaceae as new to Manipur. Addition of all these numbers sums up to 443 species of lichens so far reported from Manipur.

In our continuous effort to document lichen biota of the country with emphasis on remote areas, ecologically interesting and unexplored area in the present study 'Foundation for Environment and Economic Development Services (FEEDS)' and 'Sylvan Botanic Garden (SBG)' are surveyed (Fig. 1). FEEDS is a no-profit, non-government organization located in Hengbung, Senapati district of Manipur (Lat. N25°13'43.0" Lon. E94°0'9.9"). FEEDS was established in 1988 for promotion of sustainable farming among tribal communities as an alternative to shifting cultivation. SBG is a natural forest adopted by FEEDS for *in situ* and *ex-situ* conservation of identified species, research and education (Lat. N25°23'56.4" Lon. E93°99'86.9"). Both the sites are located about 10 km apart, but with similar altitude of approximately 1200 m from above mean sea level. FEEDS campus has thinner vegetation dominated by cultivated plants of horticultural importance. Whereas SBG has natural semi-evergreen forest with tall trees and undulating topography. In the present communication lichen diversity in these two regions are reported and ecological conditions of the area is discussed.

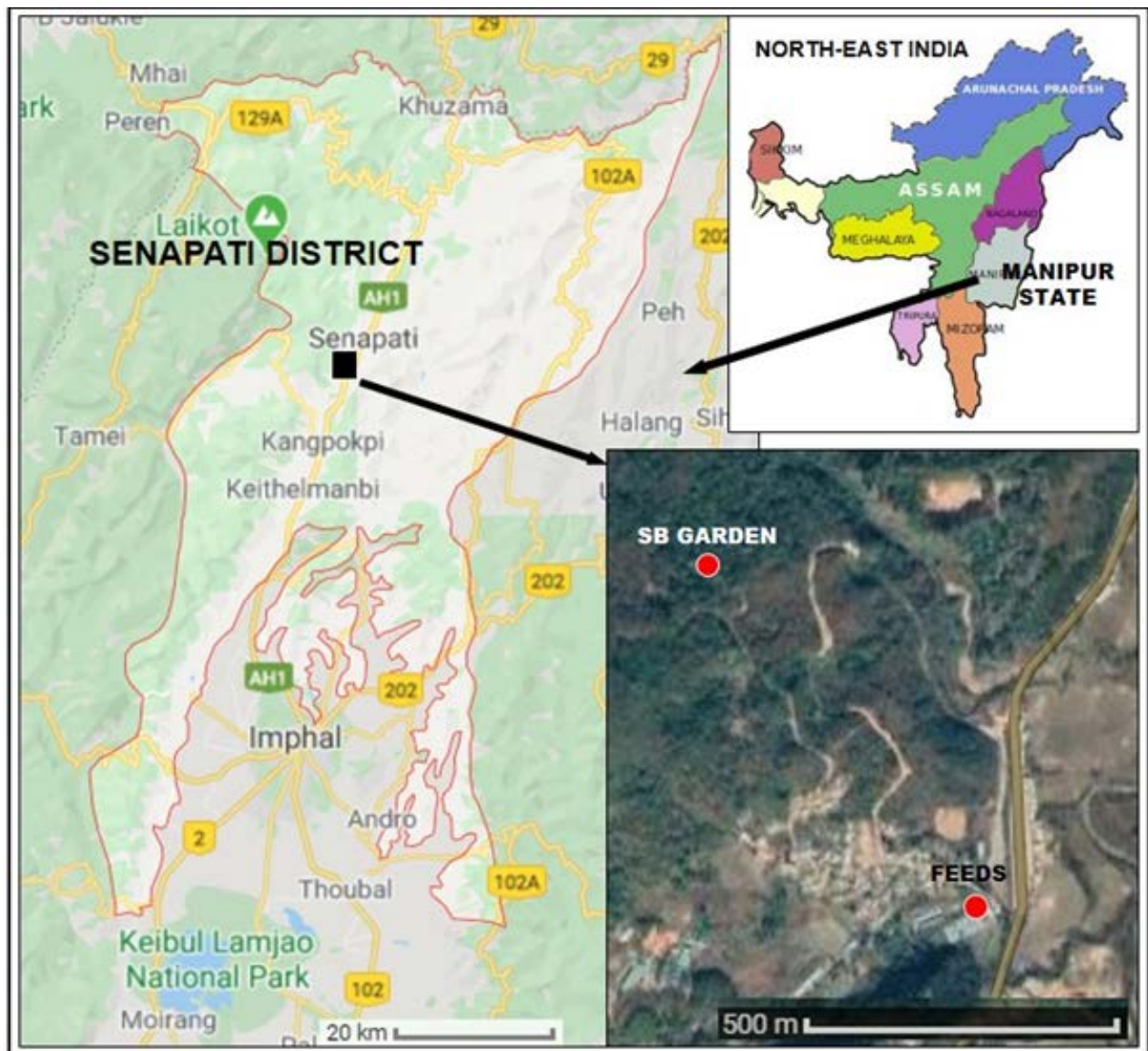


Fig. 1 – Map showing Manipur state within North-east India, Senapati district and location of SBG and FEEDS

Materials & Methods

Lichens from FEEDS campus and SBG were collected on 11th and 12th June 2018 respectively. A total of 250 specimens were collected from tree trunk, twigs, and soil. The specimens were thoroughly dried and preserved in the herbarium LWG of CSIR-National Botanical Research Institute, Lucknow with labels. Morphological and anatomical characters were examined using stereo zoom Leica S8APO and light DM2500 microscopes attached with camera. Thin, hand cut sections of thallus and ascomata were mounted in plain water and various measurements were taken under light microscope. Also, the sections were mounted in 10% KOH, Lugol's iodine and lactophenol cotton blue for detailed study of the structures. For spot tests the usual reagents of K, C and P were used and for identification of lichens substance by thin layer chromatography (TLC) was performed in solvent system C following Orange et al. (2001). The specimens were identified up to species level with the help of keys of Awasthi (1991, 2007), Aptroot (2012), Jagadeesh Ram (2014), Kalb et al. (2004), Lücking et al. (2009a) and Nayaka (2005). The recent classification compiled by Lücking et al. (2017) was followed segregate species into families. Recent nomenclatures are updated following Index Fungorum 2020.

FEEDS and SBG have different types of vegetations and therefore the lichen diversity between the two localities are analyzed separately. Further, to ascertain a meaning to the species composition in FEEDS and SBG the lichens are categorized into few major communities or functional groups such as type of growth forms (crustose, foliose, fruticose); cyanolichens (*Coccocarpia*, *Leptogium*, *Pseudocyphelaria*); graphidaceous (*Diorygma*, *Glyphis*, *Graphis*, *Hemitheicum*, *Pallidogramme*, *Phaeographis*); parmelioid (*Bulbothrix*, *Hypotrachyna*, *Myelochroa*, *Parmelinella*, *Parmotrema*, *Remototrachyna*); physcioid (*Dirinaria*, *Heterodermia*, *Leucodermia*, *Phaeophyscia*, *Physcia*, *Polyblastidium*, *Pyxine*) and pyrenocarpous (*Anthracotheicum*, *Pyrenula*). The indications of these communities are interpreted following published literature (Koch et al. 2013, Rikkinen 2015).

Result & Discussion

A total of 250 lichen samples were collected which resulted in 105 species under 48 genera and 24 families (Table 1). Out of the total SBG recorded more number of lichens represented by 80 species, FEEDS campus harboured 47 species while 22 species were common to both the sites. The crustose lichens are more dominant in both the localities with 60 species followed by foliose with 41 species. The fruticose lichens were very few in the area represented by four species. Similar trend of species composition was also seen in earlier studies by Devi et al. (2015) in Manipur where 50% of crustose, 44% foliose and 6% of fruticose lichens were recorded. It is interesting to note that Graphidaceae, Pyrenulaceae, Physciaceae and Parmeliaceae are the dominant families in whole study area with 16, 15, 15 and 14 species. Among the genera *Pyrenula*, *Graphis* and *Heterodermia* were dominant with 14, 10 and 9 species. These communities of lichens are typical representatives of tropical forest. Based on the general observation and number of specimens collected we can group the lichen in-to three categories; 1. Less common, 2. Common and 3. Most common. Maximum number of lichens (73) belongs less common category in the area while 22 are common. *Bulbothrix isidiza*, *Haematomma accolens*, *Heterodermia albidiflava*, *H. comosa*, *H. diademata*, *Lecanora helva*, *Parmotrema indicum*, *P. reticulatum*, *P. tinctorum* and *Pseudocyphellaria crocata* are the most common lichens in the area.

Table 1 List of lichens from FEEDS campus and SBG [Note: CR = Crustose, FL = Foliose, FR = Fruticose, + = Present, * = new to Manipur state]

	Species	Family	Habit	FEEDS	SBG	Remarks
1*	<i>Allographa epixantha</i> (Mont. & Bosch) Lücking & Kalb	Graphidaceae	CR		+	Common
2*	<i>Anthracotheicum prasinum</i> (Eschw.) R.C. Harris	Pyrenulaceae	CR	+	+	Common
3*	<i>Arthothelium confertum</i> (A.L. Smith) Makhija & Patwrdhan	Arthoniaceae	CR		+	Less common

Table 1 Continued.

	Species	Family	Habit	FEEDS	SBG	Remarks
4	<i>Bacidia submedialis</i> (Nyl.) Zahlbr.	Ramalinaceae	CR	+		Common
5	<i>Bulbothrix isidiza</i> (Nyl.) Hale	Parmeliaceae	FL	+	+	Most common
6	<i>B. setschwanensis</i> (Zahlbr.) Hale	Parmeliaceae	FL		+	Common
7	<i>Byssoloma subdiscordans</i> (Nyl.) P. James	Pilocarpaceae	CR	+		Less common
8	<i>Coniocarpon cinnabarinum</i> DC.	Arthoniaceae	CR	+		Less common
9*	<i>Cladonia coniocraea</i> (Flörke) Spreng.	Cladoniaceae	FR		+	Common
10*	<i>C. corniculata</i> Ahti & Kashiw.	Cladoniaceae	FR	+		Common
11	<i>Coccocarpia erythroxyli</i> (Spreng.) Swinscow & Krog	Coccocarpiaceae	FL		+	Less common
12*	<i>Diorygma hieroglyphicum</i> (Pers.) Staiger & Kalb	Graphidaceae	CR	+		Common
13	<i>Dirinaria consimilis</i> (Stirt.) D.D. Awasthi	Caliciaceae	FL		+	Common
14	<i>Glyphis cicatricosa</i> Ach.	Graphidaceae	CR	+	+	Common
15*	<i>Graphidastra multiformis</i> (Mont. & Bosch) G. Thor	Roccellaceae	CR		+	Less common
16*	<i>Graphis brahmanensis</i> Aptroot	Graphidaceae	CR		+	Less common
17*	<i>G. chlorotica</i> A. Massal.	Graphidaceae	CR	+		Less common
18	<i>G. cincta</i> (Pers.) Aptroot	Graphidaceae	CR	+	+	Common
19	<i>G. contortuplicata</i> Müll. Arg.	Graphidaceae	CR		+	Less common
20*	<i>G. elegans</i> (Borrer ex Sm.) Ach.	Graphidaceae	CR		+	Less common
21*	<i>G. handelii</i> Zahlbr.	Graphidaceae	CR	+	+	Less common
22	<i>G. lineola</i> Ach.	Graphidaceae	CR	+	+	Common
23	<i>G. scripta</i> (L.) Ach.	Graphidaceae	CR	+		Less common
24	<i>G. striatula</i> (Ach.) Spreng.	Graphidaceae	CR	+	+	Less common
25*	<i>G. submarginata</i> Lücking	Graphidaceae	CR		+	Less common
26*	<i>Haematomma accolens</i> (Stirt.) Hillmann	Haematommataceae	CR		+	Most common
27*	<i>Hemithecium epixanthum</i> (Mont. & Bosch) Chitale & Makhija	Graphidaceae	CR		+	Less common
28*	<i>Herpothallon echinatum</i> Aptroot, Lücking & Will-Wolf	Arthoniaceae	CR		+	Common
29*	<i>H. biacidum</i> Frisch et al.	Arthoniaceae	CR		+	Less Common
30	<i>Heterodermia albidiflava</i> (Kurok.) D.D. Awasthi	Physciaceae	FL	+	+	Most common
31*	<i>H. antillarum</i> (Vain.) Swinscow & Krog	Physciaceae	FL		+	Less common
32	<i>H. comosa</i> (Eschw.) Follmann & Redón	Physciaceae	FL		+	Most common
33	<i>H. diademata</i> (Taylor) D.D. Awasthi	Physciaceae	FL	+	+	Most common
34	<i>H. incana</i> (Stirt.) D.D. Awasthi	Physciaceae	FL		+	Less common
35	<i>H. obscurata</i> (Nyl.) Trevis.	Physciaceae	FL	+	+	Common
36*	<i>H. speciosa</i> (Wulfen) Trevis.	Physciaceae	FL		+	Less common
37*	<i>Hypotrachyna nepalensis</i> (Taylor) Divakar et al.	Parmeliaceae	FL		+	Less common
30	<i>Lecanora allophana</i> (Ach.) Nyl.	Lecanoraceae	CR	+		Less common
39	<i>L. chlarotera</i> Nyl.	Lecanoraceae	CR	+	+	Less common
40*	<i>L. helva</i> Stizenb.	Lecanoraceae	CR	+	+	Most common
41*	<i>L. imshaugii</i> Brodo	Lecanoraceae	CR		+	Less common
42*	<i>L. interjecta</i> Müll. Arg.	Lecanoraceae	CR	+		Less common
43	<i>L. pulicaris</i> (Pers.) Ach.	Lecanoraceae	CR		+	Less common
44*	<i>Lepraria cupressicola</i> (Hue) J.R. Laundon	Stereocaulaceae	CR	+	+	Less common
45*	<i>L. ecorticata</i> (J.R. Laundon) Kukwa	Stereocaulaceae	CR		+	Less common
46*	<i>L. lobificans</i> Nyl.	Stereocaulaceae	CR	+		Less common
47	<i>Leptogium austroamericanum</i> (Malme) C.W. Dodge	Collemataceae	FL		+	Less common
48*	<i>L. chloromelum</i> (Sw.) Nyl.	Collemataceae	FL		+	Less common
49*	<i>L. coralloideum</i> (Meyen & Flot.) Vain.	Collemataceae	FL	+	+	Common
50	<i>L. denticulatum</i> Nyl.	Collemataceae	FL		+	Common
51*	<i>L. phyllocarpum</i> (Pers.) Mont.	Collemataceae	FL		+	Common
52*	<i>Leucodermia leucomelos</i> (L.) Kalb	Physciaceae	FL		+	Less common
53	<i>Malmidea granifera</i> (Ach.) Kalb et al.	Malmideaceae	CR		+	Less common
54*	<i>M. papillosa</i> Weerak. & Aptroot	Malmideaceae	CR		+	Less common
55*	<i>M. subaurigera</i> (Vain.) Kalb et al.	Malmideaceae	CR		+	Less common
56*	<i>Megalaria leptocheila</i> (Tuck.) Fryday & Lendermer	Ramalinaceae	CT	+		Less common
57*	<i>Melaspilea gemella</i> (Eschw.) Nyl.	Melaspileaceae	CR	+		Less common
58	<i>Myelochroa aurulenta</i> (Tuck.) Elix & Hale	Parmeliaceae	FL		+	Common
59*	<i>M. subaurulenta</i> (Nyl.) Elix & Hale	Parmeliaceae	FL		+	Less common
60*	<i>Opegrapha dimidiata</i> Müll. Arg.	Opegraphaceae	CR		+	Less common

Table 1 Continued.

	Species	Family	Habit	FEEDS	SBG	Remarks
61	<i>Pallidogramme chrysenferon</i> (Mont.) Staige et al.	Graphidaceae	CR		+	Less common
62	<i>Parmelinella wallichiana</i> (Taylor) Elix & Hale	Parmeliaceae	FL	+		Less common
63	<i>Parmotrema austrosinense</i> (Zahlbr.) Hale	Parmeliaceae	FL		+	Common
64	<i>P. hababianum</i> (Gyeln.) Hale	Parmeliaceae	FL		+	Common
65	<i>P. indicum</i> Hale	Parmeliaceae	FL		+	Most common
66	<i>P. reticulatum</i> (Taylor) M. Choisy	Parmeliaceae	FL	+	+	Most common
67	<i>P. tinctorum</i> (Nyl.) Hale	Parmeliaceae	FL	+		Most common
68*	<i>Pertusaria erythrella</i> Müll. Arg.	Pertusariaceae	CR		+	Less common
69*	<i>P. pertusa</i> (L.) Tuck.	Pertusariaceae	CR	+		Less common
70*	<i>Phaeographis dendritica</i> (Ach.) Müll. Arg.	Graphidaceae	CR		+	Less common
71	<i>Phaeophyscia endococcina</i> (Körb.) Moberg	Physciaceae	FL		+	Less common
72	<i>P. hispidula</i> var. <i>exornatula</i> (Zahlbr.) Moberg	Physciaceae	FL	+		Less common
73	<i>P. pyrrophora</i> (Poelt) D.D. Awasthi	Physciaceae	FL		+	Less common
74*	<i>Phyllopsora furfuracea</i> (Pers.) Zahlbr.	Ramalinaceae	FL		+	Less common
75	<i>Physcia dilatata</i> Nyl.	Physciaceae	FL		+	Less common
76*	<i>P. solediosa</i> (Vain.) Lynge	Physciaceae	FL		+	Less common
77	<i>P. tribacioides</i> Nyl.	Physciaceae	FL	+		Less common
78	<i>Polyblastidium japonicum</i> (M. Satō) Kalb	Physciaceae	FL		+	Less common
79*	<i>Pseudocyphellaria crocata</i> (L.) Vain.	Lobariaceae	FL		+	Most common
80*	<i>Pyrenula andina</i> Aptroot	Pyrenulaceae	CR	+	+	Less common
81*	<i>P. bahiana</i> Malme	Pyrenulaceae	CR	+		Less common
82	<i>P. breutelii</i> (Müll. Arg.) Aptroot	Pyrenulaceae	CR	+		Less common
83*	<i>P. chlorospila</i> (Nyl.) Arnold	Pyrenulaceae	CR	+		Less common
84*	<i>P. dissimulans</i> (Müll. Arg.) R.C. Harris	Pyrenulaceae	CR	+		Less common
85	<i>P. immissa</i> (Stirt.) Zahlbr.	Pyrenulaceae	CR		+	Common
86	<i>P. leucostoma</i> Ach.	Pyrenulaceae	CR		+	Less common
87*	<i>P. macrospora</i> (Degel.) Coppins & James	Pyrenulaceae	CR		+	Less common
88*	<i>P. massariospora</i> (Starbäck) R.C. Harris	Pyrenulaceae	CR		+	Less common
89*	<i>P. mastophoroides</i> (Nyl.) Zahlbr.	Pyrenulaceae	CR	+	+	Common
90*	<i>P. microspora</i> (Nagarkar & Patw.) Upreti	Pyrenulaceae	CR	+		Less common
91*	<i>P. oculata</i> A. Singh & Upreti	Pyrenulaceae	CR	+		Less common
92	<i>P. pyrenuloides</i> (Mont.) R.C. Harris	Pyrenulaceae	CR		+	Less common
93*	<i>P. subelliptica</i> (Tuck.) R.C. Harris	Pyrenulaceae	CR		+	Less common
94	<i>Pyxine meissnerina</i> Nyl.	Caliciaceae	FL		+	Less common
95	<i>P. reticulata</i> (Vain.) Vain.	Caliciaceae	FL	+		Less common
96	<i>P. soledata</i> (Ach.) Mont.	Caliciaceae	FL		+	Less common
97	<i>P. subcinerea</i> Stirt.	Caliciaceae	FL	+		Less common
98	<i>Ramalina conduplicans</i> Vain.	Ramalinaceae	FR		+	Common
99	<i>Ramboldia manipurensis</i> (Kr.P. Singh) Kalb et al.	Ramboldiaceae	CR		+	Less common
100	<i>Remototrachyna infirma</i> (Kurok.) Divakar & A. Crespo	Parmeliaceae	FL	+	+	Less common
101*	<i>R. thryptica</i> (Hale) Divakar & A. Crespo	Parmeliaceae	FL		+	Less common
102*	<i>Sculptolumina japonica</i> (Tuck.) Marbach	Caliciaceae	CR	+		Less common
103	<i>Sphinctrina tubaeformis</i> A. Massal.	Sphinctrinaceae	CR		+	Less common
104*	<i>Tylophoron moderatum</i> Nyl.	Arthoniaceae	CR		+	Less common
105*	<i>Usnea stigmatoides</i> G. Awasthi	Parmeliaceae	FR		+	Less common

The present study added a total of 55 species as new to Manipur state. As mentioned earlier only 22 species are common between two areas while 25 species are restricted to FEEDS and 58 are found only in SBG. In both the sites proportion of crustose lichens is more followed by foliose forms. The lichen communities are functional groups categorized for the present study is given in Table 2. It can be seen that SBG has more number of cyanolichens in comparison to FEEDS. The cyanolichens are indicators of presence of high humidity and old-growth forest conditions (Scheidegger et al. 2002) as they have specialized habitat requirements (Rikkinen 2015). *Lobaria pulmonaria*, an epiphytic cyanolichen is frequently used as indicator species to identify forests of high conservation priority and ecological continuity (Scheidegger & Werth 2009). Present study clearly indicates that SBG has much humid conditions conducive for luxuriant growth of lichens.

Table 2 Proportion of various lichen communities in FEEDS and SBG

Lichen communities	FEEDS (%)	SBG (%)
Crustose	61.7	55
Foliose	36.2	41.3
Fruticose	2.1	3.7
Cyanolichens	2.1	8.7
Graphidaceous	17	16.3
Parmelioid	17	13.7
Physcioid	17	20
Pyrenocarpous	19.1	11.3

The species composition of an area responds to changes in the local ecological conditions, which can be used as good indicator of forest regeneration and ecological continuity (Plata et al. 2008, Koch et al. 2013). Ecological continuity refers to the time span a forest ecosystem requires to reach dynamic equilibrium of succession. Koch et al. (2013) studied lichens in three succession stage tropical forest in Brazil. Accordingly, the dominance of crustose lichens and pyrenocarpous (perithecia bearing) lichens are the indication of forest's late succession stage (mature forest) with low light and wind speed, but high humidity. The crustose lichens are tolerant to low luminosity and have high hydrophobicity. Reproduction through perithecia is suitable in mature forest because they do not depend on wind for spore dispersal. On the hand foliose, fruticose and graphidaceous lichens are indicators of initial succession. These foliose and fruticose lichens require light and lower humidity. As the light decreases in the forest they tend migrate to the canopy of the forest. These groups of lichens also can rehydrate and lose water quickly. In such condition crustose lichens are weak competitors (Ellis & Coppins 2006). Whereas in case of graphidaceous lichens their labia (lirella's margin), usually black and closed, grant them protection to excessive light and to dryness in areas of early succession. Further, these lichens need to be exposed to light in order to produce spores (Koch et al. 2013). In the present study both the sites had more number of foliose lichens, especially light loving parmelioid (17 and 13.7%) and physcioid lichens (17 and 20%). Further, both the sites represented equal proportion of graphidaceous lichens (17 and 16.3%). Such a result is obvious for FEEDS because the site had lots of open areas with cultivated plants and building construction. Whereas SBG although had a humid, semi-evergreen kind of forest it is still in initial stage of succession. It is also possible that SBG may be secondary regenerated forest which was once subjected shifting cultivation. The shifting cultivation (also called as *Jhum* or *Paamlou* in local language) was a well documented practice in the Manipur region (Reimeingam 2017). As mentioned earlier both the sites had luxuriant growth of lichens. Also, the proportion of pyrenocarpous lichens are more in FEEDS campus. However, both cannot be considered as indicator of mature forest. It is observed that in tropical countries proportion of crustose lichens are always higher than foliose and fruticose (Lücking et al. 2009b). Any study in such case would yield more number of crustose lichens. A large number of quantitative studies are required to draw conclusion based on crustose lichens. In case of pyrenocarpous lichens characteristic of FEEDS campus do not indicate it as a mature forest.

Conclusion

Tropical forests in the world are not only the major resource for livelihood but also most threatened diversity hotspots (Myers et al. 2000). The highest species richness of lichens is found in the tropical rain forests around the world and 500 – 600 or more species can be found just within a km² (Lücking et al. 2011). There are more lichen species than tree or bird species in any given area of tropical jungle. Unfortunately, 50% of the tropical forest are unexplored for lichens (Aptroot & Sipman 1997). It is evident from the present study that SBG has rich diversity of lichens and there is a need for intensive survey in the area. It can be mentioned here that *Herpothallon biacidum*, *Malmidea papillosa* and *Pertusaria erythrella* are described as new record to India from the same collection (Ingle et al. in prep.). The SBG and surrounding area gives an opportunity to study the

effect of shifting cultivation on lichen communities. Several indicator communities can be identified from detailed studies in forests of various regeneration stage. Such studies not only yield valuable publications but also will be a baseline for future biomonitoring studies.

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