RESEARCH ARTICLE

An Assessment of Lichens Diversity from Mandi District, Himachal Pradesh, India

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Abstract

A total of 70 species of lichens belonging to 29 genera and 15 families were found growing in eight different localities of Mandi district of Himachal Pradesh, India. The present study reveals the addition of 14 species of lichens as new to the state. The lichen genus *Lecanora* with 11 species exhibits the dominance in the area. Among the different localities of the district the area Sikandra Dhar showed maximum diversity of lichens followed by Balh valley, Barot and Mandi city as 19, 18, 17 and 16 species, respectively. The tropical zone exhibits luxuriant growth of trees like *Pinus, Shorea robusta, Prunus, Celtis, Grewia* and *Rubina*. The *Rubina* and *Populus* trees cultivated along road side bear luxuriant growth of *Candelaria concolor* together with *Physcia dilatata,* a foliose lichen. The temperate region of the district exhibits luxuriant growth of Quercus leucotricophora trees which support the luxuriant growth of Parmotrema nilgherrense, *Ramalina conduplicans*, *Ramalina sinensis, Heterodermia diademata* and *Usnea* species.

Keywords: Biodiversity, Distribution, Lichenized fungi, Western Himalaya.

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Introduction

Himachal Pradesh situated in the Western Indian Himalayan region, exhibit luxuriant growth of lichens as well as other plants due to diverse climatic conditions and elevation gradients. The lichens of the state are extensively studied since last two decades and included in different monographic and revisionary studies (Awasthi, 1953; Hoeg, 1953; Sharma and Sharma, 2000; Sharma *et al*., 2001, 2002a,b; Shrivastava *et al*., 2004a,b; Sharma and Kaur, 2005; Yadav, 2005). Nayaka *et al*. (2002a) reported 112 species belonging to 44 genera and 26 families of lichens from the Sirmaur district. Nayaka *et al*. (2002b) studies the lichens of Solan district and reported 102 species belonging to 41 genera and 18 families including six new records for the country. Srivastava *et al*. (2004a) enumerated lichens from Bilaspur, Hamirpur and Una districts and reported 70 species from all the district. Srivastava *et al*. (2004b) also studied the lichen flora of Shimla district and published 192 species under the 58 genera and 23 families. Yadav (2005) listed 503 species of lichens belonging to 107 genera and 44 families from the state based on his own work and previous. Mandi district is one of the 12 districts of Himachal Pradesh lying in the centre of state; Kullu district on its east, Hamirpur and Bilaspur to its west, Kangra district to its north, and Shimla and Solan district to its south. The maximum altitude recorded is 2500 m at Billing Hills which is dominated by *Quercus* and *Rododendron* phorophytes, while the lower altitudes are dominated by *Albizia chinensis, Ficus sycomorus, Grewia, Mangifera* and *Pinus* vegetations. The microclimatic condition, vegetation and altitudinal ranges make this district rich in lichen diversity hence an interesting site for investigation. Earlier, Yadav (2005) reported 22 species of lichens from the Mandi district. In spite of floristic studies available in the past, still a number of localities in the district have not yet explored floristically. In the present study a more intensive and systematic attempt has been made to record the floristic diversity of lichens from the unexplored areas of Mandi district.

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Materials and Methods

The present study is based on more than 500 lichen specimens collected growing on different sites of Mandi district (Fig. 1) and based on published literatures. A set of voucher specimens are preserved in the herbarium of CSIR-National Botanical Research Institute, Lucknow (LWG) and also in the herbarium of Department of Bio-Sciences, Career Point University Hamirpur (CPUH), Himachal Pradesh. The specimens were studied morphologically, anatomically and chemically. The morphological structures were studied under stereozoom microscope (Leica EZ4). The anatomical details of the thallus and fruiting bodies were studied in hand cut sections with water as mounting medium under compound microscope (Awasthi, 2007). The chemical substance in the thallus were identified through colour test technique by applying aqueous potassium hydroxide (K), Steiner's stable paraphenylenediamine (PD) and aqueous calcium hypochlorite (C) reagents. Thin layer chromatography was performed for identification of the lichen substances in solvent system A and

solvent system C, following the techniques of Orange *et al*. (2001). For the authentic identification of different lichen taxa, following the literatures of Awasthi (1991, 2007), Nayaka (2004), Divakar and Upreti (2005), Mishra and Upreti (2015) were consulted. The nomenclature of the identified species was updated based on the modern concept of lichen systematic referring to Index Fungorum. Lücking *et al*. (2017) was followed to arrange species under different families.

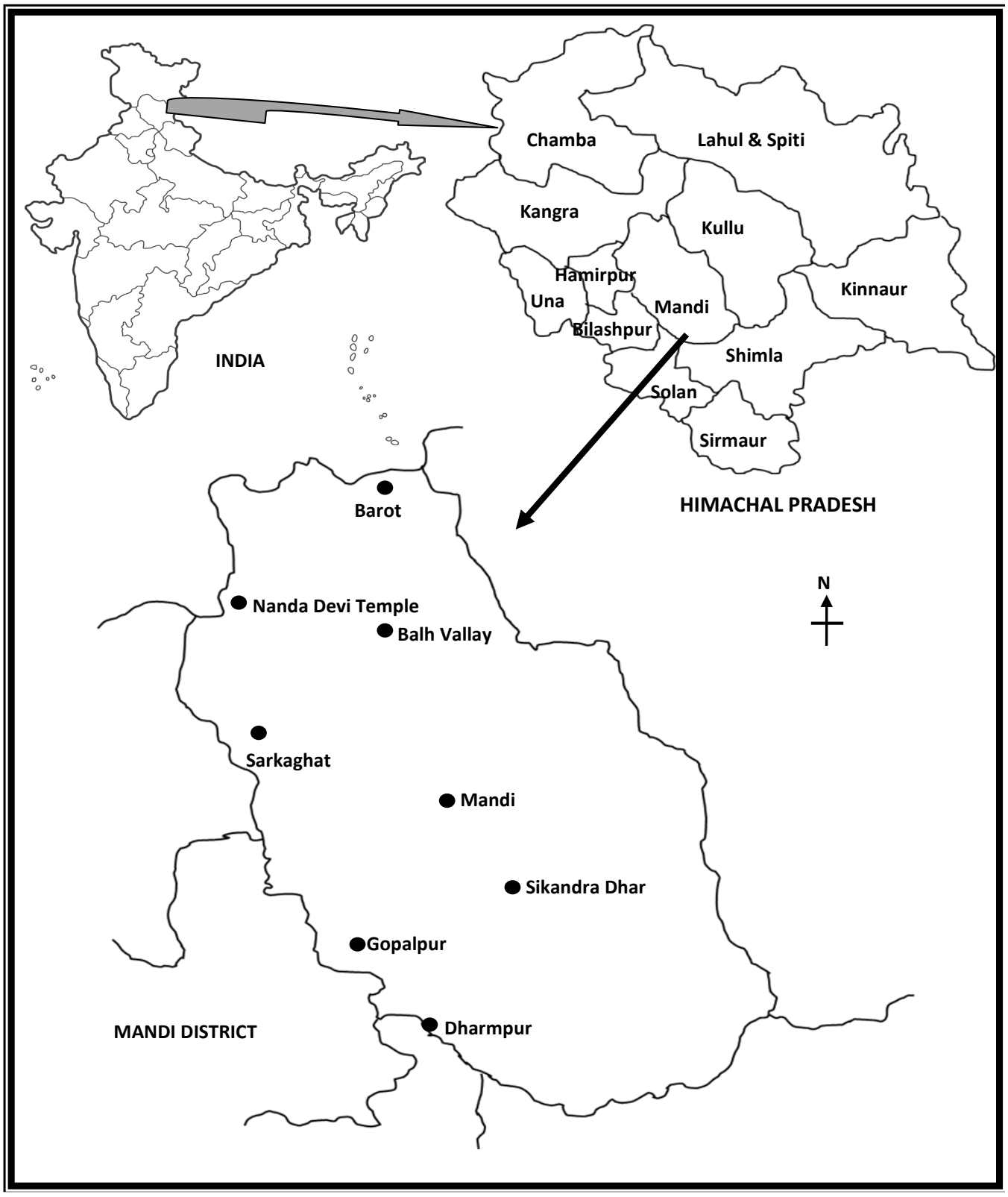

Fig. 1: Map showing collection sites in Mandi district, Himachal Pradesh

Results and discussion

The present study resulted the occurrence of 70 species of lichens belonging to 29 genera and 15 families from the Mandi district (Table 1). Among different families Parmeliaceae is the common and highly diverse family in the district with five genera and 13 species followed by the Lecanoraceae with three

Table 1: The list of lichens taxa recorded in Mandi district, Himachal Pradesh.

S.N.	*Families and taxa*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*GF*	*SUB*
A.	*Caliciaceae*										
1.	*Dirinaria applanata* (Fée) D.D. Awasthi	-	-	+	-	+	-	-	-	Fo	Co
2.	*Pyxine cocoes* (Sw.) Nyl.	+	+	+	+	+	+	+	+	Fo	Co
3.	*P. petricola* Nyl.	-	-	+	-	-	-	-	+	Fo	Co
4.	*P. reticulata* (Vain.) Vain.*	+	-	-	-	+	-	-	-	Fo	Co
B.	*Candelariaceae*										
5.	*Candelaria concolor* (Dicks.) Arnold	-	+	-	-	-	-	-	-	Fo	Co
C.	*Cladoniaceae*										
6.	*Cladonia coniocraea* (Flörke) Spreng	-	+	-	-	-	-	-	-	Fr	Co
7.	*C. fruticulosa* Kremp.*	-	+	+	-	-	-	-	-	Fr	Te
D.	*Collemataceae*										
8.	*Collema rugosum* Kremp.	-	-	-	-	-	-	-	+	Fo	Sa
9.	*Leptogium cyanescens* (Ach.) Körb.	-	-	-	-	-	-	+	-	Fo	Sa
E.	*Graphidaceae*										
10.	*Diploschistes actinostomus* (Ach.) Zahlbr.	+	-	-	-	+	-	-	-	Cr	Sa
11.	*D. rampoddensis* (Nyl.) Zahlbr.	-	-	-	-	-	-	+	-	Cr	Sa
F.	*Lecanoraceae*										
12.	*Circinaria caesiocinerea* (Nyl. ex Malbr.) A. Nordin, Savić & Tibell	-	-	-	-	-	-	-	+	Cr	Sa
13.	*C. calcarea* (L.) A. Nordin, Savić & Tibell	-	-	-	-	-	-	-	+	Cr	Sa
14.	*Lecanora achroa* Nyl.	+	-	-	-	-	-	-	-	Cr	Co
15.	*L. alba* Lumbsch	+	-	-	-	-	-	-	-	Cr	Co
16.	*L. cenisia* Ach.	+	-	-	+	-	-	-	-	Cr	Co
17.	*L. chlarotera* Nyl.*	+	+	-	-	+	+	-	-	Cr	Co
18.	*L. fimbriatula* Stirt.	-	-	+	+	+	-	-	-	Cr	Co
19.	*L. helva* Stizenb	+	-	-	-	-	-	-	-	Cr	Co
20.	*L. indica* Zahlbr.	-	+	-	-	-	-	-	-	Cr	Sa
21.	*L. leuteomarginata* Nayaka, Upreti & Lumbsh*	-	-	+	-	-	-	-	-	Cr	Sa
22.	*L. perplexa* Brodo*	+	-	-	-	-	-	-	-	Cr	Co
23.	*L. subimmersa* (Fée) Vain.	-	-	+	-	-	-	-	-	Cr	Sa
24.	*L. tropica* Zahlbr.	+	-	-	-	-	-	-	-	Cr	Sa
25.	*Omphalodina pseudistera* (Nyl.) S.Y. Kondr., L. Lőkös & Farkas	+	-	-	+	-	+	-	-	Cr	Sa
G.	*Lobariaceae*										
26.	*Lobaria pindarensis* Räsänen	-	-	-	-	-	-	+	-	Fo	Te
27.	*L. retigera* (Bory) Trevis.	-	-	-	-	-	-	+	-	Fo	Te
H.	*Parmeliaceae*										
28.	*Bulbothrix setschwanensis* (Zahlbr.) Hale	-	+	-	+	-	+	-	-	Fo	Co
29.	*Canoparmelia aptata* (Kremp.) Elix & Hale	-	-	-	-	+	+	-	-	Fo	Co
30.	*C. eruptens* (Kurok.) Elix & Hale	+	-	-	-	-	-	-	-	Fo	Co
31.	*C. pustulescens* (Kurok.) Elix*	-	-	+	-	-	-	-	-	Fo	Co
32.	*C. texana* (Tuck.) Elix & Hale	-	-	-	+	-	+	-	-	Fo	Co
33.	*Parmotrema austrosinense* (Zahlbr.) Hale	-	-	+	-	-	-	-	-	Fo	Co

34.	*P. grayanum* (Hue) Hale*	+	-	-	-	-	-	-	-	Fo	Co
35.	*P. nilgherrense* (Nyl.) Hale	-	-	-	-	-	-	-	+	Fo	Co
36.	*P. praesorediosum* (Nyl.) Hale	-	-	+	-	-	-	-	-	Fo	Co
37.	*P. tinctorum* (Despr. ex Nyl.) Hale	-	+	-	-	-	-	-	-	Fo	Co
38.	*Punctelia subrudecta* (Nyl.) Krog	-	-	+	-	+	-	-	-	Fo	Te
39.	*P. rudecta* (Ach.) Krog	-	-	-	+	-	+	-	+	Fo	Co
40.	*Xanthoparmelia antleriformis* (Elix) Elix & J. Johnst*	-	-	+	-	-	-	-	-	Fo	Sa
I.	*Physciaceae*										
41.	*Heterodermia albidiflava* (Kurok.) D.D. Awasthi	-	-	+	-	-	-	-	-	Fo	Co
42.	*H. diademata* (Taylor) D.D. Awasthi	-	-	+	-	-	-	+	+	Fo	Co
43.	*H. pseudospeciosa* (Kurok.) W.L. Culb.	+	+	-	-	-	-	-	-	Fo	Co
44.	*Hyperphyscia adglutinata* (Flörke) H. Mayrhofer & Poelt.	-	-	+	-	+	+	-	-	Fo	Co
45.	*Phaeophyscia ciliata* (Hoffm.) Moberg	-	-	-	-	+	-	-	-	Fo	Co
46.	*P. hispidula* (Ach.) Essl.	-	-	-	+	-	+	+	-	Fo	Co
47.	*P. orbicularis* (Neck.) Moberg	+	-	-	-	+	-	-	-	Fo	Co
48.	*Physcia dilatata* Nyl.	-	+	-	-	-	+	-	-	Fo	Co
49.	*P. tribacioides* Nyl.	-	+	-	-	-	+	-	-	Fo	Co
50.	*Physconia muscigena* (Ach.) Poelt	+	-	-	-	+	-	-	-	Fo	Sa
J.	*Peltigeraceae*										
51.	*Peltigera dolichorrhiza* (Nyl.) Nyl.	-	-	-	-	-	-	-	+	Fo	Te
52.	*P. neckeri* Hepp ex Müll. Arg.	-	-	-	-	-	-	+	-	Fo	Te
53.	*P. praetextata* (Flörke ex Sommerf.) Zopf.	-	-	-	-	-	-	+	-	Fo	Te
54.	*P. rufescens* (Weiss) Humb.	-	-	-	-	-	-	+	-	Fo	Te
K.	*Pyrenulaceae*										
55.	*Pyrenula complanata* (Mont.) Trevis.	-	-	-	-	-	-	+	+	Fo	Co
56.	*P. duplicans* (Nyl.) Aptroot	-	-	-	-	-	-	+	+	Fo	Co
57.	*P. mamillana* (Ach.) Trevis	-	-	-	-	-	-	+	-	Fo	Co
58.	*P. oculata* Ajay Singh & Upreti*	-	-	-	-	-	-	-	+	Cr	Sa
59.	*P. platystoma* (Müll. Arg.) Aptroot*	-	-	-	-	-	-	-	+	Cr	Co
60.	*P. subumbilicata* (C. Knight) Aptroot	-	-	-	-	-	-	+	+	Fo	Co
L.	*Ramalinaceae*										
61.	*Bacidia spadiacea* (Ach.) Zahlbr.*	+	-	-	-	-	-	-	-	Cr	Sa
62.	*Ramalina conduplicans* Vain.	-	-	-	-	-	-	+	-	Fr	Ra
63.	*R. sinensis* Jatta	-	-	-	-	-	-	+	+	Fr	Co
M.	*Stereocaulaceae*										
64.	*Lepraria caesioalba* (B.de Lesd.) J.R. Laundon*	+	-	-	+	-	-	-	-	L	Sa
65.	*L. caesiella* R.C. Harris*	-	-	+	-	-	-	-	-	L	Sa
66.	*L. straminea* Vain.*	-	-	+	-	-	-	-	-	L	Sa
N.	*Teloschistaceae*										
67.	*Gyalolechia bassiae* (Ach.) Søchting, Frödén & Arup & Ahti	+	-	-	-	-	+	-	-	Cr	Co
O.	*Verrucariaceae*										
68.	*Dermatocarpon miniatum* (L.) W. Mann	-	-	+	-	-	-	-	-	Fo	Sa
69.	*D. vellereum* Zschacke	-	+	-	-	-	-	+	-	Fo	Sa
70.	*Staurothele areolata* (Ach.) Lettau	-	-	-	-	-	-	-	+	Cr	Sa

Abbreviations: GF – Growth Forms, **+** Present, **-** Absent, **Cr**- Crustose, **Fo**- Foliose, **Fr**- Fruticose, **L**- Leprose, **Co**- Corticolous, **Sa**- Saxicolous, **Te**-Terricolous, **Ra**- Ramicolous.

* - New addition to the state.

Localities: A- Sikandra Dhar, **B**- Naina Devi Dhar, **C**- Balh Valley, **D**- Sarkaghat, **E**- Gopalpur, **F**- Dharmpur, **G**-Barot, **H-**Mandi.

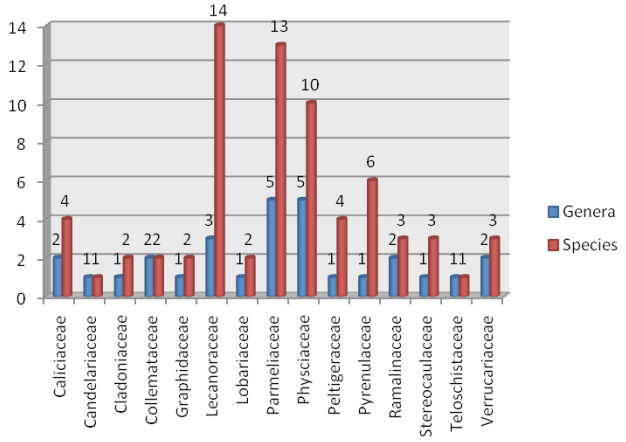

Fig. 2: Lichen families and their diversity in Mandi district.

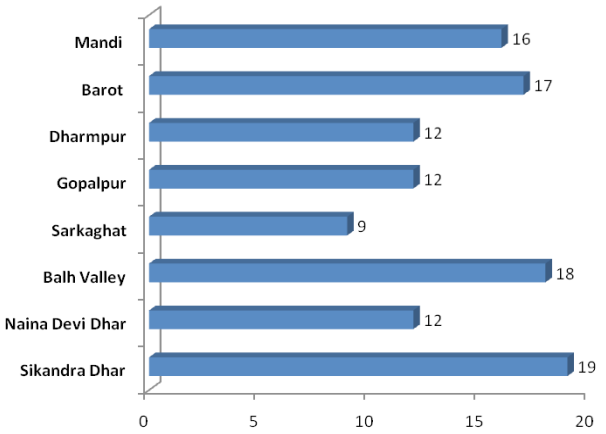

Fig. 3: Graph showing lichen diversity in different localities of Mandi district.

genera and 14 species (Fig. 2). The genus *Lecanora* is dominant with 11 species followed by *Pyrenula* and *Parmotrema* with 6 and 5 species each. Among the different growth forms of lichens, the foliose growth forms dominant the area followed by crustose, fruticose, leprose and dimorphic as 43, 21, 4, 3 and 2 species respectively. The corticolous and saxicolous lichens are dominant with 41 and 21 species, while terricolous lichens represented by eight species in the area.

Bacidia spadiacea (Ach.) Zahlbr., *Cladonia fruticulosa* Kremp., *Canoparmelia pustulescens* (Kurok.) Elix, *Lecanora chlarotera* Nyl., *L. leuteomarginata* Nayaka, Upreti & Lumbsh, *L. perplexa* Brodo, *Lepraria caesioalba* (B. de Lesd.) J.R. Laundon, *L. caesiella* R.C. Harris, *L. straminea* Vain., *Parmotrema grayanum* (Hue) Hale, *Pyrenula oculata* Ajay Singh & Upreti, *P. platystoma* (Müll. Arg.) Aptroot, *Pyxine reticulata* (Vain.) Vain. and *Xanthoparmelia antleriformis* (Elix) Elix & J. Johnst, species reported earlier from different states of the country (Singh and Sinha, 2010), now these species are first time reported from the Himachal Pradesh. Among the eight forest localities, Sikandra Dhar area exhibited maximum diversity of lichens represented 19 species (Fig. 3), it may be due to devoid of any direct anthropogenic activities in the area and further a good sign of favorable environmental conditions. *Lecanora chlarotera, Parmotrema praesorediosum, P. tinctorum, Phaeophyscia hispidula, P. orbicularis, Physcia dilatata* and *Pyxine cocoes* are the common lichens species in the area.

The tropical zone (500-1500 m) exhibit luxuriant growth of *Candelaria concolor* together with *Physcia dilatata* whitish grey foliose lichen. The species of lichen family Parmeliaceae together with Physciaceae are dominant on both the cultivated and other trees. *Bulbothrix meizospora*, *Canoparmelia ecaperata* and *Parmotrema reticulatum* are the common Parmelioid lichens found growing on *Pinus* and *Shorea robusta* trees on its thick rough bark. The member of lichen family Physciaceae also grow luxuriantly on *Shorea robusta* tree and other substrate in the tropical areas of the district. The common lichens on *Shora robusta* are *Dirinaria applanata*, *Heterodermia diademata*, *Pyxine subcinerea* and the crustose lichen genera *Circinaria caesiocinerea*, *Diploschistes actinostomus, Lecanora achroa, Pyrenula complanata* and *Bacidia spadiacea.*

The temperate region (1500-3500 m) of the district up to an altitude of 2000 m exhibit luxuriant growth of Quercus leucotricophora trees on its trunk and twigs bear luxuriant growth of Parmelioid lichens such as Parmotrema nilgherrense together with *Ramalina conduplicans*, *Ramalina sinensis* and *Usnea* species, together with the *Heterodermia diademata* and *Usnea* species grow luxuriantly on the bark of *Rhododendron* trees. The *Alnus nepalensis* trees having smooth bark provide excellent substratum for colonization of Pyrenocarpous and Graphidaceous lichens. The common species of Pyrenocarpous lichens are *Pyrenula complanata*, *P. oculata* and *P. duplicans*, while species of the *Lecanora* also exhibit their luxuriant growth on *Alnus* trees. The saxicolous and terricolous lichens also grow luxuriantly on exposed rocks or rocks in moist humid places covered under trees or near the streams. The common saxoicolous lichens of the temperate region are *Bacidia spadiacea*, *Dermatocarpon miniatum*, *Staurothele areolata, Lepraria caesioalba, Physconia muscigena* and *Xanthoparmelia antleriformis* (Mishra and Upreti, 2015).

Conclusion

Among the major localities of mandi District of H. P., the Sikandra Dhar area is showing maximum diversity of lichens with 19 species, whereas the other localities such as Balh Valley, Barot and Mandi city represented 18, 17 and 16 species respectively. The lichen species of the genus such as *Ramalina, Parmotrema* and *Caloplaca* were recorded only from the pollution free areas of the inner reserve forest. The present study further added 13 species to the lichen biota of Himachal Pradesh. The occurrence of maximum foliose lichen species in the district clearly indicates the richness of lichens. So far the district is not explored extensively and intensively for its lichen wealth. After the complete exploration of the district a clear picture of the status of lichen diversity of this district will be available, in near future. The present enumeration of lichens will act as a baseline data for carrying out future biomonitoring studies in the area.

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