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Distribution, Diversity of Lichens in Terai region of Kumaun with reference to Environmental Pollution

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ABSTRACT

The present study is an attempt to explore the diversity and distribution of lichen flora of Terai region of Kumaun Himalaya of Uttarakhand, which includes different localities of district Udham Singh Nagar, Ramnagar and Jim Corbett Tiger Reserve. An enumeration of 146 species belonging to 46 genera and 24 families is provided, based on the account of lichen species published in literature, specimens preserved in herbarium and fresh collection of lichens from localities not explored earlier. Based on the available diversity and distribution pattern of lichens, an attempt has been made to map, distinguish the polluted and non-polluted localities of the study area.

1) INTRODUCTION

The Kumaun region consists of a large Himalayan tract, together with two submontane strips called the 'terai' and the 'bhabar'. Terai region is a belt of marshy grasslands, Savannas and forests located in the foothills of Himalaya. The floristic accounts of different plant groups including lichens are well explored from Kumaun region [1], however both terai and bhabar areas have not been explored for their lichen diversity. The floristic account of angiosperms, fern and fern-allies from the area are well known [2]. Out of the six districts of Uttarakhand, except Udham Singh Nagar, most of the districts are located in higher altitudes and exhibit fairly good growth of most of the species of different lichen growth forms. However, Udham Singh Nagar popularly known as "Gateway of Kumaun" is situated in the foothills of the Himalaya having a subtropical type of climate and has less diversity of lichens. After creation of Uttarakhand a new state from Uttar Pradesh in the year 2000, the Terai being a plain area in a hill state exploited exhaustively for development of industrial activities. Due to fast pace of industrialization and urbanization in the area the forests has been removed for agriculture, cultivation and other human activities. Heavy industrialization and urbanization in the area resulted into few scattered open canopy deciduous forest. The three main forests of the terai region of Kumaun are Tanda near Rudrapur, forests near Bazpur and Khatima, The trees of *Shorea robusta*, *Mallotus philippensis*, *Ficus bengalensis*, *Terminalia arjuna* and *Toona ciliata* form the major forests vegetation in the area.

Udham Singh Nagar (USN) is one of the major district of Terai regions with in an area of 3,000 sq. Km. between 28^0-30^0 N and 78^0-81^0 E. The district comprised of Jaspur, Kashipur, Bazpur, Gadarpur, Rudrapur, Sitarganj, Khatima including Ramnagar and Corbett Tiger Reserve as it major locality.

Pant [2] enumerated 594 species of angiosperm and 22 fern and fern- allies from the reserve. The Himalayan region of India is well explored for lichens in the past two centuries. A large number of lichens were collected and described in a number of revisionary and monographic studies on Indian lichens from the Himalayan region. The Terai region of Kumaun were not explored exhaustively for collection of lichens, therefore accounts of few lichen taxa are available on the earlier revisionary and monographic studies. Upreti and Upreti and Chatterjee [3] enumerated 69 species representing 21 genera of lichens found growing on different tree species in seven forests sites in Jim Corbett Tiger Reserve.

Upreti and Divakar [4] enumerated 108 species representing 35 genera of lichens found growing on 12 major tree species and other substrates in thirteen sites of Corbett Tiger Reserve. Nayaka et al., [5] enumerated 42 species of lichens belonging 25 genera, 15 families with the addition of 33 new species to the lichen flora of Terai of Uttar Pradesh, Bahraich, Katarniaghat Wildlife Sanctuary. Mishra et al., [6] enumerated 28 species of lichens belonging to 17 genera and 13 families in three forests localities of Udham Singh Nagar district with 6 species as new records to the state and *Bacidia delicata* (Larbal. *ex* Leighton) Coppins, as new record for Indian lichen

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biota. Except few cursory collection, most of the localities of the Terai region were not explored earlier, therefore an exhaustive lichen collection were undertaken in the area. In the present study an attempt has been made to map the Terai region of Kumaun for its environmental pollution status, based on the distribution pattern of different pollution tolerant and sensitive species of lichens. The published account of lichen species known from the area and specimens lodged in herbarium of LWG and species encountered during the recent fresh collection were employed for the present lichen zone mapping studies.

More than 300 lichen specimens were collected from Jaspur, Bazpur, Kashipur, Gadarpur, Rudrapur Tanda forests, Kichha, Nakulla, Sitarganj, Nanak sagar and Khatima. Most of the lichen specimens were collected from *Magnifera indica*, *Eucalyptus* base near ground, *Shorea robusta*, *Mallotus philippensis*, *Syzygium cumini*, *Murraya koengii* and *Ficus bengalensis.* The lichen specimens were examined morphologically, anatomically and chemically following Awasthi [7, 8, 9]. The external morphology has invariably been studied under dissecting microscope. The anatomy of the thallus and apothecia were studied under compound microscope. The colour tests for identification of chemicals were performed by well-known chemical reagents such as potassium hydroxide (K), para-phenyline-diamine (Pd) and calcium hypochlorite (C) on thalli and medulla of the plant. The lichen substances were investigated with thin layer chromatography in solvent system A (toluene: 1-4 dioxane: acetic acid in the ratio 180:60:4) [10].

2) MATERIAL AND METHODS

More than 300 lichen specimens were collected from Jaspur, Bazpur, Kashipur, Gadarpur, Rudrapur Tanda forests, Kichha, Nakulla, Sitarganj, Nanak sagar and Khatima. Most of the lichen specimens were collected from *Magnifera indica*, *Eucalyptus* base near ground, *Shorea robusta*, *Mallotus philippensis*, *Syzygium cumini*, *Murraya koengii* and *Ficus bengalensis.* The lichen specimens were examined morphologically, anatomically and chemically following Awasthi [7, 8, 9]. The external morphology has invariably been studied under dissecting microscope. The anatomy of the thallus and apothecia were studied under compound microscope. The colour tests for identification of chemicals were performed by well-known chemical reagents such as potassium hydroxide (K), para-phenyline-diamine (Pd) and calcium hypochlorite (C) on thalli and medulla of the plant. The lichen substances were investigated with thin layer chromatography in solvent system A (toluene: 1-4 dioxane: acetic acid in the ratio 180:60:4) [10].

3) RESULTS AND DISCUSSION

The Himalayan region is represented by more than 1000 species of lichen out of which 541 species are known to occur in Uttarakhand state [11]. Based on the examination of specimens, freshly collected and preserved herbarium of LWG and published account of lichens in literature, the Terai region of Kumaun comprised of 146 species of lichens belonging to 46 genera and 24 families (**Table 1**).

Table 1: Distribution of lichen taxa in Udham Singh Nagar and Jim Corbett Tiger Reserve

S.No.	LICHEN TAXA	LOCALITES																	
	Arthoniaceae	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	*Arthonia subgyrosa* Nyl.	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
2.	*Arthonia* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
3.	*Arthonia impolitella Nyl.*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
4.	*Arthonia medusula* (Pers.) Nyl.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
5.	*Arthonia radiata* (Pers.) Nyl.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
6.	*Arthothelium albescens* Patw. and Makhija	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
7.	*Arthothelium chiodectoides* (Nyl.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
8.	*Cryptothecia lunulata* (Zahlbr.) Makh. & Patw.	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+
9.	*Cryptothecia stirtonii* A.L. Smith	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
10.	*Herpothellon* sp.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Brigantiaceae																		
11.	*Brigantiaea leucoxantha* (Spreng.) R. Sant. & Hafellner	-	-	-	-	+	-	+	-	+	+	-	+	-	+	+	+	+	-
12.	*Brigantiaea* sp.	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*
	Caliciaceae																		
13.	*Amandinea subduplicata* (Vainio) Marbach	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
	Catillariaceae																		
14.	*Catillaria nilgirensis* Pant & Awasthi	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
	Chrysothriaceae																		
15.	*Chrysothrix candelaris* (L.) Laundon	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
	Coccarpiaceae																		
16.	*Coccocarpia pellita* (Ach.) Mull. Arg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
	Collemataceae																		
17.	*Leptogium austro-americanum*	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-

	(Malme) Dodge																		
18.	*Leptogium azureum* (Swartz) Vainio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Graphidaceae																			
19.	*Diorygma hieroglyphicum (*Pers.*)* Staiger & Kalb	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
20.	*Diorygma junghuhnii* (Mont & Bosch.) Kalb. Staiger & Elix	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
21.	*Fissurina* sp.	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
22.	*Fissurina dumastii* Fée	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
23.	*Graphis ajarekarii* Patw. & C. R. Kulk.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
24.	*Graphis capillacea* Stirt.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
25.	*Graphis chlorotica* A. Massal.	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
26.	*Graphis crebra* Vain.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
27.	*Graphis duplicata* Ach.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
28.	*Graphis glaucescens* Fée	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
29.	*Graphis implexula* Stirton	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
30.	*Graphis lineola* Ach.	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
31.	*Graphis longiramea* Müll. Arg.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
32.	*Graphis nakanishiana* Patw. & Kulk.	-	-	-	-	-	-	-	+	-	+	-	+	-	+	-	-	-
33.	*Graphis nigroglauca* Leighton	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
34.	*Graphis pinicola* Zahlbr.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
35.	*Graphis pyrrohocheiloides* Zahlbr.	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-
36.	*Graphis scripta* (L.) Ach.	-	-	+	-	+	-	+	+	-	-	-	+	-	+	-	-	-
37.	*Graphis subashinae* Nagarkar & Patw.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
38.	*Graphis submarginata* Lucking	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
39.	*Hemithecium aphanes* (Mont.) Nakan. Kashw.	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
40.	*Hemithecium caesiorodians* (Leighton) V. Tiwari & Upreti Combo nova	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
41.	*Hemithecium nepalensis* (Awasthi & K. Singh) V. Tiwari & Upreti combo nova	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
42.	*Hemithecium* sp.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
43.	*Phaeographis albolabiata* Pat. & Kulkarni	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
44.	*Phaeographis divaricoides* Räsänen	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
45.	*Phaeographis firmula* (Stirton) V. Tewari and Upreti	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
46.	*Phaeographis instrata* (Stirton) Zahlbr.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
47.	*Phaeographis subdividens* (Leighton) Müll. Arg	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Lecanoraceae																			
48.	*Lecanora achroa* Nyl.	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-
49.	*Lecanora cinereofusca* H. Magn	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
50.	*Lecanora fimbriatula* Stirton	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
51.	*Lecanora helva* Stizenb.	-	-	+	-	-	-	-	-	-	-	+	+	-	-	-	-	-
52.	*Lecanora queenslandica* Knight in Bailey	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-
53.	*Lecanora pulicaris* (Pers.) Ach.	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
54.	*Lecanora tropica* Zahlbr.	-	-	-	-	-	+	-	+	-	-	-	+	-	+	-	-	-
55.	*Lecanora xylophila* Hue.	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
56.	*Rambolidia* sp.	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
Lecideaceae																			
57.	*Lecidia* sp.	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-	-
Letrouitiaceae																			
58.	*Letrouitia leucoxantha* (Sprengel) R.	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	+	-	-

	Sant. & Haf. In Haf. & Bellem.																		
59.	*Letrouitia transgressa* (Malme) Haf. & Bellem	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monoblastaceae																			
60.	*Anisomeridium americanum* (A. Massal.) R.C. Harris	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61.	*Anisomeridium albisedum* (Nyl.) R. C. Harris	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Parmeliaceae																			
62.	*Bulbothrix isidiza* (Nyl.) Hale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
63.	*Parmelia praesorediosa* Nyl.	-	-	-	-	-	-	-											
64.	*Parmotrema mesotropum* (Mull. Arg.) Hale	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-
65.	*Parmotrema praesorediosum* (Nyl.) Hale	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-
66.	*Parmotrema sacatilobum* (Taylor) Hale	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-
67.	*Parmotrema tinctorum* (Nyl.) Hale	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+
Pertusariaceae																			
68.	*Pertusaria acuta* Mull. Arg.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
69.	*Pertusaria coccodes* (Ach.) Nyl.	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*
70.	*Pertusaria concinna* Erichsen	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
71.	*Pertusaria dispressa* (Fée) Mont. V. d. Bosch.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
72.	*Pertusaria himalayensis* Awasthi & Srivastava	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-
73.	*Pertusaria leioplacella* Nyl.	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-
74.	*Pertusaria leucostoma* (Bernh.) A. Massal	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.	*Pertusaria pertusa* (Weigel) Tuck	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
76.	*Pertusaria punctata* Nyl.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
77.	*Pertusaria quassiae* (Fée) Nyl.	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
78.	*Pertusaria rigida* (Müll.) Arg.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
79.	*Pertusaria subdepressa* Müll. Arg.	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*
Physciaceae																			
80.	*Buellia curtisii* (Tuck.) Smash in Brodo	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
81.	*Buellia inornata* Nyl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+
82.	*Buellia stigmea* Tuck.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
83.	*Dirinaria aegialita* (Afz. in Ach.) Moore	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
84.	*Dirinaria appalanta* (Fee) D. D. Awasthi	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
85.	*Dirinaria confluens* (Fr.) Awasthi	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
86.	*Dirinaria consimilis* (Stirton) Awasthi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
87.	*Hyperphyscia adglutinata* (Florke) Mayrhofer & Poelt.	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
88.	*Hyperphyscia adglutinata* var. *adglutinata* (Florke) Mayrhofer & Poelt.	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
89.	*Hyperphyscia adglutinata* var. *pyrithrocardia* (Mull. Arg.) D. D. Awasthi Com. nov	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
90.	*Heterodermia microphylla* (Kurokawa) Sko	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*
91.	*Phaeophyscia hispidula* (Ach.) Moberg.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
92.	*Phylliscum indicum* Upreti	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-
93.	*Physcia clementi* (Sm. in Sm. & Sow.) Lynge	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-

94.	*Physcia dilatata* Nyl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
95.	*Pyxine coccoes* (Sw.) Nyl.	+	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
96.	*Pyxine reticulata* (Vain.) Vain	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
97.	*Pyxine sorediata* (Ach.) Mont.	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
98.	*Pyxine subcinerea* Stirt.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
99.	*Rinodina sophodes* (Ach.) Massal.	+	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Pilocarpaceae																			
100.	*Micarea* sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
101.	*Tapellaria saxicola* Vezda & Poelt	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*
Porinaceae																			
102.	*Clathroporina anoptella* (Stirton) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
103.	*Clathroporina duplicascens* (Nyl.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Pyrenulaceae																			
104.	*Anthracothecium himalayense* (Räsänen) D. D. Awasthi	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
105.	*Pyrenula aggregata* Fée	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
106.	*Pyrenula aspistea* (Ach.) Ach.	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-
107.	*Pyrenula brunnea* Fée	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
108.	*Pyrenula conspercata* Müll. Arg.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
109.	*Pyrenula immersa* Müll. Arg.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
110.	*Pyrenula immissa* (Stirton) Müll. Arg.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
111.	*Pyrenula interducta* (Nyl.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-
112.	*Pyrenula introducta* (Stirton) Zahlbr.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
113.	*Pyrenula mastophorizans* Müll. Arg.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
114.	*Pyrenula sublaevigata* (Patw. & Makhija) Upreti	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
115.	*Pyrenula submastrophora* A. Singh & Upreti	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
116.	*Pyrenula subrizalensis* A. Singh & Upreti	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
117.	*Pyrenula sulcata* (Stirton) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Ramaliaceae																			
118.	*Bacidia alutacea* (Krempel.) Zahlbr.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119.	*Bacidia arnoldiana* Korber	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
120.	*Bacidia convexula* (Müll. Arg.) Zahlbr.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
121.	*Bacidia delicata* (Larbal. ex Leight) Coppins	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
122.	*Bacidia incongruens* (Stirt.) Zahlbr.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123.	*Bacidia laurocerasi* (Del. *ex* Duby) Ozenda & Clauz	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-
124.	*Bacidia medialis* (Tuck. In Nyl.) Zahlbr.	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-
125.	*Bacidia millegrana* (Taylor) Mull. Arg.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
126.	*Bacidia nigrofusca* (Müll. Arg.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-
127.	*Bacidia nigrosticta* Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
128.	*Bacidia phaeolomoides* (Müll. Arg.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
129.	*Bacidia psorina* (Nyl. ex Hue) G. Pant & D. D. Awasthi	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
130.	*Bacidia rubella* (Hoffm.) Massal.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
131.	*Bacidia rufescens* (Müll. Arg.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
132.	*Bacidia submedialis* (Nyl.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Roccellaceae																			
133.	*Opeghrapha dimidiata* Müll. Arg.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

134.	*Opeghrapha inequalis* Fée	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
135.	*Opeghrapha rufescens* Pers.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
136.	*Opegrapha varia* Pers.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
137.	*Opeghrapha vulgata* (Ach.) Ach.	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Stereocaulaceae																			
138.	*Lepraria lobificans* Nyl.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Teloschistaceae																			
139.	*Caloplaca bassiae* (Willd. ex Ach.) Zahlbr.	+	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
140.	*Caloplaca malaensis* (Räsänen) Awasthi	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	-	-
141.	*Caloplaca subnigricans* Magn.	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Trypetheliaceae																			
142.	*Polymeridium* sp.	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Verrucariceae																			
143.	*Endocarpon pallidum* Ach.	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*
144.	*Endocarpon rosettum* Singh & Upreti	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
145.	*Staurothele fissa* (Taylor) zwacke	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
146.	*Verrucaria cincta* (Flag.) Hepp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-

Abbreviations: + Present, - Absent, * Jim Corbett Tiger Reserve
Localities: 1-Jaspur, 2-Kashipur, 3-Bazpur, 4-Gadarpur, 5-Rudrapur, 6-Sitarganj, 7-Khatima, 8-Chuhi, 9-Dhikala, 10-Sultan, 11-Malani, 12-Paterpani, 13-Jhirna, 14-Bijrani, 15-Jamunagaur, 16-Mohan, 17-Lohachaur, 18-Vatan vasa

Among the different localities, Tanda forest in Rudrapur, Khatima forests of district Udham Singh Nagar and Chuhi Srot area in Jim Corbett Tiger Reserve have the rich diversity of lichens represented by 19 each and 28 species respectively. Both the localities have dense forest of *Shorea robusta*, *Murraya koengii* and *Mallotus philippensis*. The trees of *Syzygium cumini* in moist shady places along the stream provide suitable habitat for many lichens to colonize. All the tree species have wide variation in bark nature thus provide varied lichen taxa to colonize. The rough old and dry bark exhibits growth of Graphidaceous and Pyrenocarpous lichen genera, *Graphis*, *Diorygma*, *Phaeographis* and *Pyrenula* respectively.

The Bazpur forests in USN and Sultan, Malani, Paterpani, Jhirna and Jamunaguar in Jim Corbett Tiger Reserve showed the moderate growth of lichens. The localities have tourist pressure and forest remains in patches provide few habitats in centre of the forest suitable for lichens to colonize. The isolated *Shorea robusta* trees and cultivated trees of *Magnifera indica* provide niche for few lichens to colonize.

The Jaspur, Kashipur, Gadarpur, Sitarganj in USN, Dhikala, Bijrani, Mohan, Lohachaur and Vatan Vasa in Jim Corbett Tiger Reserve showed scarce growth of lichens. The localities situated in urban areas (industrial) or in areas having deforested lands showed poor growth of lichens. Mostly the pollution tolerant species of lichen genera *Pyxine*, *Dirinaria* and *Rinodina* belonging to family Physciaceae (well known pollution tolerant lichens) are found growing on cultivated *Magnifera indica* and *Shorea robusta* trees in the urban and industrial sites.

The Terai region showed dominance of crustose lichens as out of 146 species known from the area, 116 species belongs to the crustose growth form. The moist, shady and unpolluted sites showed rich diversity of foliose lichens represented by 27 species. The leprose and squamulose growth forms are represented by 3 species each.

Among the different phorophytes, *Syzygium cumini* exhibit the rich diversity of epiphytic lichens represented by 52 species followed by *Shorea robusta* and *Mallotus philippensis* with 31 and 29 species respectively. *Murraya koengii*, a small shrub together with *Ficus bengalensis* also provide suitable habitat for good growth of few lichens represented by 10 and 8 species respectively. The *Magnifera* trees in Tanda, Bazpur and Khatima localities showed complete absence of lichens while in more or less pollution free area of Jim Corbett Tiger reserve. *Magnifera* bear luxuriant growth of 7 epiphytic lichens.

Among the different lichen genera *Bacidia* and *Graphis* with 15 species each showed their dominance followed by *Pyrenula* and *Pertusaria* represented by 13 and 12 species respectively. The Physciaceae is the dominant family represented by 8 genera and 17 species followed by family Graphidaceae which is represented by 5 genera and 28 species.

The Jaspur and Gadarpur are the tehsils of USN and devoid of forest vegetation. The Jaspur have cultivated tress of *Magnifera indica*, along the road side in most places show luxuriant growth of *Pyxine* species along with crustose species of lichen genera *Bacidia, Caloplaca, Rinodina sophodes*, *Lecanora* and *Anisomeridium*. However, the Gadarpur area showed occurrence of a *Hyperphyscia* and *Pyxine* with three species of custose lichen genera *Anisomeridium, Caloplaca bassaie* and *Rinodina*.

The Bazpur forests on the way to Kaladhungi and before Kaladhungi have luxuriant growth of crustose lichens represented by 18 species belonging to 9 genera together with two foliose lichen species of genera *Pyxine* and *Hyperphyscia.*

The forests of Tanda have mixed vegetation of *Murraya koengii, Mallotus philippensis* together with the trees of *Shorea robusta*, *Syzygium cumini.* The Tanda forests exhibit occurrence of 19 species belonging to 12 genera. Except *Hyperphyscia adglutinata*, *Dirinaria*, *Phaeophyscia* and *Pyxine*, foliose lichen, the area also showed luxuriant growth

of crustose genera *Anthracothecium*, *Bacidia*, *Diorygma*, *Brigantiaea*, *Graphis*, *Micarea* and *Rinodina* species.

The Khatima forest comprises of dense *Shorea robusta* trees together with *Terminalia arjuna* and *Toona ciliata*. The phorophytes of the forest provide perfect niche for growth of both crustose and foliose species (*Dirinaria*, *Pyxine* and *Hyperphyscia*). The study area showed dominance of 19 lichen taxa. According to Van Herk et al., [12], the Physcoid lichens are considered as the pollution tolerant lichens and their presence indicates nitrophilous environment. Out of the 46 genera recorded from the study area 29 species within 8 genera belongs to the pollution tolerant species of lichens, which were mostly found growing in more or less polluted sites near industrial areas or in city centre having higher anthropogenic activities. The pollution tolerant genera includes *Buellia*, *Dirinaria*, *Lecanora*, *Hyperphyscia*, *Phaeophyscia*, *Physcia*, *Pyxine* and *Rinodina*.

15 species of 10 genera of lichens belongs to pollution sensitive species as they showed their occurrence mostly in the areas having less industrial and human activities. The species of genera *Anthracothecium*, *Amandinea*, *Catillaria*, *Cladonia*, *Chrysothrix*, *Clathoporina*, *Coccocarpia*, *Collema*, *Leptogium*, *Thelotrema* belongs to the pollution sensitive group of lichens.

About 121 semi-tolerant species belonging to 31 genera dominates the area having moderate human activities. The semi-tolerant lichen species includes species of lichen genera *Arthonia*, *Arthothelium*, *Anisomeridium*, *Bacidia*, *Diorygma*, *Bulbothrix*, *Caloplaca*, *Cryptothecia*, *Chrysothrix*, *Diploschistes*, *Endocarpon*, *Fissurina*, *Graphis*, *Lecidia*, *Lepraria*, *Hemithecium*, *Herpothellon*, *Opegrapha*, *Letrouitia*, *Parmotrema*, *Pertusaria*, *Pyrenula*, *Parmelia*, *Phaeographis*, *Phylliscum*, *Staurothele*, *Tapellaria*, *Verrucaria*, *Polymeridium* and *Micarea*.

The district Udham Singh Nagar can be distinguished into three distinct zones on the basis of degree of pollution level (**Fig. 1**). The Bazpur, Khatima and Rudrapur comes under the highly polluted sites due to industrialization and urbanization represented 23 tolerant, 29 semi-sensitive and single sensitive species (*Anthracothecium himalayense*) followed by semi-sensitive sites *viz*. Gadarpur, Jaspur and Sitarganj. The semi-sensitive sites showed 7 tolerant species followed by 7 semi-sensitive species. Though Kashipur is also industrialized, but the city showed least growth of lichens represented by only one semi-sensitive species (*Anisomeridium americanum*) sites. The study area can be mapped with three distinct zones with varied degree of pollution based on the number of tolerant, semi-tolerant and sensitive species of lichens (**Fig. 2**). The distribution and diversity of three categories of lichen species i.e. tolerant, semi-tolerant and sensitive clearly distinguish the highly, moderately and more or less pollution free localities in the study area. The study provides general quantitative estimation of environmental condition of the area.

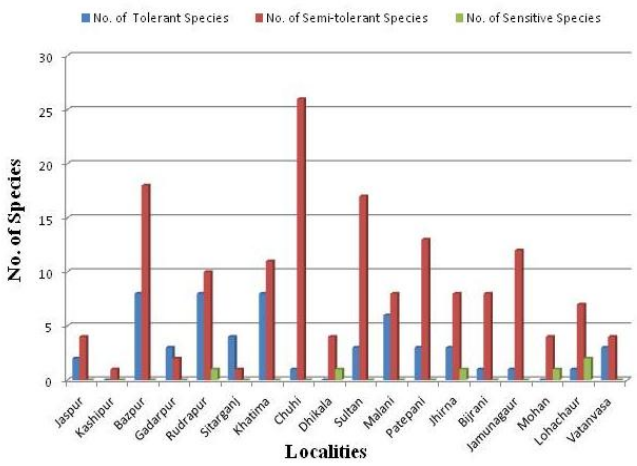

Fig. 1: Distribution of lichen species in Terai Region of kumaun

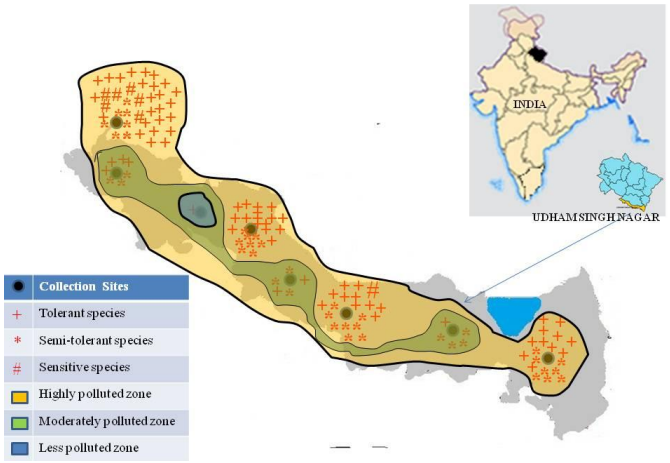

Fig. 2: Map showing distribution of tolerant, semi-tolerant and sensitive species of lichen in three distinct lichens zones in Terai region of Kumaun

4) CONCLUSION

The present study provides an enumeration of diversity and distribution of lichen species for carrying out future bio-monitoring studies in the area. The periodical change in diversity and distribution in lichen species can be co-related to the change in the environmental condition of the area.

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