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Lichens biodiversity in Uttarakhand and significance of precise species identification for promoting lichen conservation and trade

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Abstract

Uttarakhand is considered a reservoir of lichen-diversity. Besides their economic importance, lichens are valuable biomonitors of air pollution. At present, approximately 747 species of lichens are reported from the state of Uttarakhand. This study aims at studying the lichen biodiversity of the Kumaun and Garhwal region of Uttarakhand using secondary data, from published literature. In view of rich lichen-biodiversity in the state, it has been suggested that lichen-trade has potential of providing good employment opportunities to the local people in Uttarakhand. However, due to ignorance in precise lichen identification/grading, their share in the total trade-profit remains minimal. Precise species identification in lichen is also crucial for the conservation of rare, endangered, and threatened (RET) and endemic lichens. Due to climatic change and anthropogenic factors many species of lichens are at the verge of extinction. Moreover, it has been estimated that many of the species might already have extincted without ever being identified, possibly/partially due to their cryptic morphology. Unavailability of sufficient number of trained human resource in lichen-taxonomy/identification is another issue jeopardizing the conservation efforts. Therefore, we advocate development of a resource group for training the people in lichen research and trade with precise lichen-identification methods. Additionally, the characterization of lichen biodiversity needs to be complemented with modern methods such as DNA-barcoding and advance variants of complementary chemotaxonomy. The lichen resource group may also participate in sensitizing stakeholders in lichen biodiversity-conservation as well through community awareness programs.

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Introduction

The word 'lichen' was first coined by Theophrastus, the father of botany (371 – 284 B. C). It was originally used for one of its form visible as the superficial growth on the bark of olive trees. Lichen is also commonly known as stone flower. In Garhwal region of Uttarakhand local name of lichen is 'Mukku' and in Kumaun region locally it is known as Jhoola. Lichens represent an example of the mutualistic interaction. The lichen is defined as a symbiotic relationship between an alga and a fungus, also known as photobiont and mycobiont respectively. The Greek meaning of symbiosis is 'living together'.

The lichenized fungi mostly form mutualistic association with green algae or cyanobacterium, which take part in the photosynthesis, whereas, the fungal counterpart takes part in absorption and provides support to the association (Shukla *et al.,* 2014). The main body of lichens (also known as thallus) is mostly represented by its fungal partner that contains the phycobiont cells inside. Therefore, the lichens are mostly studied with fungi and are placed in the kingdom Mycota. Approximately 95% of mycobionts in all lichens belong to Ascomycota, whereas, the remaining approximately 5% fungal partners in lichens combinedly belong to Basidiomycota and Deuteriomycota.

Lichens have three cardinal growth forms: Crustose, Foliose and Fruticose. Lichens are able to survive for many years in very diverse habitats. The lichens growing on barks are called corticolous lichens, those inhabiting wood are known as legnicolous**,** growing on rocks are saxicolous lichens and those inhabiting soil are known as terricolous lichens (Thormann *et al.,* 2006). Lichen also well known for their commercial and ethnic uses (Upreti *et al.,* 2005).

In Uttarakhand, both Kumaun and Garhwal regions are among the biggest reservoirs of the plant diversity including lichen flora. The state of Uttarakhand has total 53,524 Km² areas, and 64% of this is covered by the forest (Kumar, 2010). In India, approximately 2305 species of Lichens have been reported belonging to 305 genera and 75 families. From these about 1000 species are found in Himalayan region. Approximately 747 species of Lichens are reported from Uttarakhand (Mishra *et al.,* 2016). After 2016, some more new species also reported by lichenologists that are reviewed in the present article. Being a biodiversity hotspot Uttarakhand is abode to many therapeutically and economically important floras. Numerous of the lichens are known for their industrial and therapeutic applications.

Many of them are of medicinal importance and display anti-microbial, anti-oxidant, anti-bacterial or anti-cancerous properties due to the presence of relevant secondary metabolites in their thalli (Xu *et al.,* 2016). Industrially they are also used for the synthesis of litmus paper, dyes perfumes and as food. Lichens also serve as valuable biomonitors and bioindicators of air pollution.

Lichens are highly sensitive to air pollution, especially to sulphur dioxide (SO_2) pollution and also to certain heavy metal toxicity (Bajpai *et al.*, 2019). Therefore, distribution of lichens also indicates the air quality and presence of heavy metals in any geographical area. In the growing cities, with increasing industrialization and traffic the abundance and diversity of lichens is being severely harmed. However, the less industrialized hilly areas are rich repertoirs of lichen biodiversity (Shukla *et al.*, 2007).

The lichen flora from Indian Himalayas has been documented by many lichenologists in past. Many lichen species have been identified and documented from all the districts of Uttarakhand (Kumaun & Garhwal) in dividually; however, the combined data highlighting the (approximate) GPS-coordinates for these different lichen-abodes have not been reported yet.

This study is an attempt to present the current scenario of lichen biodiversity and its localization/ distribution within various districts of Uttarakhand, identification methods in current practice, major threats to the lichen biodiversity, lichen collection and trading system functional within the Himalayan state-Uttarakhand, status of endemic, rare and

endangered lichen species, and the challenges associated with conservation-efforts focused for lichens. Additionally, we also discuss the significance of precise species identification for promoting lichen conservation and trade in Uttarakhand.

Lichen Collection System and Market in Uttarakhand

According to Shah *et al* approximately, 750 metric tons of lichens are collected from the hilly areas of Uttarakhand and 800 metric tons are collected from the other regions of India (Shah *et al.,* 1998). Whereas a newer report suggests that annually approximately 2400 tonnes (24K quintals) of lichen collected from Uttarakhand-hills is sold at three state herbal mandis of Uttarakhand Forest Development Corporation situated at Tanakpur, Rishikesh and Ramnagar (The Pioneer, 8 Feb 2008).

Different organizations have been involved in the collections of lichens in Kumaun and Garhwal region. Earlier, the lichen collection business was based on the contractor system and the forest department of the state used to directly invite tenders from the contractors for the harvesting of all the forest products which resulted in uncontrolled exploitation of forest products.

Though Zila Bhesagh Sangh Sahkari Samiti (ZBSSS) (a registered public institution central society under corporative samiti Act 1965) was already operational in almost all districts since 1983, but its role was limited to regulating the trade just at the extraction level, and possibly due to its limited resources not enough for covering the large intended area, this organization couldn't efficiently control the overexploitation. Therefore, to control this overexploitation of forest products the Van Vikash Nigam (VVN) was deputed in 2004 to provide support to the forest department (FD) in sustainable harvesting, conservation, production and the marketing of forest products. Additionally, two other semi government corporations, Garhwal Mandal Vikas Nigam (GMVN) and Kumaun Mandal Vikas Nigam (KMVN) were also delegated for selected ranges in Garhwal and Kumaun regions respectively (Kumar *et al*., 2010).

Presently there are two major channels used for collection of lichens from Uttarakhand hills: For the area under direct control of Forest department of the state, the department involves ZBSSS, VVN and/or KMVN/GMVN. The forest department opens few of its forest ranges (on rotational basis) each year and ZBSSS provides permit to local contractors who collect lichens with the help of villagers and laborers.

Villagers collect lichens on daily basis and after drying sell them to the locally established retail shop of the contractor. ZBSSS validates the quantity of lichen-mass collected by the contractor and facilitates issuing of transit pass (Ravanna) to the contractor for carrying the collected mass to VVN-depot located at three major *Mandis* of lichens: Ramnagar, Tanakpur and Rishikesh in Uttarakhand.

VVN carries out auctioning of collected lichens and finally the lichen-mass is transported to the destination for industrial use. On the other hand, for the forests under the control of Van panchayats, the Van panchayat seeks permission from ZBSSS for lichen collection and then allows villagers to collect lichens. After collection ZBSSS facilitates the transport of lichens to VVN depot for auction (Kumar *et al*., 2010) (Fig. 1).

Collection sites of lichen in Kumaun and Garhwal region studied by researcher

The state of Uttarakhand has very rich biodiversity of lichen species. This state has two regions: Kumaun and Garhwal. Many field studies have been carried out in both of these areas by different researchers for studying lichen biodiversity. Approximately, a of total 246 lichen species belonging to 45 genera and 13 families are reported in the Kumaun Himalayan region (Mishra & Upreti, 2016). The dominant reported families are Parmeliaceae and Physciaceae. In Kumaun, district Udham Singh Nagar comes under the tropical region. In this district the lichen biodiversity is low due to less forest area and increasing industrialization and urbanization. Other five districts come under the temperate regions and all are rich in forest cover and lichen diversity.

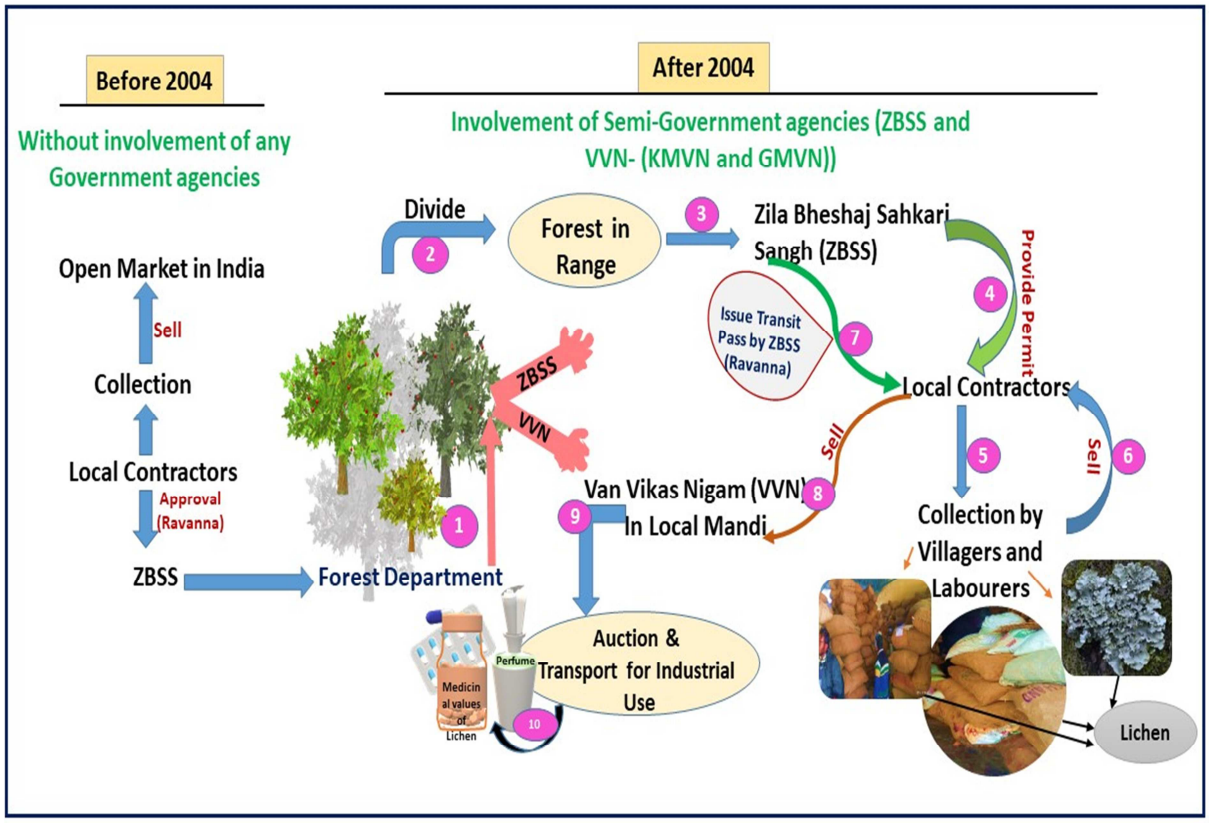

Fig. 1. Different channels used for collection of lichens from Uttarakhand hills.

The Pindari Glacier of Bageshwar and Milam Glacier of Pithoragarh are considered treasures of lichens. Similarly, the Garhwal region is also the rich in lichen biodiversity. Rai *et al.* (2015) collected total 912 samples of lichen and reported a total of 148 species of only terricolous lichens from all districts of Garhwal (Rai *et al.,* 2015). In 2009, Kumar *et al.* carried out marketing survey of lichen in three different Lichen-Mandis of Kumaun region (Tanakpur, Ramnagar and Rishikesh) (Kumar *et al.,* 2009).

In 2007, Shukla and Upreti studied on the foliose lichen *Phaeophyscia hispidula* (Shukla *et al.,* 2007). In 2005, they collected samples from 13 different areas of Pauri Garhwal and Srinagar and examined the effect of increasing traffic and urbanization on lichens (Shukla *et al.,* 2005). In 2011, Joshi *et al*, studied lichens of the Pindari Glacier area of Uttarakhand. They collected total 800 specimens of lichen from Loharkhet to Pindari Glacier in Bageshwar district of Kumaun region of Uttarakhand, belonging to total 283 species, 77 genera and 35 families (Joshi *et al.,* 2011). Rawat *et al.* (2013) collected more than 450 lichen samples from Niti and Gamsali area of Garhwal Himalaya region for diversity assessment and reported 43 species (Rawat *et al.,* 2013).

The details of available published literature used for enumerating lichen species of Uttarakhand in this review are summarized in Table 1.

Additionally, in each of the districts, distribution of lichens is demonstrated on the basis of coordinates and altitudes (Table 3 and Fig. 2).

The GPS coordinates are used for the probing of altitude, latitude and longitude of the approachable region of dominant lichen species in Uttarakhand. Triangles are drawn on map, to get a tentative overview of explored Lichen-rich areas. Latitude, longitude and altitude of three corners of triangular areas are displayed.

Table 1. Lichen-biodiversity reported from various regions of Uttarakhand by different researchers.

(A) Kumaun region

1. District: Almora

Major lichen rich/explored areas:

Sunani Binsar Grove[1]

References: (Mishra & Upreti, 2016; Kumar, 2010; Sonam *et al.,* 2017; Jagtap *et al.,* 2013) (Joshi & Tripathi 2013; Joshi *et al.,* 2013, 2014abc; Chandra *et al.,* 2016)**

Reported Lichen species:

*Bulbothrix meizospora[1], Bulbothrix setschwanensis[1], Canoparmelia aptata[1], Canoparmelia pustulescaris [1], Canoparmelia texana[1], Cetrariopsis wallichiana[1], Cetrelia cerarioides[1], Chrysothrix candelaris [1], Dermatocarpon vellereum[1], Diorygma sp.[1], Everniastrum cirrhatum[1], Everniastrum nepalense[1], Flavoparmelia caperata[1], Heterodermia diademata[1], Heterodermia speciosa[1], Hyperphyscia adglutinata[1], Lecanora polytropa[1], Leptogium askotense[1], Leptogium papillosum[1], Leptogium pedicellatum[1], Lobaria retigera[1], Parmotrema austrosinense[1], Parmotrema melanothrix[1], Parmotrema mesotropum[1], Parmotrema nilgherrense[1], Parmotrema reticulatum[1], Parmotrema tinctorum[1], Pertusaria leucosona[1], Phaeophyscia hispidula[1], Porpidia macrocarpa[1], Punctelia rudecta[1], Punctelia subrudecta[1], Ramalina conduplicans[1], Ramalina hossei[1], Ramalina sinensis[1], Trapelia coarctata[1], Umbilicaria virginis[1], Usnea orientalis Mot. [1], Buellia almorensis[*], Caloplaca squamosa[*], Dirinaria picta[*], Heterodermia himalayensis[*], Heterodermia punctifera[*], Parmotrema subtinctorium[*], Pertusaria indica[*], Pertusaria variolosa[*], Phlyctis himalayensis[*], Physcia aipolia[*],Physcia tribacioides [*], Physconia enteroxantha[*], Anisomeridium polypore**, Byssoloma subdiscordans**, Canoparmelia crozalsiana**, Caloplaca flavovirescens**, Caloplaca subsoluta**, Candelaria concolor**, Collema leptaleum var. biliosum**,Collema pulcellum var. subnigrescens**, Flavopunctelia borrerioides**, Heterodermia comosa**, Heterodermia firmula**, Heterodermia japonica**, Heterodermia obscurata**, Heterodermia pseudospeciosa**, Hyperphyscia adglutinata var. pyrithrocardia**, Myelochroa aurulenta**, Parmotrema crinitum**, Physcia dilatata**, Punctelia borreri**, Xanthoparmelia pseudocongensis**, Xanthoparmelia saxeti**, Xanthoparmelia mexicana***

2. District: Bageshwar

Major lichen rich/explored areas:

Jatoli[1], Zero Points[2], Loharkhet[3], Dwali[4], Phurkia[5], Mirtoli[6], Dhakuri[7], Khati[8], Song[9], Kapkot[10], Loharkhet[11*], Loharkhet to Dhakuri[12*], Dhakuri[13*], Dhakuri to Khati[14*], Khati to Dwali[15*], Dwali to Phurkia[16*], Phurkia[17*], Phurkia to Pindari[18*], Pindari Glacier[19*]

References: (Mishra & Upreti, 2016**; Joshi *et al.,* 2011*; Mishra *et al.,* 2014)

Reported Lichen species:

Acarospora smaragdula[1,6,7,18], Anthracothecium oculatum[3], Anthracothecium assamiense [1,7], Anthracothecium depressum[4,8,15], Anthracothecium himalayense[1,3,7,8,15], Anthracothecium manipurense[1,4,7,8,15], Anthracothecium platystomum[1,3,4,7,8,12,15], Anthracothecium thwaitesii[1,4,7,8,14,15], Arthothelium chiodectoides[4,5,16], Aspicilia almorensis[4,5,7,8,14,16], Aspicilia caesiocinerea[5,6,7,13,16,17,18], Aspicilia calcarea[2,3,4,5,6,7,8,11,15,18], Aspicilia cinerea[3,7,8,14], Aspicilia dwaliensis[2,5,6,7,8,16,17,18], Aspicilia griseocinerea[3,4,5,7,8,11,15], Aspicilia maculata[5], Bacidia laurocerasi[3], Bacidia alutacea[4,8,15], Bacidia incongruens[3,7,12], Bacidia laurocerasi[7,8,14,10], Bacidia millegrana[4,5,16], Bacidia nigrofusca[4,7,8,14,15], Bacidia phaeolomoides[7,8,14], Bacidia rosella[3,7,12], Bacidia rubella[8], Bryoria bicolor[3,7,13], Bryoria confusa[4,7,12], Bryoria smithii[3,7,12,13], Buellia aethalea[3,11], Bulbothrix isidiza[3,7,12,18], Bulbothrix meizospora[3,4,5,7,12,13,15,16], Bulbothrix

sensibilis[3,7,8,11,14], *Bulbothrix setschwanensis*[3,4,7,8,12,15], *Calicium subquercinum*[7,8,14], *Caloplaca approximata*[2,5,7,8,12,13,14,18], *Caloplaca arenaria*[5,6], *Caloplaca cinnabarina*[3,7,11,12], *Caloplaca citrina*[4,5,8,15,16], *Caloplaca cupulifera*[3,7,11,12], *Caloplaca flavocitrina*[4,8,15], *Caloplaca flavorubescens*[4,7,8,14,15], *Caloplaca flavovirescens*[4,5,7,8,14,15,16], *Caloplaca jatolii*[1], *Caloplaca lithophila*[7,8,13], *Caloplaca obliterans*[4,5,8,15,16,17], *Caloplaca ochroplaca*[4,7,8,14,15,18], *Caloplaca pachychelia*[2,5,18], *Caloplaca pyracea*[8], *Caloplaca saxicola*[5,17,18], *Caloplaca subbassiae*[3,9,11], *Caloplaca triloculans*[7,8,14], *Candelaria concolor*[1,3,7,8,10,11], *Candelaria indica*[3,4,5,9,10,16], *Candelariella vitellina*[6,7,17,18], *Canoparmelia aptata*[4], *Canoparmelia texana*[3,11], *Catapyrenium cinereum*[3,7], *Cetraria islandica*[3,17,18], *Cetraria nigricans*[5,6], *Cetrelia braunsiana*[3,4,5,7,8,12,13,14,15,17], *Cetrelia cetrarioides*[3,4,5,7,8,12,13,14,15,16], *Cetrelia collata*[7], *Cetrelia olivetorum*[4,5,7,8,14,15,16], *Cetreliopsis rhytidocarpa*[3,4,7,8,12,15], *Chrysothrix candelaris*[1,4,7,8,14,15], *Chrysothrix chlorina*[7], *Cladonia corniculata*[8], *Cladonia cartilaginea*[3,4,5,6,11,18], *Cladonia ceratophyllina*[1], *Cladonia chlorophaea*[4,5,6,7,13,17,18], *Cladonia coccifera*[5,17], *Cladonia coniocraea*[3,4,5,16], *Cladonia corniculata*[1,3,4,7,12,15], *Cladonia corymbescens*[1,3,4,6,7,12,14,15,17,18], *Cladonia delavayi*[5,18], *Cladonia didyma*[1,7,8,14], *Cladonia fenestralis*[2,5,6,7,16,18], *Cladonia fimbriata*[3,7,12], *Cladonia fruticulosa*[1], *Cladonia furcata*[3,4,5,6,7,12,13,16], *Cladonia macilenta*[1], *Cladonia macroptera*[6,18], *Cladonia pocillum*[4,5,6,16,17,18], *Cladonia pyxidata*[2,3,4,5,6,16,17,18], *Cladonia scabriuscula*[3,4,7], *Cladonia singhii*[4,7,8,15], *Cladonia squamosa*[1,7], *Cladonia subulata*[4,5,16], *Cladonia verticillata*[4,8,12], *Coccocarpia erythroxyli*[4,5,6,16,18], *Coccocarpia pellita*[1], *Collema auriculiformis*[18], *Collema auriforme*[6], *Collema coccophorum*[3,5,6,11], *Collema crispum*[5,6,18], *Collema furfuraceum*[4], *Collema kauaiense*[6], *Collema pulcellum*[3,4,7,8,11,12], *Collema subconveniens*[3,7,9,10,12], *Collema subflaccidum*[3,10], *Collema subnigrescens*[3,4,8,11], *Coniocybe coniophaea*[4,8,15], *Dermatocarpon meiophyllizum*[4,5], *Dermatocarpon miniatum*[4,5,7,8,14,15,16,17], *Dermatocarpon vellereum*[4,8,11,15], *Dermatocharpon vellereum*[3], *Diploschistes diacapsis*[1,7], *Diploschistes awasthii*[5,17], *Diploschistes diacapsis*[5,18], *Diploschistes gypsaceus*[5,17], *Diploschistes scruposus*[3,4,5,8,11,15,16,18], *Dirinaria confluens*[4,5,16], *Endocarpon nigrozonatum*[7,8,14], *Endocarpon subrosettum*[5,6,18], *Everniastrum cirrhatum*[1,3,4,7,8,12,13,14,15,16,18], *Everniastrum nepalense*[3,4,7,8,11,12,13,,14,16], *Flavocetraria cucullata*[5,17], *Flavocetrariella leucostigma*[2,5,6,18], *Flavocetrariella melaloma*[5,6,18], *Flavoparmelia caperata*[4,7,8,14,15], *Fuscopannaria saltuensis*[3,5,6,7,12], *Graphis scripta*[3], *Graphis chlorotica*[4,5,16], *Graphis duplicata*[1,7], *Graphis lineola*[7,8], *Graphis longiramea*[7,8], *Graphis proserpens*[3,4,7,8,13,14,15,16], *Graphis scripta*[4,7,8,12,13], *Haematomma puniceum*[3,7,12], *Hemithecium aphanes*[4,8], *Heterodermia albidiflava*[3,4,8,15], *Heterodermia angustiloba*[3,4,5,7,8,11,14,15,16], *Heterodermia boryi*[3,5,6,7,8,13,14,18], *Heterodermia dactyliza*[4,5,7,8,13,15,16], *Heterodermia diademata*[1,3,4,7,8,11,12,13,14,15,16], *Heterodermia dissecta*[1,3,4,5,6,7,8,11,15,18], *Heterodermia firmula*[3,7,12], *Heterodermia hypocaesia*[4,5,7,8,14,15,16], *Heterodermia incana*[7,8,13,14], *Heterodermia japonica*[3,4,8,15], *Heterodermia leucomelos*[1,3,4,5,6,7,8,12], *Heterodermia microphylla*[4,5,8,15,16], *Heterodermia obscurata*[7,13], *Heterodermia pseudospeciosa*[4,6,15], *Heterodermia rubescens*[3,11], *Heterodermia speciosa*[3,4,8], *Heterodermia tremulans*[5,6,18], *Hyperphyscia syncolla*[4,6,8,15], *Hypotrachyna adducta*[4,8,14], *Hypotrachyna awasthii*[4,5,16], *Hypotrachyna crenata*[3,7,8,14], *Hypotrachyna infirma*[7,8,14], *Hypotrachyna osseoalba*[3,5,7,8,12,15], *Hypotrachyna physcioides*[3,7,12], *Hypotrachyna pindarensis*[4,5,7,8], *Hypotrachyna pluriformis*[3,4,5,7,12,16], *Hypotrachyna radiculata*[3,7,12], *Hypotrachyna scytophylla*[1,3,4,7,8,14,15], *Ioplaca pindarensis*[1,3,7,8,12,14,15], *Lecanora alba*[3,4,7,8,10,11,13,14,15], *Lecanora argentata*[1,7], *Lecanora austrointumescens*[1,7], *Lecanora campestris*[8], *Lecanora cenisia*[3,8,11,15], *Lecanora cinereofusca*[1,3,4,8,9,10,11,14,15], *Lecanora dubyi*[19], *Lecanora fimbriatula*[3,4,7,8,12,14,15], *Lecanora flavidofusca*[1,4,7,16], *Lecanora formosula*[4,8,15], *Lecanora garovaglii*[18], *Lecanora helva*[3,10], *Lecanora hensseniae*[4,8,15], *Lecanora impudens*[4,8,15], *Lecanora imshaugii*[3,7,12], *Lecanora insignis*[1], *Lecanora interjecta* [4,8,15], *Lecanora japonica*[4,7,8,14,15,16], *Lecanora meridionalis*[3,7,12], *Lecanora muralis*[4,8,18,19], *Lecanora perplexa*[1,3,7,9,10,11], *Lecanora phaedrophthalma*[18], *Lecanora subimmersa*[3,4,7,8,11,14,15,18], *Lecanora subrugosa*[4,7,8,12,14,15], *Lecidea paratropoides*[2,5,18], *Lecidella carpathica*[4,5], *Lepraria lobificans*[7,8,14], *Lepraria vouauxii*[5,17], *Leptogium*

pedicellatum[3], *Leptogium trichophorum*[3], *Leptogium asiaticum*[3,7,8,12,13,14], *Leptogium askotense*[1,3,7,12], *Leptogium burgessii*[2,4,8,15], *Leptogium burnetiae*[1,3,4,5,6,7,8,11,12,13,14,15,16,18], *Leptogium cyanescens*[3,4,11], *Leptogium delavayi*[1,7,8,11,13,14], *Leptogium furfuraceum*[1,12], *Leptogium javanicum*[3,7,12], *Leptogium pedicellatum*[4,5,7,8,12,13,14,15,18], *Leptogium saturninum*[3,7,12], *Leptogium trichophorum*[4,7,8,11,12,13,14,15], *Lithothelium himalayense*[8,14], *Lithothelium obtectum*[1,7], *Lobaria discolor*[7], *Lobaria isidiosa*[4,7,12,13], *Lobaria kurokawae*[1,2,3,4,5,6,7,8,12,13,14,18], *Lobaria meridionalis*[4,8,15], *Lobaria pindarensis*[3,7], *Lobaria pseudopulmonaria*[1,5,6,18], *Lobaria quercizans*[4], *Lobaria retigera*[3,4,5,6,7,8,11,12,13,14,15,16,18], *Lobothalli flavidofusca*[5], *Lobothalli frustulosa*[5], *Lobothalli garovaglii*[2,5], *Lobothalli japonica*[5], *Lobothalli muralis*[2,5,6], *Lobothalli perplexa*[2], *Lobothalli phaedrophthalma*[2,6], *Lobothallia alphoplaca*[5,6,18], *Lobothallia praeradiosa*[2,5,6,18], *Lopadium saxicola*[1,7], *Loplaca pindarensis*[13], *Menegazzia terebrata*[7,8], *Miriquidica mexicana*[2,5,18], *Myelochroa aurulenta*[3,4,5,7,8,14,16], *Myelochroa entotheiochroa*[2], *Myelochroa macrogalbinica*[7,13], *Myelochroa metarevoluta*[4,8], *Myelochroa subaurulenta*[1,3,4,7,8,12,14,15], *Myelochroa upretii*[4,8,15], *Myelochroa xantholepis*[7,8,14], *Nephroma helveticum*[1,4,5,6,7,8,13,15], *Nephroma isidiosum*[1], *Nephromopsis ahtii*[7], *Nephromopsis nephromoides*[3,712,13], *Nephromopsis pallescencens*[1,3,5,7,8], *Nephromopsis pallescens*[12,13,14,15,16], *Nephromopsis stracheyi*[1,4,7,8,13,14,15], *Ochrolechia harmandii*[1], *Ochrolechia pallescens*[7,13], *Ochrolechia rosella*[1,3,7], *Ochrolechia subpallescens*[7,13], *Ochrolechia yasudae*[3,4,7,12], *Parmelaria meiophora*[4,8], *Parmelaria subthomsonii*[3,4,7,12], *Parmelaria thomsonii*[3,7,8,12,13], *Parmelia marmariza*[7,13], *Parmelia meiophora*[7], *Parmeliella papillata*[1], *Parmelinella wallichiana*[3,4,7,8,11,12,14,15], *Parmotrema direagens*[7,8,14], *Parmotrema eunetum*[3,7,12], *Parmotrema grayanum*[3,7,12,13], *Parmotrema hababianum*[3], *Parmotrema indicum*[3,11], *Parmotrema nilgherrense*[3,4,5,7,8,12,13,14,15,16], *Parmotrema praesorediosum*[3,7,10,11,12], *Parmotrema reticulatum*[1,3,7,8,11,12,14], *Parmotrema sancti- angelii*[3,7,12], *Parmotrema tinctorum*[3,10], *Peltigera canina*[3,4,7,8,12,14,15], *Peltigera didactyla*[5,6,18], *Peltigera dolichorrhiza*[3,7,8,12], *Peltigera leucophlebia*[1,4,5,6], *Peltigera polydactylon*[1,3,4,5,6,7,8,12,14,15], *Peltigera praetextata*[1,2,3,4,5,6,7,8,14,15], *Peltigera rufescens*[1,4,5,6,8,15,16], *Pertusaria leucosorodes*[3,7,11,12], *Pertusaria multipuncta*[3,4,7,8,14,15], *Pertusaria pallidula*[3,7], *Pertusaria pertusa*[1,3,7], *Pertusaria punctata*[3,7], *Pertusaria quassiae*[3,7,8,11,12], *Pertusaria albescens*[4,7,8,13,15], *Pertusaria amara*[1,7], *Pertusaria bryontha*[4,8,15], *Pertusaria concinna*[4,8], *Pertusaria coronata*[3,7,8,11,13,14], *Pertusaria kodaikanalensis*[4,8,15], *Pertusaria leucosora*[4,7,8,14,15], *Phaeophyscia orbicularis*[3,4,7], *Phaeophyscia dilatata*[3,7,8], *Phaeophyscia endococcina*[3,4,5,6,10], *Phaeophyscia hispidula*[1,3,4,5,7,8,9,11,13,14,15,16], *Phaeophyscia nepalensis*[4,8,15], *Phaeophyscia primaria*[4,5], *Phaeophyscia pyrrhophora*[1,3,7], *Phaeophyscia ciliata*[1,5,6,7,18], *Phaeophyscia constipata*[7,8], *Phaeophyscia endococcina*[4,11,17,18], *Phaeophyscia pyrrhophora*[12,13], *Phyllopsora catervisorediata*[5,7,15,16], *Phyllopsora corallina*[3,7,8,11,14], *Phyllopsora parvifolia*[4,5,7,13,18], *Physcia caesia*[5,6,18], *Physcia dilatata*[6,8,14], *Physcia phaea*[18], *Platismatia erosa*[3,7], *Porpidia macrocarpa*[4,5,6,8,15,17], *Porpidia albocaerulescens*[4,5,8,15,18], *Porpidia crustulata*[3,4,5,7], *Psora himalayana*[2,6], *Pyrenula immissa*[1,3,4,7,12], *Pyrenula introducta*[3,7,8,12,14], *Pyrenula neoculata*[3,7,12],*Pyrenula pinguis*[1,3,7,12], *Pyrenula subumbilicata*[1,3,4,7,8,12,14,15], *Pyrenula albella*[1], *Pyrenula anamalaiensis*[1,7], *Pyrenula glabrescens*[7,8,14], *Pyrenula globifera*[8], *Pyrenula himalayana*[3,7], *Pyrenula pyrenuloides*[7,8], *Pyrenula quassiicola*[1,4,7,8], *Pyxine minuta*[3,11], *Pyxine philippina*[3,4,10], *Pyxine himalayensis*[3,4,7,11,12], *Pyxine subcinerea*[3,7,8,11,14], *Pyxine sorediata*[3,7,8,11,12,14], *Ramalina sinensis*[1,4,5,7,8,13,14,15,16], *Ramalina celastri*[3,7], *Ramalina conduplicans*[1,3,4,7,8,12,14,15,16], *Rhizocarpon badioatrum*[6,18], *Rhizocarpon geographicum*[2,5,6,18], *Rhizocarpon macrosporum*[5,6,18], *Rhizocarpon sublucidum*[5,18], *Rhizoplaca chrysoleuca*[2,4,5,6,18], *Rinodina conradii*[4,5,7], *Sarcogyne privigna*[2,5,18], *Solorina simensis*[4,5,8,15,16,17], *Sphinctrina tubaeformis*[4,8,15], *Staurothele fissa*[5], *Stereocaulon foliolosum*[1,2,3,4,5,6,7,8,12,13,14,15,16,17,18], *Stereocaulon glareosum*[3,4,5,6,7,12,16,18], *Stereocaulon himalayense*[5,6,18], *Stereocaulon myriocarpum*[1,2,3,4,5,6,7,8,13,15,18], *Stereocaulon paradoxum*[3,7,12], *Stereocaulon piluliferum*[1,3,7,8,12,13,14,18], *Stereocaulon pomiferum*[3,4,5,6,7,8,12,15,18], *Sticta damaecornis*[4,5,7,8,14,16], *Sticta henryana*[7], *Sticta indica*[1,3,4], *Sticta nylanderiana*[1,3,4,7,8,12,13,14,15], *Sticta orbicularis*[3,7], *Sticta platyphylloides*[3,7,12], *Sticta*

praetextata[4,5,7,8,14,16], *Sulcaria sulcata*[1,3,7,12,13], *Tephromela atra*[5,18], *Tephromela khatiensis*[1,3,4,7,8,12,14,15], *Thamnolia vermicularis*[2,5,6,18], *Trapelia coarctata*[4,8,15], *Tuckneraria laureri*[7,13], *Umbilicaria indica*[1,3,4,5,6,7,8,13,15,18], *Umbilicaria vellea*[1], *Usnea compressa*[3,4,7,8,12,13,14,15,16], *Usnea dendritica*[1], *Usnea eumitrioides*[7,8,14], *Usnea longissima*[1,3,4,5,7,8,12,13,14,16,17,18], *Usnea baileyi*[7], *Usnea nepalensis*[3,7,8,12,13], *Usnea orientalis*[1,3,4,5,7,8,12,13], *Usnea pangiana*[4,7,8,15], *Usnea perplexans*[4,7,8,12,14], *Usnea robusta*[4,5,16], *Usnea sordida*[6,8,13,14], *Usnea splendens*[3,4,7,8,12,14,15], *Usnea subfloridana*[3,4,7], *Usnea thomsonii*[4,5,8,15,16], *Usnea undulata*[4,8,15], *Verrucaria acrotella*[3,4,7,8,14,15], *Xanthoria elegans*[2,5,6,18], *Xanthoria sorediata*[2,5,6,18], *Anthracothecium globiferum*[*], *Anthracothecium oculatum*[*], *Arthonia antillarum*[*], *Bryoria tenuis*[*], *Caloplaca squamosa*[*], *Hypotrachyna physcioides*[*], *Pertusaria pallidula*[*], *Pyxine meissnerina*[*], *Trypethelium endosulphureum*[*], *Tylophoron protrudens* [*]

3. District: Pithoragarh

Major lichen rich/explored areas:

Kalamuni[1], Khuliya Top[2], Munsiyari[3], Munsiyari Nilum[4], Nain singh Top[5], Nilum Bogudiyar[6], Bogudiyar Naher Devi[7], Naher Devi Mapanga[8], Mapanga Rilkot[9], Rilkot Bulfu[10], Bulfu[11], Beilju[12], Martoli[13], Martoli-Milam[14], Milam[15], Milam Glacier V.[16]

References: (Mishra & Upreti, 2016**; Joshi *et al.*, 2012), (Chandra & Joshi 2018, Joshi et al. 2014de)**

Reported Lichen species:

Acarospora badiofusca[7], *Acarospora bullata*[12,15], *Acarospora fusca*[2], *Acarospora peltastica*[9], *Acarospora saxicola*[4,6,7], *Acarospora smaragdula*[9], *Acarospora strigata*[7], *Anisomeridium nidulans*[2], *Arthopyrenia alboatra*[5], *Arthothelium abnorme*[2], *Aspicilia maculate*[2,4,13], *Aspicilia almorensis*[2,7], *Aspicilia caesiocinerea*[2,6,13], *Aspicilia calcarea*[1,4,8,9,12,13,15], *Aspicilia cinerea*[3,6], *Aspicilia dwaliensis*[5], *Buellia maculata*[4], *Bulbothrix meizospora*[1,3,4], *Bulbothrix sensibilis*[4], *Bulbothrix setschwanensis*[4], *Byssoloma subdiscordans*[2], *Caloplaca approximata*[5], *Caloplaca arenaria*[11], *Caloplaca cerina*[2], *Caloplaca citrina*[13], *Caloplaca cupulifera*[4], *Caloplaca flavorubescens*[3,5], *Caloplaca flavovirescens*[3], *Caloplaca lithophila*[3], *Caloplaca lypera*[2,3], *Caloplaca ochroplaca*[2,3], *Caloplaca squamosa*[4], *Candelaria indica*[4,7], *Candelariella aurella*[8,15], *Candelariella vitellina*[11], *Canoparmelia texana*[4], *Cetrelia braunsiana*[1,2,5,6], *Cetrelia cetrarioides*[3], *Cetrelia olivetorum*[1], *Cetreliopsis rhytidocarpa*[5], *Chrysothrix candelaris*[6], *Cladonia cartilaginea*[6], *Cladonia chlorophyceae*[2], *Cladonia coccifera*[2], *Cladonia corniculata*[3], *Cladonia corymbescens*[2], *Cladonia leuteoalbum*[2], *Cladonia macilenta*[5], *Cladonia pyxidata*[4,8,11,13], *Cladonia ramulosa*[5], *Cladonia rangiferina*[7], *Cladonia sqaumosa*[2], *Coccocarpia erythroxyli*[6,8], *Collema crispum*[4], *Collema cristatum*[9], *Collema fuscovirens*[9,12,14], *Collema leptaleum*[3], *Collema polycarpon*[12], *Collema pulcellum*[5,6], *Collema shiroumanum*[4], *Collema tenax*[4], *Dermatocarpon miniatum*[2,4,6,7,8,9,10], *Dermatocarpon vellereum*[4,5,6,7,8,9], *Dimelaena oreina*[8,13], *Diploschistes actinostomus*[4], *Diploschistes candissimus Diploschistes actinostomus*[6], *Diploschistes scruposus*[4,7,13], *Endocarpon nanum*[15], *Endocarpon pusillum*[5], *Everniastrum cirrhatum*[1,2,3,5,7], *Everniastrum nepalense*[5], *Flavoparmelia caperata*[4,6], *Flavopunctelia flaventior*[1], *Fuscopannaria subgemmascens*[2], *Fuscopannarria saltuensis*[4], *Graphis anfractuosum*[2], *Graphis duplicata*[2], *Graphis lineola*[2], *Graphis proserpens*[2], *Graphis scripta*[1], *Heterodermia albidiflava*[4,5], *Heterodermia angustiloba*[1,2,3], *Heterodermia boryi*[1,2,3], *Heterodermia comosa*[1,2,3], *Heterodermia dactyliza*[1,2], *Heterodermia diademata*[1,2,3,4,5,6,8], *Heterodermia dissecta*[6], *Heterodermia firmula*[6], *Heterodermia hypocaesia*[3,6], *Heterodermia incana*[3], *Heterodermia japonica*[3], *Heterodermia leucomelos*[2,5,6,7], *Heterodermia microphylla*[3,7], *Heterodermia pseudospeciosa*[2,3,5], *Heterodermia rubescens*[3,5], *Heterodermia speciosa*[3,5], *Hypotrachyna exsecta*[1], *Hypotrachyna flexilis*[2], *Hypotrachyna pluriformis*[6], *Hypotrachyna scytophylla*[3,6,7], *Lecanora achroa*[1], *Lecanora alba*[2], *Lecanora cinereofusca*[5], *Lecanora campestris*[7], *Lecanora concilianda*[5], *Lecanora concilians*[2], *Lecanora fimbriatula*[1,2,5], *Lecanora flavidofusa*[1,2],

*Lecanora formosula[2], Lecanora helva[2], Lecanora indica[6], Lecanora japonica[2], Lecanora muralis[6,7,9,10,11,12,13,15,16], Lecanora polytropa[13], Lecanora subimmersa[6], Lecanora sulfurescens [2], Lecanora valesiaca[16], Lecidea paraclitica[5], Lecidea turgidula[5], Lepraria lobificans[4,13], Leprocaulon arbuscula[2], Leptogium asiaticum[5], Leptogium askotense[1,2,7], Leptogium burnetiae[2,4,6], Leptogium delavayi[1,4,5,6], Leptogium denticulatum[2], Leptogium furfuraceum[4,5,6], Leptogium pedicellatum[4,5,6,8,10], Leptogium saturninum[2], Leptogium trichophorum[1,3,5,6], Lithothelium himalayense[3], Lobaria kurokawae[2,5], Lobaria meridionalis[2], Lobaria pindarensis[2], Lobaria retigera[1,2,3,4,5,6,7,8], Lobothallia praeradiosa[9,12,13,16], Loplaca pindarensis[2,3], Maronea constans[5], Melanelia tominii[16], Myelochroa aurulenta[3,5], Myelochroa metarevoluta[2], Myelochroa subaurulenta[1,5], Myelochroa upretii[3], Myelochroa xantholepis[2,6], Nephroma helveticum[2,5,6], Nephromopsis nephromoides[1,2], Nephromopsis stracheyi[1,2,4], Nephromopsis pallescens[1,2,5,6,16], Ochrolechia rosella[1,2,5], Ochrolechia subpallescens[2,5], Ochrolechia yasudae[1,2], Pannaria emodii[5], Parmelaria subthomsonii[2,4,5], Parmelaria thomsonii[1,5,6], Parmelinella wallichiana[3,4], Parmotrema austrosinense[3], Parmotrema indicum[4], Parmotrema nilgherrense[1,2,3,5,6], Parmotrema praesorediosum[4], Parmotrema reticulatum[3,4,5,6,8], Parmotrema sancti-angelii[4], Parmotrema tinctorum[4], Peltigera canina[1,2,4,7,8], Peltigera dolichorrhiza[5,6], Peltigera elisabethae[7,8], Peltigera membranacea[6], Peltigera praetextata[2,8], Peltigera rufescens[4,6,7,8], Peltula patellata[12], Pertusaria albescens[1], Pertusaria amara[2], Pertusaria coronata[2], Pertusaria leucosora[1,4,6,8], Pertusaria leucosorodes[2,5], Pertusaria leucostoma[5], Pertusaria rigida[1], Pertusaria subochracea[2], Phaeophyscia hispidula[2,4,5,6,8], Phaeophyscia pyrrhophora[6], Physcia dilatata[2,3,4,7], Physcia phaea[11,15], Pleopsidium flavum[6,9],Porpidia albocaerulescens [2,6,7], Porpidia macrocarpa[2,8,9], Psora decipiens[8,10], Punctelia rudecta[4], Punctelia subrudecta[4,6,8], Pyrenula immissa[1,4], Pyrenula introducta[1,3], Pyrenula subumbilicata[1], Pyxine himalayensis[4,5], Pyxine subcinerea[3,4], Ramalina conduplicans[1,2,5], Ramalina hossei[8], Ramalina roesleri[5], Ramalina sinensis[1,2,5], Rhizocarpon disporum[8], Rhizocarpon geographicum[8,12,13,15], Rhizocarpon macrosporum[15], Rhizoplaca chrysoleuca[11,13,15], Rinodina sophodes[2], Rinodina straussii[12], Staurothele fissa[2], Stereocaulon foliolosum[1,2,5,6,7,8,11], Stereocaulon glareosum[9,10], Stereocaulon massartianum[6], Stereocaulon paradoxum[1,6], Sticta limbata[4,6,7], Sticta nylanderiana[2], Sticta platyphyllos[2], Sulcaria Sulcata[2], Tephromela khatiensis[3,6], Umbilicaria indica[2,5,7], Umbilicaria virginis[7], Umbilicaria yunnana[2,5], Usnea aciculifera[5], Usnea compressa[5], Usnea eumitrioides[2,4,5], Usnea longissima[1,2,5,6], Usnea orientalis[2,5], Usnea pectinata[2], Usnea subfloridana[2,5], Verrucaria acrotella[2,4,6,8], Xanthoparmelia coreana[16], Xanthoparmelia mexicana[8], Xanthoparmelia stenophylla[9,14,15], Xanthoria elegans[6,11,12,13,14,15], Xanthoria parietina[14], Xanthoria sorediata[11], Xanthoparmelia tinctina[16], Acarospora hassei[*], Allocetraria oakesiana[*], Amandinea montana[*], Anisomeridium biforme[*], Biatora vernalis[*], Biatora subduplex[*], Biatorella conspersa[*], Buellia betulinoides[*], Caloplaca cerina[*], Caloplaca ferruginea[*], Caloplaca squamosa[*], Chapsa leprocarpa[*], Cryptothecia dispersa[*], Cryptothecia polymorpha[*], Cryptothecia subtecta[*], Diorygma megaspermum[*], Heterodermia flabellata[*], Heterodermia himalayensis[*], Hypotrachyna imbricatula[*], Hypotrachyna physcioides[*], Parmotrema cooperi[*], Parmotrema pseudocrinitum[*], Parmotrema ravum[*], Parmotrema subtinctorium[*], Pertusaria indica[*], Pertusaria melastomella[*], Pertusaria pseudococcodes[*], Pertusaria pustulata[*], Pertusaria submultipuncta[*], Phaeographina limbata[*], Phyllophora buettneri [*], Phyllopsora isidiotyla[*], Physcia dimidiata[*], Physconia enteroxantha[*], Platygramme wattiana[*], Porina subhibernica[*], Pyxine meissnerina[*], Sulcaria virens[*], Tylophoron protrudens[*], Usnea pectinata[*],Amandinea submontana**, Aspicilia maculate**, Blennothallia crispa**, Bulbothrix isidiza**, Brownliella cinnabarina**, Candelaria concolor**, Cladonia fimbriata**, Collema subflaccidum**, Cratiria obscurior**, Endocarpon subrosettum**, Enchylium polycarpon**, Heterodermia himalayana**, Heterodermia upretii**, Loplaca pindarensis**, Lasallia pustulata**, Lecanora frustulosa**, Lecidea elaeochroma**, Lecidella carpathica**, Lecidella stigmatea**, Melanelixia villosella**, Montanelia*

*panniformis***, Mycobilimbia hunana***, Lobothallia radiosa***,Myriolecis dispersa***, Myriospora smaragdula***, Parmotrema grayanum***, Phaeophyscia ciliata***, Phaeophyscia constipate***, Physcia stellaris***, Physconia detersa***, Physconia distorta***, Pyxine berteriana var. himalaica***, Polycauliona candelaria***, Physcia gomukhensis***, Rhizocarpon distinctum***, Sarcogyne privigna***, Verrucaria coerulea***, Usnea himalayana***

4. District: Champawat

Major lichen rich/explored areas:

Banlekh Forest[1]

References: (Mishra & Upreti, 2016* ; Sonam *et al.,* 2017; Kumar *et al.,* 2010)

Reported Lichen species:

Bulbothrix bulbochaeta[1], Bulbothrix meizospora[1], Canoparmelia texana[1], Everniastrum cirrhatum[1], Everniastrum nepalense[1], Heterodermia diademata[1], Heterodermia podocarpa[1], Leptogium askotense[1], Lobaria kurokawae[1], Parmotrema hababianum[1], Parmotrema mesotropom[1], Parmotrema nilgherrense[1],Parmotrema tinctorum[1], Parmotrema wallichiana[1], Phaeophyscia hispidula[1], Punctelia rudecta[1], Ramalina conduplicans[1], Ramalina himalayensis[1], Ramalina sinensis[1], Rimelia reticulata[1], Usnea aciculifera[1], Usnea longissima[1], Usnea orientalis[1], Usnea pectinata[1,] Anthracothecium macrosporum[*], Baculifera remensa[*], Caloplaca abuensis[*], Caloplaca ferruginea[*], Graphis subvirginea[*], Heterodermia himalayensis[*], Parmotrema crinitum[*], Parmotrema subtinctorium[*], Pertusaria indica[*], Pertusaria melastomella[*], Pertusaria submultipuncta[*], Phaeographis angulosa[*], Punctelia neutralis[*], Pyrenula subochraceoflavens[*], Thelidiopsis mangiferae[*]

5. District: Udham Singh Nagar

Major lichen rich/explored areas:

Jaspur[1], Rudarpur[2], Bazpur[3], Gadarpur[4], Sitarganj[5], Khatima[6], Chuhi[7], Dhikala[8], Sultan[9], Malani[10], Paterpani[11], Jhirna[12], Bijrani[13], Jamunagaur[14], Mohan[15], Lohachaur[16], Vatan vasa[17], Kashipur[18], Jim Corbett Tiger Reserve[19]

References: (Mishra *et al.,* 2016)

Reported Lichen species:

Anisomeridium albisedum[3,5], Anisomeridium americanum[1,3,4,18], Amandinea subduplicata[6], Anthracothecium himalayense[2], Arthonia impolitella[7], Arthonia medusula[7], Arthonia radiata[7], Arthonia sp.[13], Arthonia subgyrosa[3,9], Arthothelium albescens[14], Arthothelium chiodectoides[14], Bacidia alutacea[3], Bacidia arnoldiana[12], Bacidia convexula[9], Bacidia delicata[3], Bacidia incongruens[3], Bacidia laurocerasi[8,14], Bacidia medialis[8,9,14], Bacidia millegrana[14], Bacidia nigrofusca[11,12,13], Bacidia phaeolomoides[15], Bacidia psorina[2], Bacidia rubella[1], Bacidia rufescens[11], Bacidia submedialis[14], Brigantiaea leucoxantha[2,6,8,9,11,13,14,15,16], Brigantiaea sp.[19], Buellia curtisii[10], Buellia inornata[14,17], Buellia stigma[12], Bulbothrix isidiza[17], Caloplaca bassiae[3,4,6], Caloplaca malaensis[10,12,14], Caloplaca subnigricans[7], Catillaria nilgirensis[12], Chrysothrix candelaris[7,10], Clathroporina anoptella[16], Clathroporina duplicascens[16], Coccocarpia pellita[15], Cryptothecia lunulata[7,8,9,10,11,12,13,14,15,16,17], Cryptothecia stirtonii[12], Diorygma hieroglyphicum[2],Diorygma junghuhnii[7], Dirinaria aegialita[9,10], Dirinaria appalanta[6,7], Dirinaria confluens[10,11], Dirinaria consimilis[16,17], Endocarpon pallidum[19], Endocarpon rosettum[5], Fissurina dumastii[19], Fissurina sp.[19], Graphis ajarekarii[7], Graphis capillacea[7], Graphis chlorotica[2,3], Graphis crebra[2], Graphis duplicata[7], Graphis glaucescens[11], Graphis implexula[7], Graphis lineola[2,3], Graphis longiramea[2], Graphis nakanishiana[7,9,11,13], Graphis nigroglauca[7], Graphis pinicola[7], Graphis pyrrohocheiloides[6,13], Graphis scripta[2,3,6,7,11,13], Graphis subashinae[6], Graphis

submarginata[2,3], *Hemithecium aphanes*[7,11], *Hemithecium caesiorodian*[19], *Hemithecium nepalensis*[19], *Hemithecium sp.*[7], *Herpothallon sp.*[3], *Heterodermia microphylla*[19], *Hyperphyscia adglutinata*[2,3,4,6], *Lecanora achroa*[2,3,6], *Lecanora cinereofusca*[19], *Lecanora fimbriatula*[9], *Lecanora helva*[3,10,11], *Lecanora pulicaris*[10], *Lecanora queenslandica*[10,12], *Lecanora tropica*[5,7,11,13], *Lecanora xylophila*[19], *Lecidea sp.* [7,9,14], *Lepraria lobificans*[6], *Leptogium azureum*[16], *Leptogium austroamericanum*[8], *Letrouitia leucoxantha*[6,7,8,9,15], *Micarea sp.*[2], *Opegrapha dimidiata*[3], *Opegrapha inequalis*[11], *Opegrapha rufescens*[9], *Opegrapha vulgata*[3,9], *Opegrapha varia*[3], *Parmotrema mesotropum*[6,16], *Parmotrema praesorediosum*[6,10], *Parmotrema saccatilobum*[7,11], *Parmotrema tinctorum*[6,16,17], *Pertusaria acuta*11, *Pertusaria coccodes*[19], *Pertusaria concinna*[10], *Pertusaria dispressa*[7], *Pertusaria himalayensis*[7,11], *Pertusaria leioplacella*[9,12], *Pertusaria leucostoma*[3], *Pertusaria pertusa*[17], *Pertusaria punctata*[9], *Pertusaria quassiae*[10], *Pertusaria rigida*[16], *Pertusaria subdepressa*[19], *Phaeographis albolabiata*[12], *Phaeographis divaricoides*[7], *Phaeographis firmula*[7], *Phaeographis instrata*[7], *Phaeographis subdividens*[7], *Phaeophyscia hispidula*[2], *Phylliscum indicum*[12,16],*Physcia clementiana*[10], *Physcia dilatata*[17], *Polymeridium sp.*[5], *Pyrenula aggregata*[3], *Pyrenula aspistea*[9,11], *Pyrenula brunnea*[10], *Pyrenula conspercata*[13], *Pyrenula immissa*[9], *Pyrenula introducta*[9,16,14], *Pyrenula mastophorizans*[9], *Pyrenula sublaevigata*[9], *Pyrenula submastrophora*[3], *Pyrenula subrizalensis*[7], *Pyrenula sulcata*[14], *Pyxine cocoes*[1,2,3,4,5,6], *Pyxine reticulata*[6], *Pyxine sorediata*[2,3], *Pyxine subcinerea*[6], *Rambolidia sp.*[19], *Rinodina sophodes*[1,2,4,5,6], *Staurothele fissa*[16], *Tapellaria saxicola*[19], *Verrucaria cincta*[15]

6. District: Nainital

Major lichen rich/explored areas:

Nainital[1]

References: (Mishra & Upreti, 2016*; Mishra *et al.,* 2016)

Reported Lichen species:

Candelaria concolor[1], *Candelaria indica*[1], *Collema subconveniens*[1], *Leptogium askotense*[1], *Leptogium burgessii*[1], *Leptogium delavayi*[1], *Lobaria retigera*[1], *Bulbothrix meizospora*[1], *Bulbothrix setschwanensis*[1], *Canoparmelia aptata*[1], *Canoparmelia eruptens*[1], *Canoparmelia texana*[1], *Cetrelia braunsiana*[1], *Everniastrum cirrhatum*[1], *Everniastrum nepalense*[1], *Flavocetrariella leucostigma*[1], *Flavoparmelia caperata*[1], *Hypotrachyna flexilis*[1], *Myelochroa aurulenta*[1], *Myelochroa perisidians*[1], *Myelochroa subaurulenta*[1], *Parmelaria thomsonii*[1], *Parmelinella wallichiana*[1], *Parmotrema austrosinense*[1], *Parmotrema nilgherrense*[1], *Parmotrema praesorediosum*[1], *Parmotrema reticulatum*[1], *Parmotrema tinctorum*[1], *Punctelia rudecta*[1], *Punctelia subrudecta*[1], *Peltigera praetextata*[1], *Peltigera rufescens*[1], *Dirinaria applanata*[1], *Heterodermia boryi*[1], *Heterodermia diademata*[1], *Heterodermia dissecta*[1], *Heterodermia firmula*[1], *Heterodermia incana*[1], *Heterodermia japonica*[1], *Heterodermia microphylla*[1], *Heterodermia pellucida*[1], *Phaeophyscia endococcina*[1], *Phaeophyscia hispidula*[1], *Physcia dilatata*[1], *Pyxine berteriana*[1], *Pyxine berteriana*[1], *Pyxine subcinerea*[1]

Amandinea montana[*], *Canoparmelia eruptens*[*], *Graphis subserpentina*[*], *Hafellia tetrapla*[*], *Heterodermia indica*[*], *Pertusaria amarkantakana*[*], *Pertusaria melastomella*[*], *Phaeographis inusta*[*], *Trypethelium eluteriae*[*]

(B) Garhwal region

1. District: Uttarkashi

Major lichen rich/explored areas:

Naitwar to Harki Dun to Morinda Tal[1]

References: (Karakoti *et al.,* 2014; Mishra *et al.,* 2015)

Reported Lichen species:

Maronea melanocarpa[1], *Acarospora sp.I*[1], *Acarospora sp.II*[1], *Acarospora sp.III*[1], *Allocetraria stracheyi*[1], *Anthracothecium platystomum*[1], *Anthracothecium subruanum*[1], *Anthracothecium thwaitesii*[1], *Arthothelium*

chiodectoides[1], Aspicilia almorensis[1], Aspicilia calcarea[1], Aspicilia dwaliensis[1], Bacidia millegrana[1], Bacidia personata[1], Bryoria smithii[1], Bulbothrix meizospora[1], Calicium abietinum[1], Caloplaca cinnabarina[1], Caloplaca flavorubescens[1], Caloplaca himalayana[1], Caloplaca ochroplaca[1], Caloplaca pachycheila[1], Caloplaca pindarensis[1], Caloplaca subsoluta[1], Candelaria concolor[1], Candelaria indica[1], Candelariella aurella[1], Canomaculina subtinctoria[1], Canoparmelia texana[1], Cetraria muricata[1], Cetraria nigricans[1], Cetrelia braunsiana[1], Cetrelia cetrarioides[1], Cetrelia pseudolivetorum[1], Cetreliopsis rhytidocarpa[1], Chrysothrix chlorina[1], Cladonia awasthiana[1], Cladonia cariosa1, Cladonia cartilaginea1, Cladonia chlorophaea1, Cladonia coniocraea1, Cladonia corniculata1, Cladonia didyma1, Cladonia fenestralis1, Cladonia fimbriata1, Cladonia furcata1, Cladonia macroceras1, Cladonia ochrochlora[1], Cladonia pocillum[1], Cladonia pyxidata[1], Cladonia rangiferina[1], Cladonia scabriuscula[1], Cladonia subradiata[1], Cladonia subulata[1], Coccocarpia erythroxyli[1], Collema japonicum[1], Collema nigrescens[1], Collema subconveniens[1], Dermatocarpon meiophyllizum[1], Dermatocarpon miniatum[1], Dermatocarpon vellereum[1], Diploschistes muscorum[1], Emodomelanelia massonii[1], Endocarpon rosettum[1], Evernia mesomorpha[1], Everniastrum cirrhatum[1], Everniastrum nepalense[1], Flavocetraria cucullata[1], Flavocetraria nivalis[1], Flavoparmelia caperata[1], Flavopunctelia flaventior[1], Flavopunctelia soredica[1], Graphis chlorotica[1], Graphis intermediella[1], Graphis proserpens[1], Graphis scripta[1], Graphis sikkimensis[1], Heterodermia albidiflava[1], Heterodermia boryi[1], Heterodermia diademata[1], Heterodermia firmula[1], Heterodermia incana[1], Heterodermia isidiophora[1], Heterodermia japonica[1], Heterodermia leucomelos[1], Heterodermia obscurata[1], Heterodermia pseudospeciosa[1], Heterodermia speciosa[1], Hyperphyscia adglutinata[1], Hypotrachyna crenata[1], Hypotrachyna immaculata[1], Hypotrachyna infirma[1], Hypotrachyna pindarensis[1], Hypotrachyna pluriformis[1], Hypotrachyna scytophylla[1], Ioplaca pindarensis[1], Lecanora austrointumescens[1], Lecanora caesiorubella[1], Lecanora cinerofusca[1], Lecanora concilians[1], Lecanora consilianda[1], Lecanora formosula[1], Lecanora interjecta[1], Lecanora japonica[1], Lecanora muralis[1], Lecanora subimmersa[1], Lecidea granifera[1], Lecidella elaechroma[1], Lepraria sp[1]., Leptogium askotense[1], Leptogium burnetiae[1], Leptogium furfuraceum[1], Leptogium saturninum[1], Lithothelium thiorencens[1], Lobaria isidiosa[1], Lobaria kurokawae[1], Lobaria pindarensis[1], Lobaria retigera[1], Lepraria lobata[1], Leprocaulon adhaerens[1], Leprocaulon coriense[1], Leprocaulon textum[1], Melania hepatizone[1], Menegazzia terebrata[1], Mycobilimbia hunana[1], Myelochroa aurulenta[1], Myelochroa denegans[1], Nephroma helveticum[1], Nephromopsis laii[1] , Nephromopsis pallescens[1], Normandina pulchella[1], Ochrolechia rosella[1], Pannaria emodii [1], Parmelia meiophora[1], Parmelia squarrosa[1], Parmelinella wallichiana[1], Parmotrema hababianum[1], Parmotrema nilgherrense[1], Parmotrema praesorediosum[1], Parmotrema pseudonilgherrense[1], Parmotrema pseudotinctorum[1], Parmotrema reticulatum[1], Parmotrema sancti-angelii[1], Parmotrema thomsonii[1], Parmotrema tinctorum[1], Peltigera collina[1], Peltigera polydactylon[1], Peltigera praetextata[1], Peltigera rufescens[1], Pertusaria albescens[1], Pertusaria amara[1], Pertusaria composita[1], Pertusaria granulata[1], Pertusaria leucosora[1], Pertusaria multipuncta[1], Phaeophyscia constipate[1], Phaeophyscia hispidula[1], Phaeophyscia nepalensis[1], Phaeophyscia primaria[1], Phyllopsora furfuracea[1], Phyllopsora haemophaea[1], Phyllopsora himalayensis[1], Phyllopsora swinscowii[1], Physcia adscendens[1] Physcia crispa[1], Physcia dilatata[1], Physciella nepalensis[1], Physconia detersa[1], Physconia muscigena[1], Placidium squamulosum[1], Porpidia albocaerulescens [1], Porpidia crustulata[1], Punctelia borreri[1], Punctelia rudecta[1], Punctelia subrudecta[1], Pyrenula bahiana[1], Pyrenula defosa[1], Pyrenula immissa[1], Pyrenula introducta[1], Pyrenula leucostoma[1], Pyrenula leucotrypa[1], Pyrenula mastophoroides[1], Pyrenula ochraceoflavens[1], Pyrenula oculata[1], Pyrenula pinguis[1], Pyrenula platystoma[1], Pyrenula submastophora[1], Pyxine berteriana[1], Pyxine cocoes[1], Pyxine sorediata[1], Pyxine subcinerea[1], Ramalina conduplicans[1], Ramalina hossei[1], Ramalina roesleri[1], Ramalina sinensis[1], Rematotrachyna scytophylla[1], Rhizocarpon geographicum[1], Rhizoplaca chrysoleuca[1], Rinodina oxydata[1], Sarcogyne privigna[1],

Stereocaulon foliolosum[1], *Stereocaulon myriocarpum*[1], *Stereocaulon pomiferum*[1], *Sticta limbata*[1], *Sticta platyphylloides*[1], *Sticta praetextata*[1], *Sticta weigelii*[1], *Tephromela khatiensis*[1], *Thamnolia vermicularis*[1], *Toninia tristis*[1], *Umbilicaria indica*[1], *Umbilicaria vellea*[1], *Usnea aciculifera*[1], *Usnea longissima*[1], *Usnea orientalis*[1], *Usnea perplexans*[1], *Usnea subfloridana*[1], *Verrucaria margacea*[1], *Xanthoparmelia conspersa*[1], *Xanthoparmelia stenophylla*[1], *Xanthoparmelia terricola*[1], *Xanthoria candelaria*[1], *Xanthoria elegans*[1]

2. District: Chamoli

Major lichen rich/explored areas:

Gamsali to Niti[1], Badrinath Valley, Bhimpul and Vasudhara[2]

References: (Rawat *et al.,* 2013; Upadhyay *et al.,* 2020; Gupta *et al.,* 2016).

Reported Lichen species:

Amandinea punctata[1], *Chrysothrix candelaris*[1], *Cladonia fimbriata*[1], *Cladonia subsquamosa*[2], *Cladonia furcata*[1], *Cladonia pyxidata*[1],*Leptogium burnetiae*[1], *Lecanora frustulosa*[1] , *Lecanora muralis*[1], *Lobothallia alphoplaca*[1], *Allocetraria nygricascens*[1], *Dolichousnea longissima*[1] , *Evernia mesomorpha*[1], *Everniastrum cirrhatum*[1], *Flavoparmelia caperata*[1], *Flavopunctelia flaventior*[1], *Flavopunctelia soredica*[1], *Hypogymnia tubulosa*[1], *Melanelia tominii*[1], *Melanelia disjuncta*[2], *Melanelixia fuliginosa*[1], *Melanelixia vilosella*[1], *Melanohalea infumata*[2], *Normandina pulchella*[2], *Parmelia sulcata*[1], *Parmelia squarrosa*[2], *Parmotrema rampoddense*[1], *Rhizoplaca peltata*[1], *Xanthoparmelia bellatula*[1], *Xanthoparmelia conspersa*[1], *Xanthoparmelia stenophylla*[1], *Usnea perplexans*[1] , *Usnea subfloridana*[1], *Vulpicida pinastri*[1], *Peltigera collina*[2], *Peltigera didactyla*[1], *Peltigera praetextata*[1], *Peltigera rufescens*[1], *Anaptychia kaspica*[1], *Dimelaena oreina*[1], *Physcia gomukensis*[1], *Physcia stellaris*[1], *Physconia detersa*[1], *Porpidia macrocarpa*[1], *Ramalina sinensis*[1], *Rhizocarpon geographicum*[1], *Remototracgyna incognita*[2], *Caloplaca saxicola*[1], *Xanthoria sorediata*[1], *Diploschistes scruposus*[1], *Lecidella alaiensis*[2], *Rinodina megaspora*[2], *Parmotrema melanothrix*[1], *Phaeophyscia endococcina*[1], *Phaeophyscia hispidula*[1], *Xanthoria candelaria*[1]

3. District: Dehradun

Major lichen rich/explored areas:

References: (Shukla *et al.,* 2014; Bajpai *et al.,* 2018; Rani *et al.,* 2011)

Reported Lichen species:

Phaeophyscia hispidula[1], *Usnea aciculifera*[1], *Usnea compressa*[1], *Usnea eumitrioides*[1], *Usnea himalayana*[1], *Usnea lucea*[1], *Usnea longissima*[1], *Usnea orientalis*[1], *Usnea perplexans*[1], *Usnea robusta*[1], *Usnea sordida*[1], *Usnea splendens*[1], *Usnea subfloridana*[1], *Usnea thomsonii*[1], *Lepraria ecorticata*[1] , *Lepraria leuckertiana*[1], *Lepraria isidiata*[1], *Leprocaulon adhaerens*[1], *Leprocaulon coriense*[1], *Leprocaulon textum*[1]

4. District: Haridwar

Major lichen rich/explored areas:

References: (Shukla *et al.,* 2013; Rai *et al.,* 2015)

Reported Lichen species:

Pyxine subcinerea

5. District: Rudraprayag

Major lichen rich/explored areas: Chopta –Tungnath[1]

References: (Bajpai *et al.,* 2018; Rai *et al.,* 2012)

Reported Lichen species:

Bryoria confusa[1], *Cetrelia olivetorum*[1], *Cladonia cartilaginea*[1], *Cladonia coccifera*[1], *Cladonia furcata*[1], *Cladonia pyxidata*[1], *Cladonia scabriuscula*[1], *Cladonia subulata*[1], *Everniastrum cirrhatum*[1], *Heterodermia hypocaesia*[1], *Heterodermia obscurata*[1], *Lepraria caeseoalba*[1], *Lepraria neglecta*[1], *Melanelia stygia*[1], *Physconia grisea*[1], *Ramalina hossei*[1], *Stereocaulon alpinum*[1], *Stereocaulon foliolosum*[1], *Stereocaulon massartianum*[1], *Stereocaulon pomiferum*[1] , *Lepraria caesioalba*[1], *Lepraria cupressicola*[1], *Leprocaulon arbuscula*[1], *Leprocaulon textum* [1]

6. District: Pauri

Major lichen rich/explored areas: Park of forest dept., Khirsu[1]

References: (Bajpai *et al.,* 2018; Shukla *et al.,* 2005)

Reported Lichen species:

Chrysothrix chlorina[1], *Chrysothrix candelaris*[1], *Cladonia cartilaginea*[1], *Graphis hossei*[1], *Haematomma puniceum*[1], *Lecanora sp.* [1], *Lecanora achroella*[1], *Lecanora leprosa*[1], *Bulbothrix meizospora*[1], *Canomaculina subtinectoria*[1], *Canoparmelia texana*[1], *Everniastrum cirrhatum*[1], *Everniastrum nepalense*[1], *Flavoparmelia caperata*[1], *Hypotrachyna infirma*[1], *Myelochroa aurulenta*[1], *Myelochroa leucotyliza*[1], *Parmotrema austrosinense*[1], *Parmotrema praesorediosum*[1], *Punctelia borreri*[1], *Punctelia rudecta*[1], *Rimelia reticulata*[1], *Pertusaria alpina*[1], *Pertusaria cinchonae*[1], *Pertusaria coronata*[1], *Buellia placodiomorpha*[1], *Heterodermia albidiflava*[1], *Heterodermia dendritica*[1], *Heterodermia diademata*[1], *Heterodermia firmula*[1], *Heterodermia himalayensis*[1], *Heterodermia japonica*[1], *Heterodermia obscurata*[1], *Phaeophyscia hispidula*[1], *Phaeophyscia endococcina*[1], *Pyxine subcinerea*[1], *Pyxine petricola*[1], *Protoblastenia russula*[1], *Ramalina conduplicans*[1], *Caloplaca flavorubescens*[1], *Loplaca pindarensis*[1], *Usnea eumitrioides*[1], *Usnea orientalis*[1] , *Lepraria eburnea*[1], *Lepraria elobata*[1], *Lepraria isidiata*[1], *Lepraria lobata*[1], *Lepraria lobata*[1], *Leprocaulon coriense*[1], *Leprocaulon textum*[1]

7. District: Tehri (including other district of Garhwal)

Major lichen rich/explored areas:

References: (Bajpai *et al.,* 2018; Rai *et al.,* 2015)

Reported Lichen species:

Acarospora schleicheri, Allocetraria ambigua, Allocetraria flavonigrescens, Allocetraria stracheyi, Bryoria confusa, Bulbothrix meizospora, Cetraria aculeata, Cetraria islandica, Cetraria laevigata, Cetraria nigricans, Cetraria odontella, Cetrelia olivetorum, Cladia aggregata, Cladonia awasthiana, Cladonia borealis, Cladonia cariosa, Cladonia cartilaginea, Cladonia ceratophyllina, Cladonia chlorophaea, Cladonia coccifera, Cladonia coniocraea, Cladonia corniculata, Cladonia corymbescens, Cladonia crispata, Cladonia delavayi, Cladonia fenestralis, Cladonia fimbriata, Cladonia fruticulosa, Cladonia furcata, Cladonia humilis, Cladonia laii, Cladonia macilenta, Cladonia macroceras, Cladonia macroptera, Cladonia mongolica, Cladonia ochrochlora, Cladonia pocillum, Cladonia pyxidata, Cladonia ramulosa, Cladonia rangiferina, Cladonia rei, Cladonia scabriuscula, Cladonia singhii, Cladonia squamosa, Cladonia subradiata, Cladonia subulata, Cladonia verticillata, Coccocarpia erythroxyli, Coccocarpia palmicola, Coccocarpia pellita, Collema furfuraceum, Collema furfureolum, Collema polycarpon, Collema pulchellum var. subnigrescens, Collema ryssoleum, Collema subconveniens, Collema subflaccidum, Collema tenax, Collema tenax var. corallinum, Dermatocarpon vellereum, Endocarpon subrosettum, Evernia mesomorpha, Everniastrum cirrhatum, Flavocetraria cucullata, Flavoparmelia caperata, Flavopunctelia soredica, Fuscopannaria saltuensis, Heterodermia angustiloba, Heterodermia diademata, Heterodermia firmula, Heterodermia

hypocaesia, Heterodermia leucomelos, Heterodermia microphylla, Heterodermia obscurata, Heterodermia pseudospeciosa, Heterodermia rubescens, Heterodermia speciosa, Hypogymnia enteromorpha, Hypotrachyna adducta, Hypotrachyna crenata, Lempholemma chalazanum, Lepraria caesioalba, Lepraria lobificans, Lepraria neglecta, Leptogium askotense, Leptogium burnetiae, Leptogium cyanescens, Leptogium denticulatum, Leptogium pedicellatum, Leptogium phyllocarpum, Leptogium saturninum, Leptogium teretiusculum, Leptogium trichophorum, Melanelia hepatizon, Melanelia stygia, Melanesia japonica, Melanelia panniformis, Melanelia tominii, Melanelixia villosella, Mycobilimbia hunana, Mycobilimbia philippina, Nephroma helveticum, Nephroma parile, Parmelia masonii, Parmelia sulcata, Parmelinella wallichiana, Peccania synaliza, Peltigera canina, Peltigera didactyla, Peltigera dolichorrhiza, Peltigera elisabethae, Peltigera horizontalis, Peltigera lepidophora, Peltigera malacea, Peltigera membranacea, Peltigera pindarensis, Peltigera polydactylon, Peltigera polydactylon, Peltigera rufescens, Phaeophyscia hispidula, Physcia adscendens, Peltigera caesia, Peltigera dilatata, Physconia detersa, Physconia grisea, Ramalina hossei, Rhizoplaca chrysoleuca, Rhizoplaca melanophthalma, Stereocaulon alpinum, Stereocaulon foliolosum, Stereocaulon massartianum, Stereocaulon myriocarpum, Stereocaulon pomiferum, Sticta henryana, Sticta indica, Sticta limbata, Sticta nylanderiana, Sticta platyphylloides, Sticta praetextata, Toninia tristis, Toninia tristis, Toninia vermicularis, Umbilicaria indica, Xanthoparmelia terricola, Lepraria lobata, Leprocaulon coriense

(*second study)

Distribution of Usnea species reported from various regions of Uttarakhand (Shukla *et al.,* 2014)

Almora	*Usnea aciculifera, Usnea angulata, Usnea baileyi, Usnea compressa, Usnea dendritica, Usnea eumitrioides, Usnea fragilis, Usnea himalayana, Usnea indica, Usnea longissima, Usnea nepalensis, Usnea orientalis, Usnea pangiana, Usnea perplexans, Usnea rubicunda, Usnea sordida, Usnea splendens, Usnea subfloridana, Usnea thomsonii, Usnea undulata*
Champawat	*Usnea compressa, Usnea eumitrioides, Usnea himalayana, Usnea longissima, Usnea nepalensis, Usnea norkettii, Usnea orientalis, Usnea pseudosinensis, Usnea sinensis, Usnea sordida, Usnea splendens, Usnea subfloridana, Usnea thomsonii, Usnea undulata*
Bageshwar	*Usnea compressa, Usnea longissima, Usnea luridorufa, Usnea nepalensis, Usnea orientalis, Usnea pangiana, Usnea robusta, Usnea subfloridana, Usnea thomsonii*
Pithoragarh	*Usnea aciculifera, Usnea angulata, Usnea compressa, Usnea eumitrioides, Usnea longissima, Usnea orientalis, Usnea pangiana, Usnea pseudosinensis, Usnea rubicunda, Usnea sordida, Usnea spinosula, Usnea splendens, Usnea subflorida, Usnea subfloridana, Usnea undulate*
Nainital	*Usnea eumitrioides, Usnea orientalis, Usnea sinensis, Usnea sordida, Usnea splendens, Usnea subfloridana, Usnea thomsonii*
Udham Singh Nagar	-
Chamoli	*Usnea aciculifera, Usnea baileyi, Usnea splendens, Usnea undulata*
Haridwar	-
Dehradun	*Usnea aciculifera, Usnea compressa, Usnea eumitrioides, Usnea himalayana, Usnea lucea, Usnea longissima, Usnea orientalis, Usnea perplexans, Usnea robusta, Usnea sordida, Usnea splendens, Usnea subfloridana, Usnea thomsonii*

Rudraprayag	-
Pauri	*Usnea aciculifera, Usnea eumitrioides, Usnea orientalis*
Tehri	*Usnea eumitrioides, Usnea longissima, Usnea orientalis, Usnea rubicunda, Usnea undulata*
Uttarkashi	*Usnea aciculifera, Usnea angulata, Usnea compressa, Usnea longissima, Usnea orientalis, Usnea perplexans, Usnea subfloridana, Usnea thomsoni, Usnea undulata*

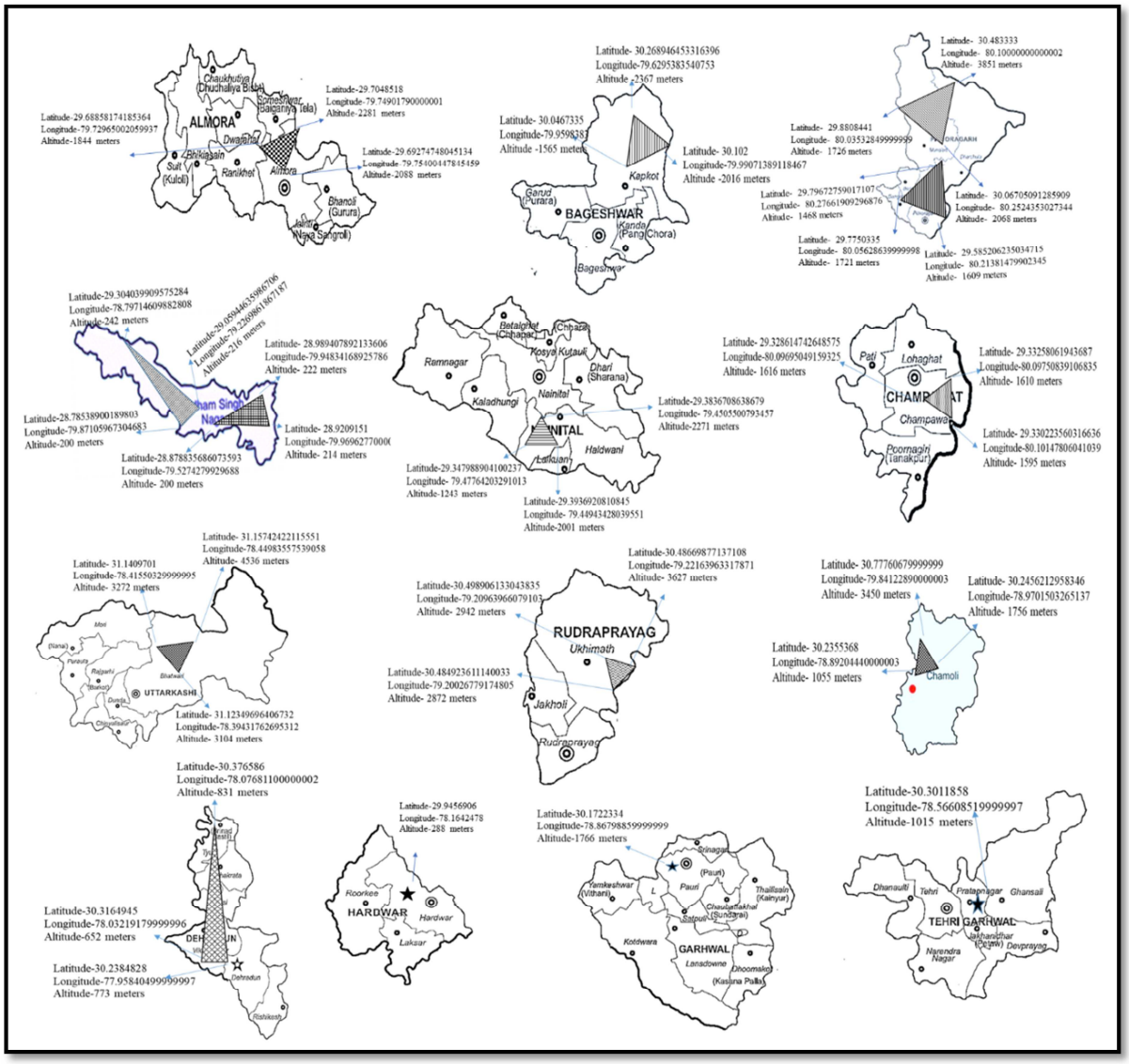

Fig. 2. Accessed lichen-rich area(s) (by various researchers) in different districts with approximate GPS coordinates and Altitudes.

Lichen Identification Methods

After collection of specimens, it is necessary to identify the particular species. There are many techniques of identification such as molecular techniques, chemical techniques and morpho-anatomical identification techniques. In molecular techniques, DNA barcoding is used for the species level identification and in chemical technique UV light, spot test followed by thin layer chromatography are used.

Similarly, the light microscope is used for the anatomical identification. For morphological identification the shape, size, colour etc are the important factors.

According to the literature, the DNA-barcoding is relatively less used technique, particularly in Uttarakhand (and nationwide as well) but the chemical and morpho-anatomical techniques are common and abundantly used technique for identification of lichens

Though, chemotaxonomy upto some extent could be and has been used in the differentiation of lichens with similar morphotypes but it is not applicable universally across all species. On the contrary, DNA-barcoding in recently have shown great potential in precisely identifying various organisms including lichenized fungi as well (Kelly *et al.,* 2011) (Table 2).

Table 2. Lichen species of Kumaun and Garhwal Himalaya.

Name of District	Reported/identified Lichen species of Kumaun and Garhwal Region	Identification Technique*	References
Almora	39	M, A, C	(Jagtap *et al.,* 2013)
Bageshwar	361	M, A, C	(Joshi *et al.,* 2011)
Champawat	15	M	(Kumar *et al.,* 2010)
Udham Singh Nagar	146	M, A, C	(Mishra *et al.,* 2016) (Mishra *et al.,* 2016)
Pithoragarh	376	M, A, C	(Joshi *et al.,* 2012)
Nainital	105	M, A	(Kholia *et al.,* 2012)
Chamoli	43	M, A, C	(Rawat *et al.,* 2013) (Gupta *et al.*, 2016)
Rudraprayag	20	M, A, C	(Rai *et al.,* 2012)
Dehradun	14	M, A	(Rani *et al.,* 2011) (Shukla *et al.,* 2014)
Uttarkashi	214	M, A, C	(Karakoti *et al.,* 2014)
Pauri	43	M, A, C	(Shukla *et al.,* 2005)
Tehri Garhwal	146	M, A, C	(Rai *et al.,* 2015)
Haridwar		M, A, C	(Shukla *et al.,* 2013)

*M- Morphological, A- Anatomical, C- Chemical

Table 3. Explored lichen-rich areas of Uttarakhand with approximate GPS coordinate(s) and altitudes.

Districts of Uttarakhand	Accessed Lichen-rich Areas		
	Latitude DD (decimal degrees)	Longitude DD (decimal degrees)	Altitude (meters)
Almora	29.68858174185364 - 29.69274748045134- 29.7048518	79.72965002059937 - 79.75400447845459 - 79.74901790000001	1844-2088-2281
Bageshwar	30.0467335- 30.102- 30.268946453316396	79.959838- 79.99071389118467- 79.629538354075	1565 -2016 – 2367
Champawat	29.330223560316636- 29.33258061943687- 29.328614742648575	80.10147806041039 - 80.09750839106835- 80.09695049159325	1595-1610-1616
Udham Singh Nagar	28.785389001898O3- 29.05944635986706- 29.30403990957528, 28.878835686073593- 28.9209151- 28.989407892133606	79.87105967304683- 79.226986186718- 78.7971460988280, 79.5274279929688- 79.96962770000005- 79.94834168925786	200- 216- 242, 200- 214- 222
Pithoragarh	29.8808441 -30.06705091285909 - 30.483333, 29.79672759017107 - 29.585206235034715 - 29.7750335	80.0353284999999- 80.2524353027344- 80.10000000000002, 80.27661909296876 - 80.21381479902345 - 80.05628639999998	1726-2068-3851, 1468-1609-1721
Nainital	29.34798890410023- 29.3936920810845- 29.3836708638679	79.4776420329101- 79.4494342803955- 79.4505500793457	1243-2001-2271

Districts of Uttarakhand	Accessed Lichen-rich Areas		
	Latitude DD (decimal degrees)	Longitude DD (decimal degrees)	Altitude (meters)
Chamoli	30.2355368-30.2456212958346-30.77760679999999	78.89204440000003-78.9701503265137-79.84122890000003	1055-1756-3450
Rudraprayag	30.484923611140033-30.498906133043835-30.48669877137108	79.20026779174805-79.20963966079103 -79.22163963317871	2872-2942-3627
Pauri	30.1722334	78.86798859999999	1766
Dehradun	30.3164945-30.2384828 –30.376586	78.03219179999996 -77.95840499999997-78.07681100000002	652-773-831
Haridwar	29.9456906	78.1642478	288
Uttarkashi	31.12349696406732 –31.1409701-31.15742422115551	78.39431762695312-78.41550329999995-78.44983557539058	2000-3272-4536
Tehri Garhwal	30.3011858	78.56608519999997	1015

Formatting Department: Please note that internal boundaries need to be shown in the above table for the sake of clarity

Other than this, Bajpai *et al.* (2019), also demonstrated some ecological monitoring approach of lichens. The periodical studies also help in the monitoring of the growing vegetation of the lichens especially from higher altitudes due to climate change. Similarly, for assessment of lichen diversity some remote sensing technology such as digital elevation models (DEMs) and geographic information systems (GIS) used for analyzing the shape and growth pattern of lichens. Lichenometry method invented by Beschel in 1973, could be applied in indirect and direct methods, which help in data accuracy and correlation. In the case of direct Lichenometry, individual lichen could be studied in repeated time interval while in the indirect method the thallus shape, growth, and surface age could be studied (Bajpai *et al.,* 2019).

Endemic, Rare and Endangered Lichens

Several lichen species are evolutionary diverse and ecologically important. The diversification and genetic distance of lichens varying according to demographic regions but some factors such as climate change and forest fire deviate the diversity of lichen. Jessica *et al.* (2018), reported the *Cetradonia linearis* as an endangered and epidemic lichen species of eastern North America and first sequenced the whole genome of 32 individuals of *C. linearis* (Jessica *et al.,* 2018). Similarly, James *et al.* (2015), considered the *Hypotrachyna virginica* as an endangered and epidemic species (James *et al.,* 2015). Eric *et al* studied the *Sulcaria badia*, a rare endemic lichen of western North America (Eric *et al.,* 1998). These all three species *Cetradonia linearis, Hypotrachyna virginica,* and *Sulcaria badia*, also not reported in Uttarakhand from both Kumaun and Garhwal region yet.

Major threats to the lichen biodiversity in Uttarakhand

Various factors are responsible for the loss of lichen biodiversity from Uttarakhand, such as anthropogenic factors and pollution, of which global climatic change play a major role in biodiversity loss (Lendemer *et al.,* 2011). These threats include increase in urbanization and industrialization, deforestation, loss of habitats, forest-fires and change in ecological conditions leading to deterioration of lichen-biodiversity. Agriculture is shifting, road building projects, hydroelectric projects, and up to certain extent tourism are other potential threats for to the lichen biodiversity in Uttarakhand (Rawat *et al.,* 2014).

Challenges associated with conservation-efforts focused on lichens

- The lack of herbariums/fungarium, gardens, and proper documentation of lichens makes the process of identification and thereby that of conservation challenging in Uttarakhand. Due to vast diversity, and cryptic morphology, precise identification of lichen

species is cumbersome. Lack of proper databases/fungaria and large-scale integration of information generated through different identification methods such as morphology, microscopy, chemotaxonomy and molecular taxonomy is also missing.

- There are not many channels dedicated for lichen-biodiversity reporting. It is a need of hour that herbariums/fungarium, gardens, research labs also serve as 'reporting channels', with more user-friendly approach. These channels could also promote the lichen-biodiversity reporting by providing perks to the contributors.
- Lichens are very slow growing organisms, with few of them growing just in millimetres in years. Attempt of *in vitro* culture of lichens hasn't yielded much success as of yet. So, efforts need to be carried out in the direction of successful in-vitro culture of lichens.
- The key constituents of natural habitats of various lichens need to be identified so as to maintain and recreate the natural habitats particularly for rare and endangered lichens.
- Overexploitation is also a key challenge for the conservation of economically important species of lichen.
- Lack of knowledge among locals and people in lichen trade regarding the lichen-identification is another major challenge towards the lichen biodiversity conservation; this leads to improper exploitation of lichen biodiversity. Imparting this knowledge to people in trade and people in community (such as college students) could also be crucial for lichen biodiversity reporting.

Focusing on all these factors and striving to overcome these challenges could make a significant contribution towards the conservation of lichen biodiversity in Uttarakhand.

Precise species identification for supporting lichen-trade and conservation

The mountainous region of Uttarakhand represents a major portion of Western Himalaya and is one of the main areas for lichen collection in India. Lichen collection is an alternate income generating activity after agriculture for the poor villagers in the state. Lichens are sources of many condiments, dyes, medicines, perfumes and animal feed, and as bioindicators of atmospheric pollution (Upreti *et al.,* 2015). However, in trade as well as in biodiversity conservation research, precise identification of lichens is a challenge because of very similar and indistinguishable morphotypes of many of the lichens. Traditional, phenotype-based approaches of species identification have their own limitations and even experts also fail at times to accurately characterize species-level diversity in lichen-forming fungi. This leads to collection of adulterated biomasses that ultimately resulting in impure downstream product(s); as well as inaccurate research leads in the conservation studies.

From financial point of view as well, inaccurate identification significantly reduces the market-cost of collected lichens. Moreover, even in any case if the collected lichen is precisely identified, due to (mostly uncommon) expertise of lichen identification of collector, they do not have sufficient resources to prove the purity of lichen-mass as it gets partially pulverized after drying during its transportation. A net difference of approximately 4-9 fold has been observed in the cost of higher grade (grade I) and lower grade (grade IV) lichens (Shah *et al.,* 1998). Therefore, the imprecise identification negatively impacts the livelihood of people associated with lichen-collection in the community; as well as it harms the conservation efforts focused at rare and endangered species of lichens.

Conclusion

Lichens have numerous applications in industry and are used for production of condiments, food, dyes, perfumes and medicines. As lichen business is able to provide job opportunities to the villagers in Uttarakhand, this could reduce the migration of local people to larger cities in search of jobs. However, declining natural habitas and biodiversity of lichens is a big problem and multidirectional efforts need to be carried out to control the same. Defining the constituents of their natural habitats, developing

efficient *in-vitro* propagation protocols, controlling overexploitation and conserving/recreating the natural habitats could be a few measures. However, researchers involved in lichen-research and the community in trade also needs to be trained in precise and better lichen identification methods. For this, databases/fungaria need to be developed and large-scale integration of information generated through different identification methods such as morphology, microscopy, chemotaxonomy and molecular taxonomy is required, Starting such a program could be envisaged to help documentation and conservation of lichen biodiversity in Uttarakhand Himalaya and to assist community in the trade with accurate identification of lichens that could significantly enhance their earning and living standards in long term.

Conflicts of interest

There are no conflicts of interest to declare among the authors.

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