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Morphological and Medicinal Aspects of Some Lichens from Summerhill and Its Adjoining Areas of Shimla District of Himachal Pradesh

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Abstract: Lichens contribute significantly in ecosystem health and biodiversity. This investigation explores the range and dispersion of lichens in the study area, with a focus on their habitat preferences and environmental adaptations. Comprehensive field surveys were conducted to document lichen species, followed by taxonomic identification using morphological, anatomical, and chemical techniques. Preliminary results reveal a rich diversity of lichen species across varying habitats, including soil, rock, and tree substrates. 15 lichen species were identified within the study area, encompassing 13 genera and distributed among 8 families. Some of the lichen species present in the study sites are *Cladonia cartilaginea* Müll. Arg., *Lecanora helva* Stizenb., *Physcia dilatata* Nyl., thus showing variation in growth forms in the area. Parmeliaceae was the dominant family with 4 members followed by Cladoniaceae, Lecanoraceae and Physciaceae with 2 members each.

Keywords: Ethnobotany, Lichen Diversity, Morphological features, Western Himalayas

I. Introduction

Lichen is defined as "a self-sustaining ecosystem formed by the interaction of an exhibitant fungus and an extracellular arrangement of one or more photosynthetic partners and an indeterminate number of other microscopic organisms" (Hawksworth and Grube, 2020).

The fungal partner, which constitutes about 90% of the lichen's body, primarily determines the lichen's shape, structure, and color. The remaining portion is contributed by the photobiont, which is typically an alga or cyanobacterium. Approximately 85% of lichen-forming fungi establish symbiotic relationships with members of the Chlorophyta (green algae), while around 10% form associations with cyanobacteria. A small group of lichens also forms a mutual partnership with both chlorophytes and cyanobacteria (Honegger, 2008). The algal partner absorbs carbon dioxide and moisture from the atmosphere through the mycobiont's tissues and produces food, while the mycobiont, being heterotrophic, absorbs nutrients from the photobiont (Awasthi, 2000). (Hawksworth and Grube 2020). About 90% of the lichen plant body is made up of the fungal partner, which mainly determines the lichen's shape, structure, and colour, although the photobiont also contributes partially. Roughly 85% of lichen-forming fungi form symbiotic associations with members of Chlorophyta. On the other hand, about 10% establish partnerships with cyanobacteria. A small group of dual photobionts are known to form a simultaneous mutual partnership with both chlorophytes and cyanobacteria (Honegger 2008). The algal partner absorbs carbon dioxide and moisture from the atmosphere through the mycobiont's tissues and produces food. In return, the mycobiont, being heterotrophic, obtains nutrients from the photobiont (Awasthi 2000). Lichens play a crucial role in ecosystems as bioindicators of environmental health, particularly air quality, due to their sensitivity to pollutants like sulfur dioxide and nitrogen compounds (Prado et al., 2025). Furthermore, lichens contribute to soil formation (Kallison, 2021) and provide habitats for various organisms, enhancing biodiversity (Prado et al., 2025). Their ecological importance extends to nutrient cycling, where they assist in breaking down rock substrates and contributing to the formation of soils in harsh environments. Himachal Pradesh, a biodiversity rich region in the Western Himalayas, hosts a rich lichen flora comprising 503 species across 107 genera and 44 families. The Great Himalayan National Park (GHNP) alone supports 192 species from 65 genera and 31 families (Kumari 2024). Since they are an essential food source and can be used as therapeutic agents for a variety of illnesses, lichens have played a significant role in traditional and indigenous medical systems in many different cultures around the world, including Himachal Pradesh (Kumar et al. 2024). Their application in ethnomedicine demonstrates a wealth of traditional knowledge that has great potential to advance modern pharmacology. New bioactive compounds and medical treatments may be discovered as a result of the preservation and scientific validation of this cultural legacy. Despite the rich lichen diversity in Himachal Pradesh, there is limited research on the detailed morphological characteristics of lesser-known lichen species and their medicinal uses. Additionally, the ethnobotanical knowledge of local communities regarding lichens remains under-documented. This study aims to address these gaps by documenting the lichen species from the Summerhill area of Shimla, focusing on their morphology and traditional medicinal

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

applications. The present study aims to document some lichen species from Summerhill and its adjoining area of Shimla district of Himachal Pradesh with their morphological aspects and ethnobotanical uses.

II. Material and methods

Study area:

Shimla is the capital of Himachal Pradesh known as queen of hills and which is a rich hotspot of plant diversity including lichen diversity. Summerhill is one of the prominent localities of Shimla, the capital of Himachal Pradesh, which is situated in North-western Himalayas. It is situated at an elevation of about 2,100m above sea level and serves as a part of the seven-hill formation on which Shimla is built. The region features undulating hills, steep slopes, and deep valleys, typical of the Sub-Himalayan terrain. The area is densely forested with pine, oak, cedar (deodar), and rhododendron trees, creating a rich, temperate ecosystem ideal for the growth of organisms like lichens and mosses.

Sample collection and Identification

Lichen samples were collected during field excursions from seven distinct sites within the study area, encompassing a range of substrata including bark, rock, and soil. Lichen samples were identified with the help of lichen identification keys by Awasthi (1991, 2007). Samples were collected using a hammer and chisel to extract them from the substrata carefully. A total of 60 lichen samples were brought to the laboratory for identification. The specimens were identified by examining their physical structure, internal organisation, and chemical com position. Morphological characteristics were examined using a Stereozoom microscope (Leica EZ4W). Spot colour tests and Thin Layer Chromatography (TLC) were conducted to identify the chemical constituents present in the lichen samples. Spot test were carried out using chemical reagents such as aqueous KOH (K test), Ca $(OCl)_2$ (C test), para-phenylenediamine (P test), and iodine (I test) on the thallus and medulla (Orange et al. 2001). Thin Layer Chromatography (TLC) was employed to assess the chemical composition of lichen samples. The lichen compounds in solvent system A(Toluene/ 1,4-Dioxane/ acetic acid ratio 180:45:5) were identified by TLC, using the techniques described by Walker and James 1980. The specimens were stored at the LWG Herbarium, part of the CSIR NBRI in Lucknow.

III. Results

1). *Amandinea submontana* Marbach

Morphological observations:

Amandinea submontana is a crustose, saxicolous lichen characterized by a thin, closely adherent thallus that remains relatively inconspicuous on the substrate. The thallus ranges from continuous to areolate, exhibiting a dull grey to dark grey-brown coloration and a surface that is smooth to faintly verrucose. A prothallus is usually absent or only weakly developed along the margins. Apothecia are lecideine, black, epruinose, measuring 0.2–0.5 mm in diameter, with discs that are flat to slightly convex. The proper exciple is black, carbonized, and persistent. Asci are 8-spored and conform to the Lecanora-type. Ascospores are brown, ellipsoid, slightly narrow at the septum, and measure 10–14 × 4–7 µm.

Chemical Profile: Atranorin

Ecological Distribution: North-East India, Madhya Pradesh, North America

2). *Canoparmelia pustulescens* (Kurok.) Elix

Morphological observations

Thallus predominantly saxicolous, occasionally corticolous, reaching up to 5 cm in diameter, is closely attached to the surface. Lobes are sublinear, with blackened margins near the apices. The upper surface is rugulose and bears isidia; the isidia are irregularly inflated and rupture apically to release coarse soredia. Lower surface dark with sparse rhizines, and the medulla is white. Apothecia 2 mm diameter; ascospores measure 7–9 × 4–5 µm.

Chemical Profile: K–, C–, KC–, P–. Chemical analysis reveals the presence of sekikaic acid, homosekikaic acid, and fatty acids.

Ecological Distribution: Reported from Africa, Australia; India: Himachal Pradesh, Kerala, Tamil Nadu-Palni Hills,

3). *Flavoparmelia caperata* (L.) Hale

Morphological observations

Thallus corticolous, rarely saxicolous or terricolous, closely adnate, to 20 cm across; lobes around 10 mm in width; top side plicate, pustules develop into soralia; soredia granular; rhizines simple; medulla is white. Apothecia occasionally present, with diameter up to 3 mm.; ascospores, 16-20 x 7-10µm.

Chemical Profile: The cortex was tested to be negative for (K); on the other hand, tested positive for usnic acid. The medulla tested negative for potassium (K) and calcium hypochlorite (KC), while it tested positive, giving an orange-red colour, establishing the positive results for protocetraric acid as well as for caperatic acid.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

Ecological Distribution: Nepal, China, Japan, Sri Lanka and extensively dispersed in subtemperate zones around the globe. From Indian regions (Tamilnadu, West Bengal- Darjeeling District), states of North India- Himachal Pradesh, J & K; states of Nort-East -Manipur, Meghalaya, Nagaland).

4). *Parmotrema tinctorum* (Despr. ex Nyl.) Hale

Morphological observations:

Thallus corticolous / saxicolous, typically ranging from 8–20 cm in diameter. Lobes 10–30 mm across; cilia not present; dorsal portion greyish, spotless. Isidia grain-like to thread-like. Lower surface black in middle with nude marginal zone; medulla is white. Apothecia rare, with diameter 10 mm. Ascospores with an epispore.

Chemical Profile: Medulla K–, C+ red, KC+ red, P–. TLC showed presence of Lecanoric acid as the major compound.

Ecological Distribution: This lichen is widely distributed in Africa, China North, Central and South America, Indonesia, Australia and New Zealand

5). *Punctelia rudecta* (Ach.) Krog

Morphological observations:

Thallus corticolous or occasionally saxicolous, reaching 6–8(–10) cm in breadth, with a firm to brittle consistency. Lobes measuring 3–6 mm across. Dorsal portion is stone-green coloured, bearing punctiform to elongate pseudocyphellae. Isidia present, ranging from unbranched to coralloid, occasionally exhibiting lacinulate margins. Lower side showed beige colouration. Apothecia infrequent, up to 5 mm in diameter. Ascospores 10–17 × 5–10 µm.

Chemical Profile: Medulla tested positive for C, KC, and negative for K and P. TLC identified Lecanoric acid as the major lichen compound.

Ecological Distribution: Occurs broadly across tropical and temperate zones worldwide, India (elevations ranging from 1500 to 3200 m, with records from Himachal Pradesh, J & K, Kerala, Tamil Nadu (Nilgiri and Palni Hills), and Uttarakhand.

***6)Cladonia cartilaginea* Mull. Arg.**

Morphological observations

The species features a primary thallus with small, ascending squamules that may persist or disappear. Podetia are hard, whitish to grey, slender, subulate, and always escyphose, with a granulose to verrucose, ecorticate surface often bearing microsquamules. Tips of Hymenial discs are dark brown.

Chemical Profile: Chemical spot tests show variable reactions (K+ yellowish or K–, P+ red). Five distinct chemotypes have been reported, based on the presence of compounds like fumarprotocetraric, psoromic, homosekikaic, usnic, and related acids.

Ecological Distribution: Tropical Asia, Africa, Latin America; From Indian regions: Western Himalayan states, J & K, Southern India, Meghalaya. Manipur, Sikkim, West Bengal-Darjeeling District.

7). *Cladonia fruticulosa* Kremp

Primary thallus composed of persistent squamules tiny to average in size, cotton like and granulose, with soredia on the bottom surface. Podetia light grey, typically 10–30) mm in height; predominantly simple, occasionally branched with apices blunt. Podetial surface variably corticated; soredia granulose, frequently exposing the underlying medulla. Hymenial discs pale brown.

Chemical Profile: K–, P+ yielding a deep yellow to red reaction shown by podetia. Three strains of compounds are recognized: (1) a psoromic acid strain (2) usnic acid strain (3) a strain containing fumarprotocetraric, protocetraric, and lichesterinic acids.

Ecological Distribution: Reported from Bhutan, southeastern Asia, Africa, Australasia, and Oceania, in india, recorded from Arunachal Pradesh, Southern Indian states, Nort-East India.

***8). Candelaria concolor* (Dicks.) Stein**

Morphological observations

Thallus corticolous and foliose, forming small rosettes with tiny lobes 2 mm in length and 0.5 mm wide, bearing granular soredia at the lobe tips. Indian specimens are sterile.

Chemical Profile: Both the cortex and apothecia show K–, C–, KC–, P–. Chemical analysis indicates the presence of calycin and pulvinic acid."

Ecological Distribution: China, Japan, temperate Europe, Africa, Madagascar, North America and New Zealand, India (J & K, Nagaland)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

***9). Lecanora helva* Stizneb**

Morphological observations:

Thallus crustose, yellowish grey, smooth, ecorticate, epruinose, esorediate; ascomata apothecia, sessile, lecanorine, disk light brown or orange, with apparent margin; amphithecium with big crystals, small crystals solvable in K but not large crystals, epithecium light brown with tiny, crystalline structures, hymenium uncoloured, hypothecium uncolored; ascus 8–spored, ascospores with no colour, simple, 10–12 × 2–3 µm.

Chemical Profile: P+ displays yellow, KC– is negative, UV is negative, and K+ and C+ tests produce yellow results.

Ecological Distribution: Africa, Australia, Brazil, Colombia, Fiji, Mexico, New Caledonia, Pacific regions, USA. From Indian regions (Himalayan states and Southern states).

***10). Lecanora leuteomarginata* Nayaka, Upreti & Lumbsh**

Morphological observations:

Lichen plant body is crustose. Sessile apothecia, with a diameter ranging from 0.5 mm to 1.8 mm, cortex jelly-like, parathecium is transparent and compact, about 7 to 8 µm; the epihymenium is reddish brown with granules but without any crystalline structures; the paraphyses are simple; the ascus is clavate; the ascospores are very small and are eight in number; these are ellipsoidal in shape, and their size ranges from 5-8 X 3-4 µm.

Chemical Profile: Medulla tested positive for the K test as well as for KC test giving yellow coloration. On the other hand, gave negative results for the Pd test. TLC gave the confirmation for the presence of compounds such as atranorin as well as zeorin.

Ecological Distribution: India, Western Himalaya, Uttarakhand

***11). Lepraria granulata* Slav.-Bay**

Morphological observations:

Thallus leprose, granular, whitish grey to grey, ocassionally with faint bluish grey colour, granules creamy, soft; hyphae firmly attached to the substrate; margin delimited to diffuse; lobes poorly developed, obscure; hypothallus scarce, whitish grey, or blackish, sometime pale yellowish orange-brown lower surface; soredia abundant, coarse, up to 200–300 µm in diam.

Chemical Profile: Atranorin ±, two fatty acids, unidentified anthraquinones. K+ purple-red, C−, KC, Pd− or + faint yellowish.

Ecological Distribution: earlier known from Central and Eastern Europe. In India this lichen is found growing on rock of at an altitude of 2000 m.

***12). Lithocalla ecorticata* (J. R. Laundon) Orange comb. nov.**

Morphological observations:

Prothallus absent or sometimes developed in shaded conditions. Thallus crustose, diffuse, with leprose crust. Thallus up to 2 mm thick, with dead, decolorized granules; exhibit surface cracking. Granules fine, ecorticate, lacking projecting hyphae.

Chemical Profile: provided negative results for the K test and C test, and tested positive for Pd test compounds such as atranorin and usnic acid showed their presence.

Ecological Distribution: Great Britain; south-west Norway, India, Mongolia, Canada, Chile, China

13). *Leptogium cyanescens* (Ach.) Korb

Morphological observations

Thallus corticolous, terricolous, muscicolous, or saxicolous, adnate, reaching a diameter of about six centimetres. Lobes are orbicular and about 13mm across and 55–130 µm thick, with marginal isidia and lobules. The upper surface is lead-grey, rough, and isidiate; isidia are predominantly cylindrical, occasionally squamiform. The lower surface is smooth and etomentose. Apothecia are sessile, 1.5 mm in diameter, and isidiate. The thalline rim has a multi-layered cortex at the base and 2–3 cell layers at the periphery. The ascomatal rim is euparaplectenchymatous at the margin and centrally indistinct. Ascospores, with 2–5 transverse and 1 longitudinal septum, measuring 18–30 × 7–10 µm; another reported ascospore size range is 9–20 × 5–9 µm.

Chemical Profile: No chemical present

Ecological Distribution: Asia. Africa, North. Central and South America, and Australia. India (Himachal Pradesh, Kerala, Maharashtra, Tamil Nadu-Nilgiri and Palni Hills, Uttarakhand).

14). *Phaeophyscia pyrrhophora* (Poelt) D. D. Awasthi & M. Joshi

Morphological observations:

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

Thallus corticolous, reaching up to 10 cm in diameter; lobes narrow, 2–3(–5) mm across. Top surface stone- green to brown, without isidia or soredia. Ventral surface covered with rhizines. Medulla distinctly bicolored—yellowish in the top zone and orange-red in the lower. Apothecia small, 1(–2) mm in diameter, coronate. Ascospores measure 20–29(–36) × 9–15 µm.

Chemical Profile: Medulla reacts K+ red-violet; skyrin is the principal secondary metabolite.

Ecological Distribution: The Americas, European continent and the Island continent. India (Himachal Pradesh, Uttarakhand Sikkim, West Bengal, Nagaland, Meghalaya Kerala, Tamil Nadu).

15). ***Physcia dilatata*** **Nyl.**

Morphological observations:

Thallus primarily corticolous, occasionally saxicolous, measuring upto 10 cm in diameter; lobes 2–10 mm wide. Top surface greyish, pruinose, lacking both isidia and soredia. Lower surface grey or dark grey; lower cortex composed of paraplectenchymatous tissue. Apothecia diameter up to 1.5 mm. Ascospores (18–32 × 10–15) µm.

Chemical Profile: Medulla detected with yellow coloration for K test, indicating a positive result. Zeorin was detected as a chemical compound.

Ecological Distribution: Africa, India (subtropical to lower temperate regions of Nepal and the Indian states of Manipur and Uttarakhand).

Table 1: Ethnobotanical uses of some lichen species documented from the study area

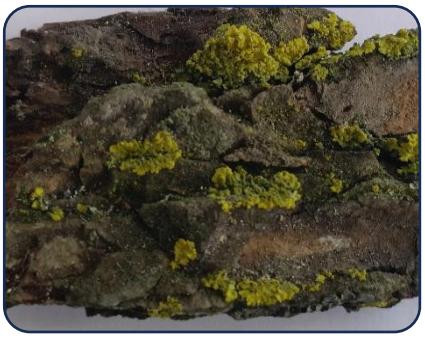
Lichen sp	Traditional use	References
Flavoparmelia caperata	The dried thallus of this lichen is crushed and converted into powdered form, which in turn is used for the treatment of wounds. Dried powdered form is also used for healing burns. A concoction of this lichen is also used for the expulsion of intestinal worms.	Crawford, 2019
Cladonia fruticulosa	An extract of this lichen is utilized to check on cutaneous infection, tuberculosis, burns, blisters, and to mitigate heart palpitations, disorientation, etc.	Crawford, 2019
Cladonia cartilaginea	It has been traditionally used for its medicinal benefits, particularly in alleviating symptoms of cough and the common cold.	Sutar et al., 2021
Parmotrema tinctorum	It is used to treat coughs and throat problems.	Singh et al., 2012

Table 2. Species name, lichen family, substrate, Altitude, Site name and Accession No. of lichens from study area.

Species name	Family	Substrate	Altitude	Site	Accession No.
Amandinea submontana Marbach	Caliciaceae	rock	1875m	Specimen examined: Shimla, Sanjauli	LIC69411
Canoparmelia pustulescens (Kurok.) Elix	Parmeliaceae	Tree bark	2045m	Shimla, Potter Hill, growing on the bark of chir pine	LIC69407
Flavoparmelia caperata (L.) Hale	Parmeliaceae	Tree bark	2056m	Specimen examined: Shimla, Potter hill	LIC69406

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

Parmotrema tinctorum (Despr. ex Nyl.) Hale	Parmeliaceae	tree	Shimla, Potter hill.	2027m	LIC69405
Punctelia rudecta (Ach.) Krog	Parmeliaceae	tree	1840m	Shimla, Annandale.	LIC69402
Cladonia cartilaginea Mull. Arg.	Cladoniaceae	soil	1878m	Shimla, Tutu.	LIC69413
Cladonia fruticulosa Kremp	Cladoniaceae	soil	2001m	Shimla, Annandale.	LIC69403
Candelaria concolor (Dicks.) Stein	Candelariaceae	Bark	2377m	Shimla, Sanjauli.	LIC69410
Lecanora helva Stizneb	Lecanoraceae	rock	2009m	Shimla, Summerhill.	LIC69401
Lecanora leuteomarginata Nayaka, Upreti & Lumbsh	Lecanoraceae	rock	1911m	Shimla, Totu.	LIC69412
Lepraria granulata Slav.-Bay	Stereocaulaceae	rock	2049m	Shimla, Summerhill.	LIC69408
Lithocalla ecorticata (J. R. Laundon) Orange	Ramalinaceae	rock	2103m	Shimla, Kamna hills.	LIC69409
Leptogium cyanescens (Ach.) Korb	Collemataceae	bark	1857m	Shimla, Annandale.	LIC69404
Phaeophyscia pyrrhophora (Poelt) D. D. Awasthi & M. Joshi	Physciaceae	bark	1904m	Shimla, Annandale.	LIC69400
Physcia dilatata Nyl.	Physciaceae	bark	1927m	Shimla, Glen.	LIC6914



ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

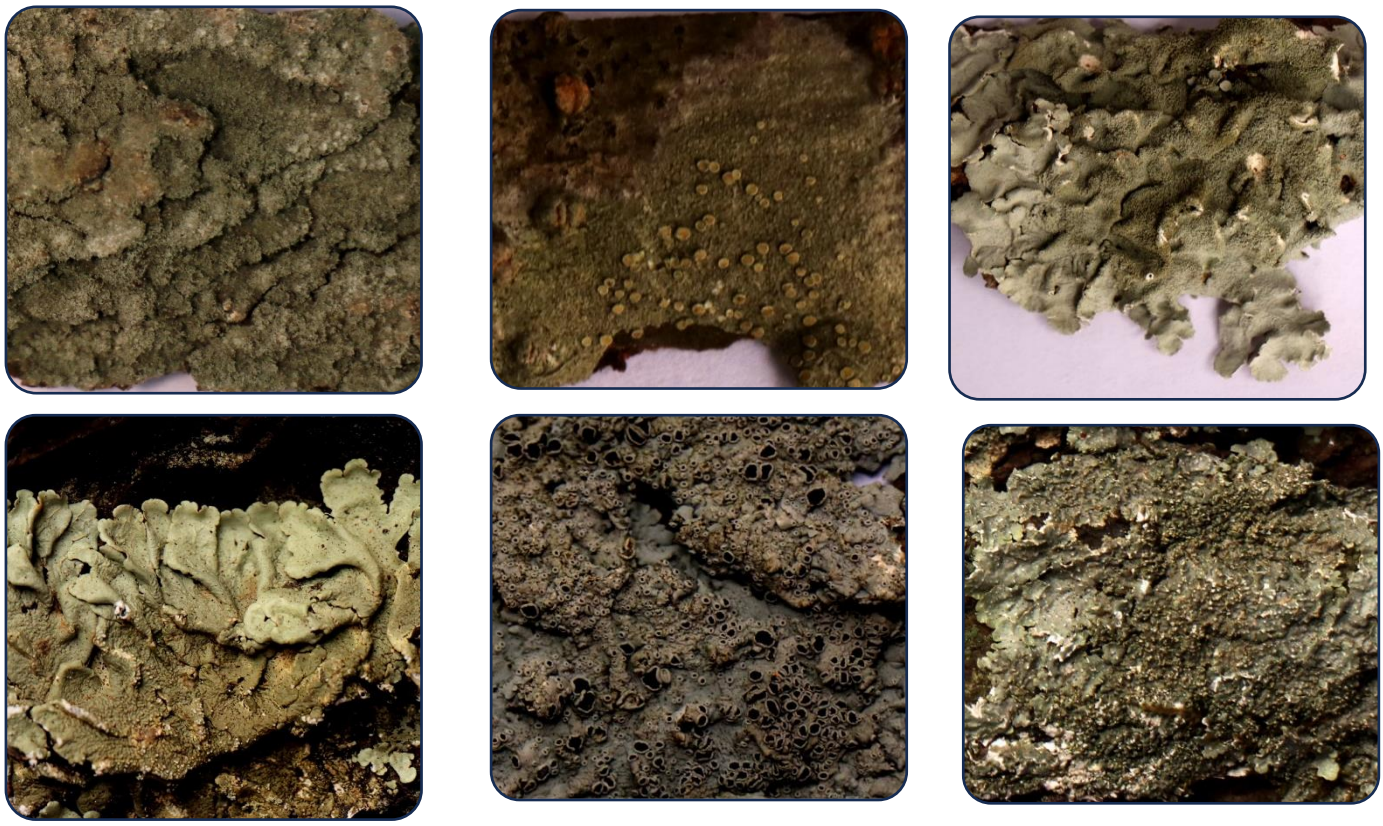


Fig 1. Amadinea submontane, Candelaria concolor, Cladonia fruticulosa, Lithocalla ecorticata, Lecanora helva, Parmotrema tinctorum, Flavoparmelia, Physcia dilatata, Punctelia rudecta

IV. Discussion

In total, 15 lichen species were identified within the study area, encompassing 13 genera and distributed among 8 families. Thakur et al., 2020 described 70 species of lichens belonging to 29 genera and 15 families were found growing in eight different localities of Mandi district of Himachal Pradesh, India.

Among the different growth forms observed, foliose lichens were the most prevalent, accounting for 53% of the recorded species. Crustose lichens followed with a representation of 33%, while fruticose types were the least common, comprising 13.3% of the total lichen diversity. This composition reflects a moderate dominance of foliose forms in the local lichen community. This pattern of dominance aligns with the findings of Srivastava et al. (2004) and Nayaka et al. (2002), who also reported a prevalence of foliose lichens in the districts of Shimla and Solan, respectively. Among the lichen families Parmeliaceae was observed to be the dominant one followed by Lecanoraceae and Cladoniaceae (Table 2). Thakur et al. (2020) mentioned Parmeliaceae as the dominant lichen family in the Mandi District area.

Among the documented species, *Flavoparmelia caperata* was reported to be dried, powdered, and applied to wounds and burns (Table 1). Similar therapeutic applications are supported by Gupta et al. (2007) and Rawat et al. (2024), who documented its use for fever and skin injuries in various traditional systems. *Cladonia fruticulosa* was traditionally used for treating skin infections, tuberculosis, burns, blisters (Table 1). Topical applications were common, particularly for cutaneous bacterial infections. These practices are consistent with earlier literature, which notes its role in addressing contagious skin conditions, dizziness, and conjunctivitis (Wang & Quin, 2013; Rawat et al., 2024).

The present study provides an account of the lichen diversity in Shimla city. However, a comprehensive and systematic revision of the overall lichen diversity across Shimla district is required, as this study primarily focuses on the lichen populations within the hills of Shimla, leaving other areas of the district unexplored. There exists a significant research gap in the understanding of lichen distribution in the broader geographical region of Shimla, necessitating further investigation into the species present in diverse ecological zones within the district.

V. Conclusion

The present investigation emphasizes the significant lichen diversity in the study area. i.e. Summerhill and its adjoining regions, Shimla, Himachal Pradesh. Among the 15 species recorded, four species were recognized as ethnobotanically crucial, as these species are used by local communities to treat ailments such as infections, wounds, and inflammatory issues. Secondary metabolites such as usnic acid, lecanoric acid, and skyrin identified in these lichen species are well known to possess antioxidant,

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

anti-inflammatory, and antimicrobial properties, indicating potential avenues for pharmaceutical applications. It is a well-established fact that global interest is now shifting towards natural product research; therefore, further phytochemical and pharmacological exploration on these as well as other native lichen species is warranted. Such investigations may lead to the discovery of novel bioactive compounds along with that, such studies appeal for the sustainable use as well as conservation of lichen diversity for the benefit of traditional medicine, biotechnology, and allied industries. This study also emphasizes the necessity of conserving lichen-rich habitats in the western Himalayas, which are still underexplored while being ecologically and medicinally significant.

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