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Epiphytic Lichens and Lichenicolous Fungi with New Records from Garhwal Region of Uttarakhand

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***Abstract*:** The study was conducted in an unexplored habitat of *Quercus* Forest of Uttarakhand Garhwal region to examine the Lichen and Lichenicolous fungi status of the area. The preliminary study reveals a total of 49 epiphytic lichens and nine lichenicolous fungi including two new records for India i.e., *Arthonia punctella, Epithamnolia pertusariae* and one new report to Uttarakhand State i.e., *Labrocarpon cannariensis*.

***Keywords*:** Chandrabadni, Lichenicolous fungi, Lichen diversity, Lichen taxonomy, New records, *Quercus* forest

Lichens are universally distributed organisms occurring in varied climatic conditions. Old growth Oak trees are of particular interest because they provide substrate for several organisms from several taxonomic groups, e.g., epiphytic lichens, bryophytes and many insects (Ek and Johannesson 2005, Jansson et al 2009). The study was conducted in unexplored dense *Q. oblongata* forest of Chandrabadni temple. In temperate zone, *Quercus* forests, are global hotspots of biodiversity and are considered as one of the most important habitats in a variety of ecosystems (Gough et al 2014). With increasing age, oak bark becomes more suitable for rare and threatened species and such trunks of old growth oak host a diverse lichen flora (Johansson et al 2009, Thor et al 2010). As texture, humidity and pH of bark provides favourable conditions that offers different types of niches to epiphytic lichens (Zedda 2002). Lichens population is important in determining impacts of disturbance on the forest structure and function. Lichens with cyanobacterial blue green symbionts, contribute significantly for forest nitrogen fixation. One of the first responses of lichen assemblages to increased nitrogen depositions is the reduction in oligotrophic lichens in favour of an increase in nitrophilous species (Pinho et al 2009), bringing about a general homogenization of the lichen vegetation (Liska and Herben 2008). Lichen diversity surveys enable estimating the effects of atmospheric pollution and other predictors in urban areas and remote environments (e.g., forest ecosystems), and in some cases, the synergistic effect of management (harvesting) and pollutants is detectable (Giordani 2007).

Lichens have been widely used for monitoring air pollution because they directly respond to the atmospheric conditions (Nimis et al 2002). Documenting the lichen population can help for assessment of future forest management on general forest health and biodiversity (Moning et al 2009, Svoboda et al 2010, Nag et al 2011). Lichen diversity rich forests are highly explored at present time while such habitats are needed to be conserved, however, there are many unexplored areas in Garhwal Himalayan region and one should focus on them. Besides overexploitation, lichen degradation by another fungus (Lichenicolous) is a major problem that can directly affect lichens' diversity by eliminating them. Lichenicolous fungi are the group of fungi that grow on Lichen thallus. They are especially adapted to the balanced association of fungal and algal organisms and together with their hosts they constitute a complex multi-biont system. The lichenicolous fungus infects the host lichen hyphae at different places and spreads mainly in the inter-hyphal matrix of the host. In recent years researchers shown interest in lichenicolous fungi as there is high possibility of finding new species and new records. This study shows the list of lichen and lichenicolous fungi occurring in the study site.

MATERIAL AND METHODS

Lichen samples were collected from Chandrabadni temple forest of Tehri district in Garhwal Himalaya, Uttarakhand. The area is in temperate zone at an altitude of about 1850-2245 m asl with minimum to maximum temperature ranges from 18°C to 31°C, the area receives adequate rainfall generally commencing from June and extending up to mid-September. Forest is dominated by

Quercus oblongata, Q. semecarpifolia with associated species like *Berberis* sp., *Rhododendron arboretum, Myrica esculenta*, *Pinus roxburghii* and some trees of *Cedrus deodara* etc. These climatic conditions are congenial for the growth of lichens in these broad-leaved forests.

Collected samples were cleaned and dried at room temperature. Morphological study was done using OLYMPUS SZ40 110AL2X WD28 stereo zoom microscope. Section was studied under OLYMPUS CX21 ILED FSI light microscope. The specimens were identified and authenticated through personal observations and available identification keys (Awasthi 1991; 2007). Chemical test K, I, KI, C, KC were applied for confirm identification of lichens.

RESULTS AND DISCUSSION

The present study was conducted in Chandrabadni Temple forest (*Q. oblongata*) to assess the diversity of epiphytic lichens and lichenicolous fungi. This unexplored forest range reveals nine lichenicolous fungi out of which two are new records for India (i.e., *Arthonia apotheciorum* and *Arthonia punctella*) The 49 epiphytic lichen species belonging to 14 families and 26 genera were observed. The eleven species belong to Lecanoraceae and Parmeliaceae, five from Physciaceae, Pertusariaceae and Ramaliniaceae. Hymeneliaceae, Verrucariaceae and Graphidaceae contains two, Caliciaceae, Chrysothricaceae, Cladoniaceae, Collemataceae, Stereocaulaceae and Teloschistaceae has only one specie (Table 1). The nine lichenicolous fungi belong to seven different families i.e., Arthoniaceae, Mycocaliciaceae, Corticaceae, Obryzaceae, Asterniaceae, Sclerotiniceae and Abrothalaceae (Table 2). The crustose taxa exhibit luxuriant growth in the area because they are under less environmental stress due to their micro structure. Out of 49 species 25 belongs to crustose group followed by foliose with 13 species and fruticose with nine species. Rich lichen diversity was observed in the forest because it is dominated by oak tress which provides best substrate for the growth of lichens. The lichen species diversity is reinforced by the exposure of tree stems to sunlight. As lichens are an important component of ecosystem and their diversity keeps the ecological process in a balanced state. Therefore, oak rich forests are of immense ecological significance and play an important role for providing suitable habitat to lichens.

New Records

1. *A. punctella* Nyl**.** Carroll. Nat. Hist. Rev. **6**: pp 533

Host: *Diplotomma alboatrum*

Distribution in India: Uttarakhand State

Taxonomy

Ascomata on thallus tissues, rarely on Ascomata, Ascomata arthonioid, Hypothecium dark greenish brown or brown, Ascospores soon becoming brown and warted, 12−17×5−6.5(7.5) µm; hymenium I+ blue; ascomata 0.07−0.22mm diam.

Material Examined: India, Uttarakhand, Tehri district, Chandrabadni Temple forest, 19°S 30°20'31" N 78°37'41" E 1480m asl. on *Diplotomma alboatrum*. Growing on *Cedrus deodara*. This species is a new record for India.

World Distribution: West region of Europe, Asia, (Turkey, Israel, Iran), North Africa and South America.

2. *Epithamnolia pertusariae* (Etayo and Diederich) Diederich and Sujia Comb. Nov.

≡ *Hainesia pertusariae* Etayo and Diederich **60**: 417 (1996)

Host: *Pertusaria sp*.

Distribution In India: Uttarakhand State

Taxonomy

Conidia needle-like, straight, 0(−1) septate, 14−22×1−5µm; conidiogenous cells vertically catenate; conidiomata disc-like with a raised margin, 80150µm diam; on Pertusaria sp. on bark.

Material examined: India, Uttarakhand, Tehri district, Chandrabadni Temple forest, 19°S 30°20'31" N 78°37'41" E 1480m asl. on *Pertusaria* sp., growing on *Quercus oblongata.* This species is a new record for INDIA.

World distribution: Northern France, Belgium and Netherland.

3. *Labrocarpon canariensis* (D. Hawksw.) Etayo and Pérez-Ortega, in Pérez-Ortega and Etayo Lichenologist **42**(3): 271 (2010)

≡ *Melaspilea canariensis* D. Hawksw., Lichenologist 14(1):84 (1982)

HOST: *Pertusaria* sp.

Distribution in India: Uttarakhand State

Taxonomy

Ascomata elongate, Ascomata simple, Ascus apex with a K/I+ blue apical dome (at least in upper part) or thick, outer gelatinized layer, Ascospores 17−20×6−8µm; ascomata 0.3−0.4×0.1−0.2mm.

Material examined: India, Uttarakhand, Tehri district, Chandrabadni Temple forest, 19°S 30°20'31" N 78°37'41" E 1480m asl. On *Pertusaria* sp. growing on *Q. oblongata*.

New report to Uttarakhand.

World distribution: Macronesia, Western Asia, South America, Australia.

The study inferred that the factors affecting the humidity regime of the forest also affected the epiphytic lichen species composition. Epiphytic lichen species diversity is affected by microclimatic conditions (air humidity, temperature, and light), and structural factors (canopy closure, vertical structure of the canopy, and shrub layer), both of which affect

Table 1. List of Epiphytic Lichens collected from Chandrabadni temple forest

Family	Lichen type	Substrate
Caliciaceae		
Buellia disciformis (Fr.) Mudd	Crustose	*Q. semecarpifolia* bark.
Chrysothricaceae		
Chrysothrix candelaris (L.) J.R. Laundon	Crustose	*Pinus* and *Q. oblongata* bark.
Cladoniaceae		
Cladonia macilenta Hoffm.	Squamulose	On soil
Collemataceae		
Collema flaccidum (Ach.) Ach	Foliose	*Q. semecarpifolia* bark.
Graphidaceae		
Graphis scripta (L.) Ach.	Crustose	*Q. semecarpifolia* bark.
Diploschistes cinereocaesius (Sw.) Vain	Crustose	*Berberis* and *Q. semecarpifolia* bark.
Hymeneliaceae		
Aspiecelia cineria (L.) Korb	Crustose	On rock.
Hymenelia lacustris M. Choisy	Crustose	On rock.
Lecanoraceae		
Lecanora achroides Vain.	Crustose	*Q. oblongata* bark.
L. allophane Nyl. [*L.subfusca* Mull. Arg.]	Crustose	On rock
L. argentata (Ach.) Malme	Crustose	*Q. semecarpifolia* bark.
L. chlarotera Nyl.	Crustose	*Q. semecarpifolia* bark.
Lcircumborealis (Brodo and Vitik)	Crustose	*Q. oblongata* bark.
L.gangaleoides Nyl.	Crustose	*Q. semecarpifolia* bark.
L. pulcaris (Pers.) Ach	Crustose	*Q. semecarpifolia* bark.
L.strobilina (Sprengel) Kieffer	Crustose	*Q. oblongata* bark.
Lecidella euphoria (Florke) Hertel	Crustose	*Q. semecarpifolia* bark.
Lecanora dispersa (Pers.) Florke	Crustose	*C. deodara* and *Q. oblongata* bark.
Lecanora fructosa	Crustose	*C. deodara* and *Q. oblongata* bark.
Parmeliaceae		
Evernia prunastri (L.) Ach.	Fruticose	*Q. semecarpifolia* bark.
Flavoparmelia caperata (L.) Hale	Foliose	*Q. semecarpifolia* bark.
Hypotrachyna cirrhata (Fr.) Divakar, et.al. [*Everniastrum cirrhatum* (Fr.) Hale ex Sipman	Foliose	*Q. semecarpifolia* bark.
H. nepalense (Taylor) Divakar, et.al. [*Everniastrum nepalense* (Taylor) Hale ex Sipman]	Foliose	*Q. oblongata* bark.
Parmotrema austrosinense (Zahlbr.) Hale	Foliose	*Q. semecarpifolia* bark.
P. latissimum (Fee) Hale	Foliose	*Q. oblongata* bark.
P. perlatum (Hudson) M.Choisy	Foliose	*Q. oblongata* bark.
P. praesorediosum (Nyl.) Hale	Foliose	*Q. semecarpifolia* bark.
Usnea eumitrioides Motyka	Fruticose	*C. deodara* and *Q. oblongata* bark.
U. florida (L.) Weber ex F.H. Wigg	Fruticose	*Q. semecarpifolia* bark.
U. orientalis Motyka.	Fruticose	*Q. semecarpifolia* bark.
Pertusariaceae		
Pertusaria albescens (Huds.) M. Choisy & Werner	Crustose	*Q. semecarpifolia* bark.
P. alpina Hepp ex Ahles	Crustose	*Q. oblongata* bark.
P. punctata Nyl.	Crustose	*C. deodara* and *Q. semecarpifolia* bark.
Pertusaria sp. DC	Crustose	*Q. oblongata* bark.
Verseghya thysanophora (R.C. Harris) S.Y. Kondr [*Lecanora thysanophora* R.C. Harris.]	Crustose	*Q. oblongata* bark.
Physciaceae		
Heterodermia himalayensis (D.D. Awasthi)	Foliose	*Q. oblongata* bark.
Phaeophyscia endococcina (Korb) Moberg	Foliose	*Q. semecarpifolia* bark.
P. hirsute (Mereschk.) Essl.	Foliose	*Q. semecarpifolia* bark.
Physcia caesia (Hoffm.) Furnr.	Foliose	*Q. semecarpifolia* bark.
P.sorediosa (Vain.) Lynge	Foliose	*Q. oblongata* bark.
Ramalinaceae		
Bacidina suffuse (Fr.) A. Schneider	Crustose	*Q. semecarpifolia* bark.
B. phacodes (Korb.) Vezda	Crustose	*Q. semecarpifolia* bark.
Ramalina farinacea (L.) Ach.	Fruticose	*Berberis* and *Q. oblongata*.
R. sinensis Jatta	Fruticose	*Q. semecarpifolia* bark.
Ramalina sp. Ach.	Fruticose	*Berberis* bark
Stereocaulaceae	Leprose	On rock.
Lepraria incana (L.) Ach.		
Teloschistaceae	Crustose	On rock
Blastenia furfuracea (H.Magn.) Arup, Sochting and Froden. [*Caloplaca furfuracea* H. Magn.]		
Verrucariaceae	Fruticose	On rock.
Dermatocarpon miniatum (L.) W. Mann	Fruticose	On rock.
D.vellereum Zschacke		

Table 2. Lichenicolous fungi from Chandrabadni temple forest

Lichenicolous fungi	Host lichen	Substrate
Arthoniaceae		
Arthonia apotheciorum (A. Massal) Almq.	*Lecanora dispersa*	*Q. oblongata*
Arthonia punctella Nyl. Carroll. Nat. Hist. Rev.	*Lecanora dispersa*	*C. deodara*
Mycocaliciaceae		
Chaenothecopsis tigillaris Acta Soc. Fauna Fl. Fenn	*Lecanora fructosa*	*C. deodara*
Corticiaceae		
Erythricium aurantiacum (Lash) D. Hawksw. And A. Henrici.	*Lecanora fructosa*	*Q. oblongata*
Obryzaceae		
Intralichen lichenum (Diederich) D. Hawksw. And M.S. Cole.	*Heterodermia himalayensis* *Ramalina* sp.	*Q. oblongata,* *Berberis* sp.
Asterinaceae		
Labrocarpon canarensis (D. Hawksw.) Etayo and Perez−Ortega	*Pertusaria sp.*	*Q. oblongata*
Abrothallaceae		
Lichenoconium erodens M.S. Christ and D. Hawksw Persoonia.	*Physcia caesia*	*Q. oblongata*
L. pyxidatae (Oudem) Petrak et H. and Sydow.	*Parmotrema arnoldii*	*Pinus roxburghii*
Sclerotiniceae		
Epithamonolia pertusariae	*Pertusaria* sp.	*Q. oblongata*

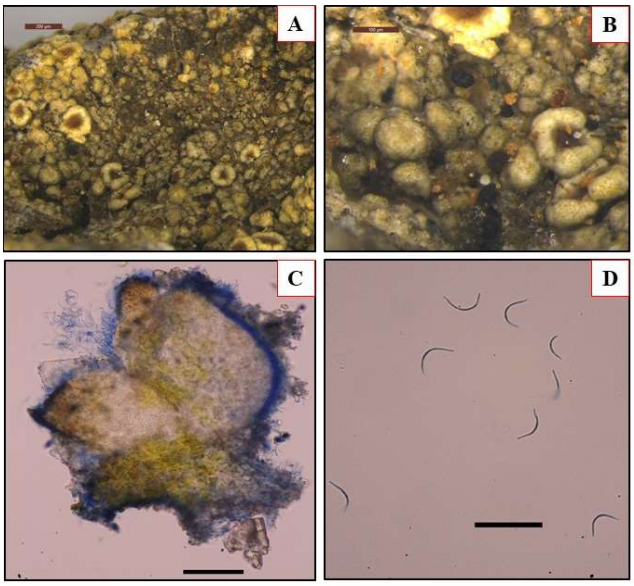

Fig. 1. Photo plate showing infected sample of *Pertusaria* lichen A. *Epithamnolia* Habitat B. Apothecia on host thallus C. Apothecial Section Bar 50 µm D. Ascospores Bar 25 µm

the microclimate in the stand. Furthermore, lichen species distribution may affect by landscape variables in addition to substrate availability, e.g., forest openness and landscape composition (Juriado et al 2003, Bolliger et al 2007). Collection of sources (wood, bark, grass) by local people impact the microclimatic conditions of forest. Villagers collect leaves by climbing tree on daily basis that affect the diversity of epiphytic lichens and the regeneration of their broken thallus. The topographic variables, such as elevation, convexity, slope, nutrients etc. were the most important factors that help in explaining the composition of epiphytic lichen species in forest. Two important macroclimatic factors, temperature and humidity, were clearly identified among the factors influencing the composition of the epiphytic lichen community. Increased light penetration increases the temperature in the stand, altering the epiphytic lichen composition due to the lower humidity (Sevgi et al 2019). Out of 49 lichen species nine are infected and the fungus which grows on these lichens is called lichenicolous fungus. *Lecanora* genus is highly infected, as four different types of lichenicolous fungi are degrading the *Lecanora* species.

CONCLUSION

Chandrabadni oak forest is a rich reservoir of epiphytic lichens on account of its luxuriant forest ecosystem with pollution free environment. Although the diversity of epiphytic lichens is often affected by various biotic and abiotic factors but nonetheless, this preliminary study on the dominance and diversity of epiphytic lichens certainly opens new horizon of lichen study in relatively less disturbed areas on a larger scale.

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