



Research article

New addition to the Lichen flora of Uttarakhand, India

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Abstract: The present paper revealed the occurrence of nine lichen species from Uttarakhand for the first time. The species belong to six families (*Cladoniaceae*, *Lecanoraceae*, *Parmeliaceae*, *Peltigeraceae*, *Physciaceae*, *Verrucariaceae*) and represents four growth forms of lichens found growing on soil, rock and soil over rock. Brief morpho-taxonomic details of all the nine species have been provided with their ecology and distribution.

Keywords: Lichens - Uttarakhand - New addition - Ecology - Distribution.

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INTRODUCTION

Indian Himalayas has been known for its floral composition and considered as one of the main hotspot consisting of different plant groups including lichens. The lichens are slow growing organism that retains uniform morphology and dependent on the atmosphere for their water and nutritional demand. The varied climatic conditions and altitudinal ranges in the Himalayas provide different substrate for the colonization and growth of lichens (Vetaas & Grytnes 2002, Grau *et al.* 2007, Kumar *et al.* 2014). Other than vascular plants, lichens are considered as most significant indicator of ecosystem fluctuations as they are more sensitive towards habitat and climatic alternation (Herk *et al.* 2002, Saipunkaew *et al.* 2007, Rai *et al.* 2011). Approximately 20,000 species of lichens are so far known from the world and it is estimated that Indian lichen flora comprises of 2319 species under 305 genera and 74 families (Singh & Sinha 2010).

India has vast geographical area, different phytogeographical regions and varied climate conditions which exhibit variation in the diversity of lichens. Among eight lichenogeographical regions in India, the Western Ghats and the Himalayas shows higher lichen diversity. The Eastern Himalayas archives higher lichen diversity with 1162 species, followed by Western Ghats and Western Himalayas with 1157 and 812 species respectively (Rai *et al.* 2014). The lichen distribution as compared to other cryptograms is highly influenced by microclimatic factors of a particular region.

The Western Himalayas occupies the extreme north–western margins of India including Jammu & Kashmir, Himachal Pradesh and Uttarakhand and sustains significant assemblage of lichen flora. The varied climatic conditions and altitudinal ranges provide varied habitats for colonization and growth of lichens. Among the different state of India, Uttarakhand represents more than 600 species of lichens followed by Himachal Pradesh and Jammu & Kashmir with 503 and 386 species respectively (Upreti & Negi 1998, Sheikh *et al.* 2006, Nayaka *et al.* 2010, Singh & Sinha 2010, Goni *et al.* 2015, Goni & Sharma 2015, Mishra 2015).

The topography of the state provide a wide altitudinal range from plain foothills to higher alpine region, hence the state exhibit tropical type of climate in the lower Himalayan region and temperate to alpine type of climate condition in higher Himalayas. About 95% of the total geographical area of Uttarakhand comprises of Himalayan Mountains which can be further divided into Garhwal and Kumaon regions in the West and East correspondingly.

MATERIALS & METHODS

Study Area

During the study the lichen samples were collected from in and around Badrinath Valley including Mana, Bhimpul and Vasudhara area (Fig. 1). The region characterized by an average maximum temperature 18°C to a minimum of -22°C. Precipitation occurs in the form of snow and heavy rainfall. Snowfall occurs in the month of December–March with the maximum rainfall in month of July and October. The area represents typical alpine habitats, extreme temperature and vegetation of valley comprises of alpine grasslands or alpine herbs and trees like *Betula* spp., *Salix* spp. and *Rhododendron* spp. The lichen growth flourish on rock and soil and this plant group make one of most eye catching vegetation in the area.

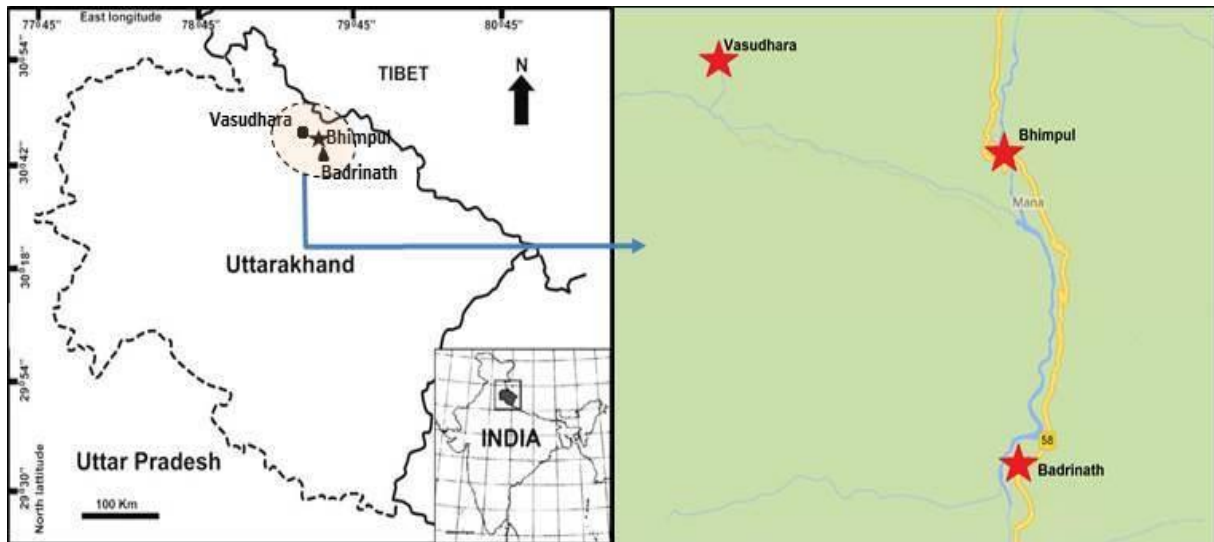


Figure 1. Location of study sites in Uttarakhand, India.

Lichen Identification

The specimens were collected from all available substrates and the sample segregated identified and preserved in the lichenology laboratory of CSIR-National Botanical Research Institute, Lucknow. The morphological characters were studied with Leica E24 binocular and anatomical structures were studied by Nikon Eclipse E 400 compound microscope. Secondary metabolites in specimens were determined using thin layer chromatography (TLC) in solvent system A (180 Toluene: 60 dioxane: 8 acetic acid) and spot test performed by (Elix & Ernst-Russel 1993, Organge *et al.* 2001). The species identified on the basis of morphological, anatomical and chemical characteristics using relevant keys for various lichen taxa (Divakar & Upreti 2005, Awasthi 2007, Upreti 2008). The voucher specimens with details of locality, date of collection and substratum were deposited at the Lichen herbarium (LWG), National Botanical Research Institute, Lucknow.

RESULT AND DISCUSSION

Lichen Flora

The present study enumerates the addition of nine lichen species as new additions to the lichen flora of Uttarakhand. *Normandina pulchella* is reported first time from the Himalayas, previously this species was reported only from Tamil Nadu (Upreti *et al.* 2008). Similarly *Rinodina megaspora* has been reported for the first time from Western Himalayas as earlier it has restricted distribution in the Eastern Himalayas only. Out of the nine new addition recorded, *Lecidella alaiensis* and *Rinodina megaspora* are only two, microlichen genera (crustose), *Remototrachyna incognita*, *Melaniella disjuncta*, *Melanohalea infumata*, *Parmelia squarrosa*, *Peltigera collina* and *Normandina pulchella* have foliose growth form, while *Cladonia subsquamosa* have a fruticose growth.

Since the study area located at higher elevation of more than 3000m, usually devoid of trees therefore all the species reported found growing on rocks and soil over rocks and on mosses. *Normandina pulchella* having squamulose to subfoliose thallus forms small colonies with other lichens and sometimes difficult to locate. *Rinodina megaspora* a crustose lichen also exhibit interesting habit forms brown powdery patches over moss tuft. The brief species description of each species with their ecology and distribution is mentioned below.

Enumeration of species

1. *Cladonia subsquamosa* Kremp. in Warming., Vidensk. Meddel. Dansk. Naturhist. Foren. Kjobenhavn 5: 366.1873 (1874). **(Fig. 2A)**
 Thallus terricolous, fruticose, dimorphic, primary squamules small, fragile, persistent. Secondary thallus podetiate, podetia grey-green to brownish, 10–20 mm tall, 1–2 mm thick at base, Podetial surface sorediate throughout along with microsquamules. Podetia K-, or K + yellow, P+ yellow-red; fumarprotocetraric acid, present in TLC.
Ecology and distribution: This species found growing on soil over rocks in moist places. In India the species is reported from Tamil Nadu-Nilgiri and Palni Hills. Outside India from Pantropical Asia, Africa, N. and S. America and Australasia.
Specimen examined: Badrinath, alt. 3175 m, on Soil, 12.10.2013, *Rai H, Khare R & Gupta S* 13-021127(LWG).
2. *Remototracygna incognita* (Kurok.) Divakar & A. Crespo., Am. J. Bot. 97(4): 586 (2010). **(Fig. 2B)**
 Thallus saxicolous, foliose loosely adnate to the substratum, lobes sub irregular, imbricate, thick, margin crenate, upper surface mineral grey to grey, smooth, densely isidiate; rhizines black, short, dichotomously branched. Apothecia lecanorine. Spore 8 in ascus, colourless, oval 10–15×4–6 µm. Thallus K+ yellow, Medulla K-, C+ rose, KC + red, P-; protolichesterinic acid present in TLC.
Ecology and distribution: The species grows on exposed rocks or soil over rock both in open exposed dry and moist habitats. In India the species is known from Meghalaya, Sikkim and West Bengal-hills. Outside India from Japan and Nepal.
Specimen examined: Between Bhimpul to Vasudhara, on rock, alt. 3229 m, 13.10.2013, *Rai H, Khare R & Gupta S* 13-021103 (LWG).
3. *Lecidella alaiensis* (Vain.) Hertel., Herzogia 2(4): 501.1973. **(Fig. 2C)**
 Thallus saxicolous, crustose, white to sooty yellow 0.5–1.8 mm thick, smooth to chinky, verru-culose. Apothecia to 0.5–1.5 mm broad, andante, shining, disc black, margin smooth persistent lecedeine or biatorine. Spores 8 in ascus, ellipsoid to broadly ellipsoid 10.5–17.0×6.0–10.5µm. Thallus K-,C-,KC-,P-, medulla K+ yellow; atranorin and zeorin is present in TLC.
Ecology and distribution: The species grows on exposed rocks and boulders. In India the species is known from Himachal Pradesh and Jammu & Kashmir. Outside India the species is reported from Afghanistan, China, Iran, Mongolia and Russia.
Specimen examined: Badrinath, East of temple, on way to Devdarshani, on boulders, alt. 3150 m, 28.09.1976, *Dange K* 76.799 (LWG-LWU).
4. *Melanelia disjuncta* (Erichsen). Essl., Mycotaxon 7(1): 46. 1978. **(Fig. 2D)**
 Thallus saxicolous, foliose, adnate, lobes to 1.5(-3) mm wide, upper side dark olive brown to blackish, lower side dark brown to black, rhizate. Apothecia to 3 mm in diam, lecedeine. Spore 8 in ascus oval ellipsoid, colourless, 9–12×5–7µm. Thallus K-,C-,KC- or KC+ faint rose, P-; perlatolic and stenosporic acids present in TLC.
Ecology and distribution: The species is known to be saxicolous but occasionally it is found on tree trunk. In India the species exhibit its restricted distribution in Jammu & Kashmir. Outside India it is known from Europe, North America.
Specimen examined: Between Bhimpul to Vasudhara, on rock, alt. 3229 m, 13.10.2013, *Rai H, Khare R & Gupta S* 13-021112 (LWG).
5. *Melanohalea infumata* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch, Mycol. Res. 108(8): 882. 2004. **(Fig. 2E)**
 Thallus saxicolous, loosely adnate to 7 cm across, lobes flat, shot and rounded, 1.0–4.0mm wide, upper side olive-green to reddish brown, without pseudocyphellae, isidiate, lower side dark brown to black, sparsely rhizinate. Apothecia not known. Thallus K-,C-,KC-,P-; No substance present in TLC.
Ecology and distribution: This species grows on exposed rocks or on soil over rock. The species is reported from Himachal Pradesh and Jammu & Kashmir. Outside India it is reported known from Karakorum, Europe and North America.

Specimen examined: Badrinath, on soil, alt. 3173 m, 13.10.2013, Rai H, Khare R & Gupta S 13-021136 (LWG).

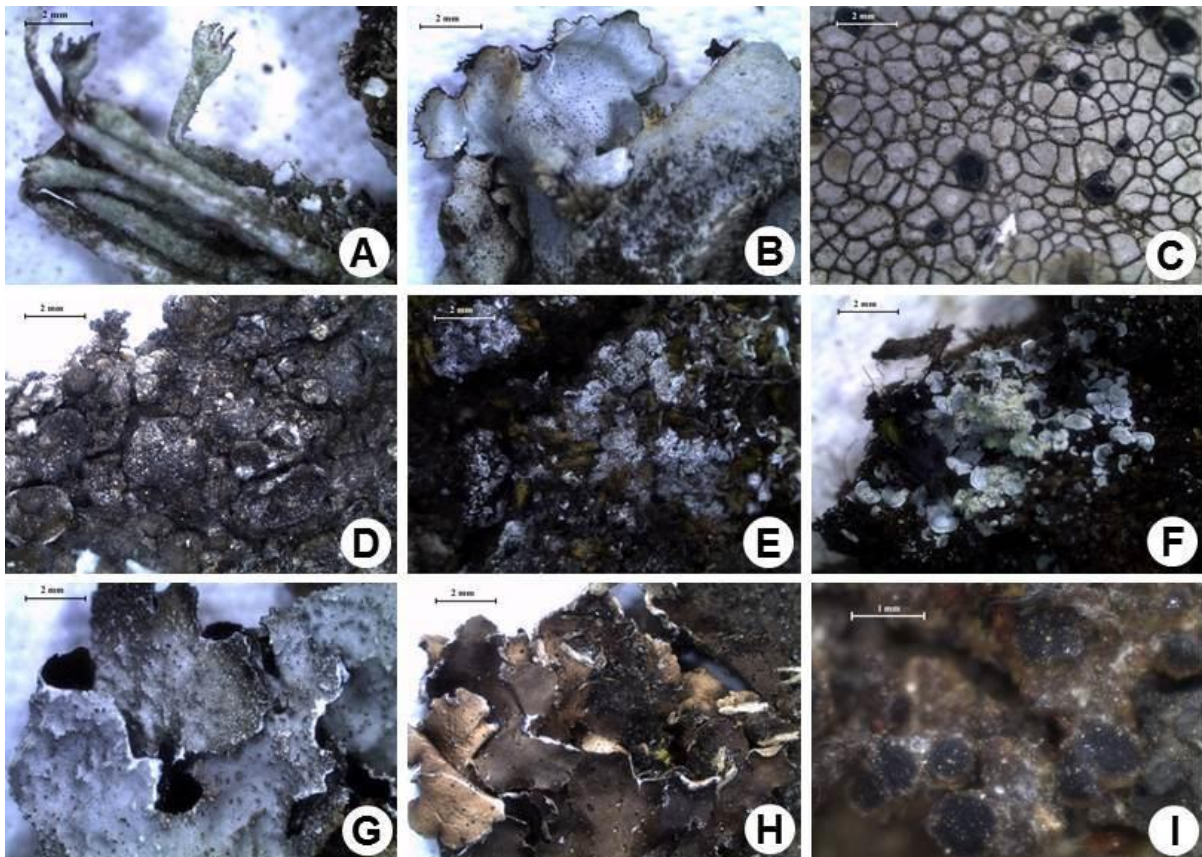


Figure 2. Microscopic image of new addition to Uttarakhand: **A**, *Cladonia subsquamosa* Kremp.; **B**, *Remototrachyna incognita* (Kurok.) Hale.; **C**, *Lecidella alaiensis* (Vain.) Hertel.; **D**, *Melanelia disjuncta* (Erichsen). Essl.; **E**, *Melanohalea infumata* (Nyl.) O. Blanco & al.; **F**, *Normandina pulchella* (Borrer) Nyl.; **G**, *Parmelia squarrosa* Hale.; **H**, *Peltigera collina* (Ach.) Schrad.; **I**, *Rinodina megaspore* (D.D. Awasthi & M.R. Agarwal) D.D. Awasthi.

6. *Normandina pulchella* (Borrer) Nyl., Ann.Sci.Nat.Bot.Ser.4,15:382 (1861).

(Fig. 2F)

Thallus corticolous, squamulose, scattered or partly contiguous forming dense colonies in irregular patches, of small cochleate to rounded squamules; squamules plane to concave, concentrically ridged, undivided or distinct with lobes, 1–2 mm wide, upper surface pale grey to greenish-grey, soredia on the surface and along the margins, medulla indistinct, photobiont layer distinct. Apothecia absent. Thallus K-, KC-, C- and P-; zeroin is present in TLC.

Ecology and distribution: The species exhibit special habit as found growing in small colonies in association with of on lichen or mosses or humus. In India the species is only known from Tamil Nadu. Outside India it is reported from all the continents except Antarctica.

Specimen examined: Between Bhimpul to Vasudhara, on soil over rock, alt. 3229 m, 13.10.2013, Rai H, Khare R & Gupta S 13-023569 (LWG).

7. *Parmelia squarrosa* Hale., Phytologia 22(1): 29, 1971.

(Fig. 2G)

Thallus corticolous rarely saxicolous, foliose, adnate; lobes sublinear, upper side pale to mineral grey, shiny, pseudocyphellae forming reticulate network, isidia along the ridges of pseudocyphellae, lower side black and shiny, densely rhizinate. Rhizines richly branched. Apothecia rare substipitate. Spores 8 in ascus, 30–35×10–16 μm. Thallus K+ yellow, medulla K+ yellow turning red C-, KC-, P+ orange-red; atranorin and salazinic acid ias present in TLC.

Ecology and distribution: The species is found growing on trunks of small shrubs or exposed rock. In India the species is distributed in Himachal Pradesh and Sikkim. Outside India it is known from Bhutan, China, Japan, Nepal, Europe and North America.

Specimen examined: Badrinath, on rock, alt. 3199 m, 12.10.2013, Rai H, Khare R & Gupta S 13-021359 (LWG).

8. *Peltigera collina* (Ach.) Schrad., J. Bot. (Schrader) 3: 78. 1801. (Fig. 2H)

Thallus terricolous, foliose, adnate, upto 3 cm across; lobes 4–6 mm wide; upper surface yellowish brown, tomentose, marginally soraliolate with granular soredia, lower surface with diffused, indistinct; brown vein; rhizines simple to confluent; photobiont a *nostoc*; medulla pale brown. Apothecia not present. Gyrophoric acid, zeorin, tenuiorin and unknown substances present in TLC.

Ecology and distribution: The species grows on soil or soil over rock or over mosses and both in moist shady and exposed areas. In India the species exhibit restricted distribution to Sikkim and Tamil Nadu. Outside India the species is reported from China; Central Europe and North America.

Specimen examined: Badrinath, on soil, alt. 3144 m, 12.10.2013, Rai H, Khare R & Gupta S 13-021138 (LWG).

9. *Rinodina megaspora* (D.D. Awasthi & M.R. Agarwal) D.D. Awasthi., Biblioth. Lichenol. 40: 4. 1991. (Fig. 2I)

Thallus crustose, granular leprose, grey to dark grey; photobiont a green alga (*Trebouxia*). Apothecia 0.8–1.5 mm diam., disc brown-black to black, margin thalline. Spores 4–8 in ascus, brown, 3 septate, smooth, lumina rounded, 31–39×13–18µm. Thallus K-, C, KC-, P-; no secondary compounds present in TLC.

Ecology and distribution: The species grows on exposed rocks over soil and exhibit its restricted distribution in Eastern Himalayas and reported only from West Bengal hills. Outside India the species has wide distribution from Australia, Bhutan, New Guinea, New Zealand, temperate region of Central and Southern Europe and North America.

Specimen examined: Badrinath, on rock, alt. 3198 m, 12.10.2013, Rai H, Khare R & Gupta S 13-021547 (LWG).

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