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Caption: Stripe-backed Weasel *Mustela strigifrons*. Medium—digital, Software—procreate, Device—iPad + Apple pencil © Dhanush Shetty.

INTRODUCTION

The union territory of Jammu & Kashmir (J&K) represents a predominant Himalayan landscape which lies between coordinates 32.733–36.966 N latitudes and 73.433–80.5 E longitudes and is one of the ‘hotspots’ of lichen diversity in India (Sheikh et al. 2006). Due to great altitudinal variation, unique terrain, diverse vegetation, and varied climate, J&K offers a wide range of habitats for the growth and colonization of lichenized fungi.

Kishtwar High Altitude National Park (KHANP) situated in district Kishtwar of J&K is surrounded by beautiful snow-capped Himalaya and lies between coordinates 75.990E longitude and 33.582N latitude. The national park covers an area of approximately 2,200 km² with an altitude range of 1,200–6,000 m. KHANP experiences temperate to alpine climatic regimes. The average temperature during the summer months is 16 °C and in winter months it ranges 9–11 °C. The average annual rainfall is about 920 mm. The upper reaches of KHANP are characterized by severe and prolonged winter and short summer seasons. The prominent vegetation includes both coniferous and broad-leaved deciduous forests. *Abies pindrow* (Royle ex D.Don) Royle, *Pinus wallichiana* A.B.Jacks., *P. gerardiana* Wall. ex D.Don, and *Cedrus deodara* (Roxb. ex D.Don) G.Don are the prominent conifers. At lower elevations, *Quercus oblongata* D.Don, *Q. floribunda* Lindl. ex A.Camus, *Aesculus indica* (Wall. ex Cambess.) Hook., *Juglans regia* L., *Prunus persica* (L.) Batsch, *Pyrus pashia* Buch.-Ham. ex D.Don, and *Fraxinus excelsior* L. are prominent.

Smith (1931), Schubert & Klement (1966), and Awasthi & Singh (1970) are the pioneer contributors to lichen study in J&K. Later, several researchers (Sheikh et al. 2006, 2009; Khan et al. 2010; Solan et al. 2010; Kumar et al. 2012; Khare et al. 2020) made significant contributions towards understanding the lichen mycota of the region. Recently, Khare et al. (2020) compiled an inventory reporting 424 lichen species from the J&K, while Kumar & Sharma (2020) added five species of parmelioid lichens from KHANP as new additions to the lichen mycota of J&K.

The studies on the lichenicolous fungi in India have been initiated recently with the publication of the first list of these fungi by Zhurbenko (2013) that included 42 taxa based on the collections from J&K. Afterwards, Joshi (2018), and Joshi et al. (2016, 2018, 2020a,b) made noteworthy contributions to this group of organisms from J&K. However, no exhaustive documentation of the lichenized and lichenicolous fungi has been attempted for KHANP. While inventorying the lichen mycota of

KHANP the authors came across several interesting specimens of lichenized and lichenicolous fungi.

MATERIALS AND METHODS

The lichen specimens were collected from different localities of the KHANP during 2017–2020. The samples were preserved in the herbaria of University of Jammu (HBJU) and CSIR-National Botanical Research Institute, Lucknow (LWG). The morpho-anatomical characters were studied under a stereo-zoom (Leica S8APO) and compound microscope (Leica DM2500), and identified by following the literature (Awasthi 1991, 2007; Joshi 2008; Marbach 2000; Hawksworth et al. 2010; Sheard 2010; Singh & Sinha 2010). The chemistry was studied through spot tests and thin layer chromatography (solvent system C) was performed following Orange et al. (2001). A brief description of only lichenicolous fungi are provided as they are not readily available.

RESULTS

ENUMERATION OF LICHENIZED FUNGI

1. ***Buellia aeruginascens*** (Nyl.) Zahlbr., Cat. Lich. Univers. 7: 331. 1931. *Lecidea disciformis* var. *aeruginascens* Nyl., Bull. Soc. linn. Normandie, sér. 2 2: 191. 1868. (Caliciaceae) (Image a).

Specimen examined: HBJU 16052, 10.xi.2020, J&K, Kishtwar district, KHANP, Palmar, on bark, 33.455N, 75.684E, 2,513 m, coll. V. Kumar & Y.P. Sharma.

Distribution: India (Mizoram) (Logesh et al. 2017), Chile, South America and Australia (Hafellner et al. 1989).

2. ***Caloplaca pachycheila*** Poelt & Hinter., Biblioth. Lichenol. 50: 168. 1993. (Teloschistaceae) (Image b).

Specimens examined: HBJU 16044, 17.vii.2018, J&K, Kishtwar district, KHANP, Palmar, on rock, 33.456N, 75.685E, 2,510 m, coll. V. Kumar & Y.P. Sharma; LWG19-035707 22.iv.2019, J&K, KHANP, Sonder, on rock, 33.471N, 75.826E, 2,090 m, coll. V. Kumar & Y.P. Sharma.

Distribution: India (Uttarakhand) (Mishra & Upreti 2015), and Pakistan (Poelt & Hinteregger 1993).

3. ***Cladonia cervicornis* ssp. *verticillata*** (Hoffm.) Ahti, The Lichenologist 12: 126 1980. *Cladonia verticillata* (Hoffm.) Schaer., Lichenum Helveticorum Spicilegium. 1: 31 1823. (Cladoniaceae) (Image c).

Specimens examined: HBJU 16060, 17.vii.2018,



J&K, Kishtwar district, KHANP, Ekhala, on soil 33.451N, 75.738E, 1,750 m, coll. V. Kumar & Y.P. Sharma; LWG 18-035706 17.vii.2018, on soil 33.470N, 75.819E, 2,100 m, coll. Kumar & Y.P. Sharma.

Distribution: India (Manipur, Meghalaya, Uttarakhand, and West Bengal) (Awasthi 2007) and widely distributed in Asia, Australasia, Europe, and America (Ahti 2007).

4. *Hafellia curatellae* (Malme) Marbach, Biblioth. Lichenol. 74: 255. 2000. *Buellia curatellae* Malme, Arkiv för Botanik 21A 14: 18 1927. (Caliciaceae) (Image d).

Specimen examined: HBJU 16047, 22.iv.2019, J&K, Kishtwar district, KHANP, Sonder, on twigs of *Cedrus deodara*, 33.469N, 75.828E, 2,240 m, coll. V. Kumar & Y.P. Sharma.

Distribution: India (Andhra Pradesh, Mizoram, Odisha, and Tamil Nadu) (Singh & Sinha 2010; Reddy et al. 2011; Nayak et al. 2016; Logesh et al. 2017), Africa, Australia, Brazil, New Caledonia, Papua New Guinea, Sri Lanka, and Thailand (Marbach 2000; Weerakoon 2014).

5. *Hafellia subnexa* Marbach, Biblioth. Lichenol. 74: 285. 2000. (Caliciaceae) (Image e).

Specimen examined: HBJU 16049, 22.iv.2019, India, J&K, Kishtwar district, KHANP, Sonder, on twigs of *Cedrus deodara* 33.471N, 75.822E, 2,048 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (Arunachal Pradesh) (Bajpai et al. 2018), Japan, Malaysia, Russia, Thailand (Marbach 2000; Buaruang et al. 2017; Ezhkin & Schumm 2018)

6. *Hafellia tetrapla* (Nyl.) Pusswald, Biblioth. Lichenol. 74: 288. 2000.

Buellia callispora var. *tetrapla* (Nyl.) J. Steiner, Bull. Herb. Boissier, sér. 2, 7: 645. 1907. (Caliciaceae) (Image f).

Specimen examined: HBJU 16050, 21.iv.2019, India, J&K, Kishtwar district, KHANP, Sonder, on twigs of *Cedrus deodara* 33.472N, 75.823E, 2,030 m, Vishal Kumar and Y. P. Sharma.

Distribution: India (Uttarakhand) (Singh & Sinha 2010; Rai et al. 2016), South America, Australia, Brazil, Hawaii, New Zealand, South Africa, Réunion, Nepal, and Uruguay. (Marbach 2000).

7. *Leptogium askotense* D.D.Awasthi, Norw. J. Bot. 24: 63 1977. (Collemataceae) (Image g).

Specimens examined: HBJU 16054, 22.iv.2019, India, J&K, Kishtwar district, KHANP, Ekhala, on bark 33.450N, 75.739E, 1,830 m, Vishal Kumar & Y.P. Sharma;

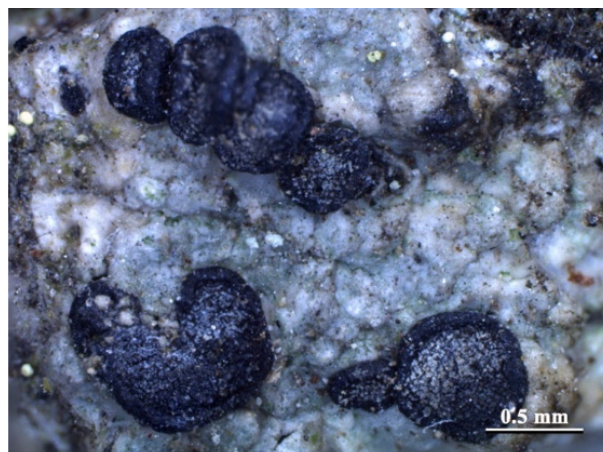


Image a. *Buellia aeruginascens* (Nyl.) Zahlbr. © Lichen lab., CSIR-NBRI



Image b. *Caloplaca pachycheila* Poelt & Hinter. © Lichen lab., CSIR-NBRI

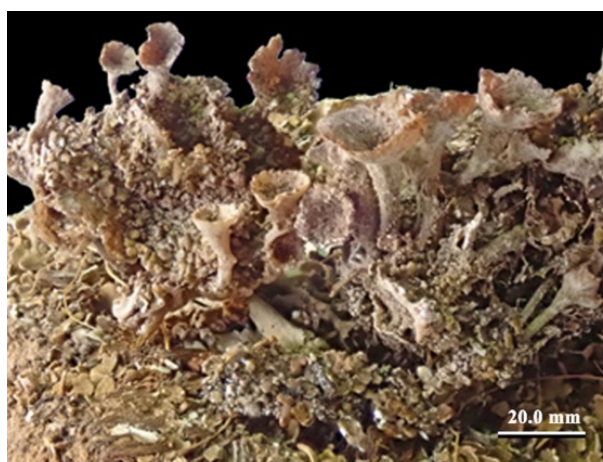


Image c. *Cladonia cervicornis* subsp. *verticillata* (Hoffm.) Ahti. © Lichen lab., CSIR-NBRI

LWG19-035708, 22.iv.2019, on bark 33.451N, 75.741E, 1,750 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (Arunachal Pradesh, Manipur, Sikkim, Uttarakhand, and West Bengal (Singh & Sinha 2010) and China (Xia et al. 2018).

8. *Nephromopsis laii* (A. Thell & Randlane) Saag & A. Thell, Bryologist 100: 111 1997. *Cetrariopsis laii* A.Thell & Randlane, Cryptogamie Bryologie Lichénologie 16: 46 1995. (Parmeliaceae) (Image h).

Specimen examined: HBJU 16092, 10.vii.2017, India, J&K, Kishtwar district, KHANP, Marwah, on bark 33.667N, 75.700E, 2,600 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (Sikkim, Nagaland and West Bengal), China, Japan, Nepal, Taiwan and Vietnam (Singh & Sinha 2010).

9. *Polycauliona phlogina* (Acharius) Arup, Frödén & Söchting, Nordic J Bot. 31: 53 2013. *Parmelia citrina* var. *phlogina* Ach., Methodus, Sectio post. Stockholmiae: 180 1803. *Scythioria phlogina* (Ach.) S.Y. Kondr., Kärnefelt, Elix, Thell & Hur, Acta bot. Hung. 56: 164 2014. *Caloplaca phlogina* (Ach.) Flagey, Mém. Soc. ému. Doubs, sér. 6 1: 250 1886. (Teloschistaceae) (Image i).

Specimen examined: HBJU 16074, 22.iv.2019, India, J&K, Kishtwar district, KHANP, Sonder, on decaying wood of *Cedrus deodara* 33.472N, 75.819E, 2,050 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (Madhya Pradesh and Uttarakhand) (Joshi 2008), Caribbean, Fennoscandia, North America, and Mexico (Arup 2006).

10. *Pyxine cognata* Stirt., Proc. Roy. phil. Soc. Glasgow 11: 311 1879. *Pyxine berteriana* var. *himalaica* D.D. Awasthi, Phytomorphology 30: 366 1982. (Caliciaceae) (Image j).

Specimen examined: HBJU 16072, 17.vii.2018, India, J&K, Kishtwar district, KHANP, Palmar, on bark 33.455N, 75.683E, 2,500 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (Arunachal Pradesh, Himachal Pradesh, Madhya Pradesh, Manipur, Nagaland, Tamil Nadu, and Uttarakhand (Singh & Sinha 2010)), Australia (Elix 2009), Brazil (Aptroot et al. 2014), China (Yang et al. 2019), and Thailand (Mongkolsuk et al. 2012).

11. *Rinodina conradii* Körb., Syst. lich. Germ.: 123 1855. (Physciaceae) (Image k).

Specimen examined: HBJU 16056, 10.vii.2017, India, J&K, Kishtwar district, KHANP, Marwah, on bark 33.669N, 75.700E, 2,530 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (West Bengal hills) (Singh & Sinha

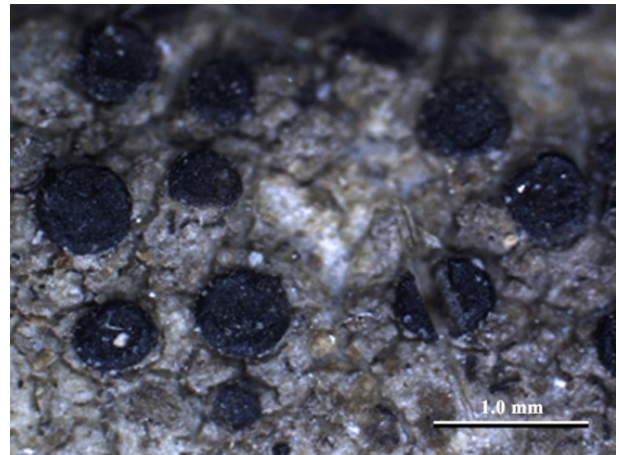


Image d. *Hafellia curatellae* (Malme) Marbach. © Lichen lab., CSIR-NBRI

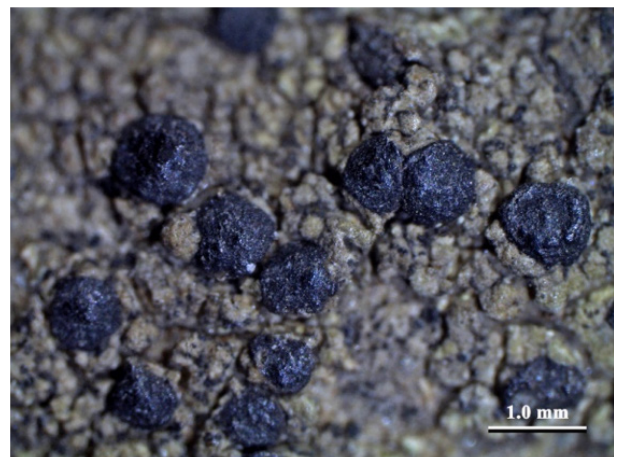


Image e. *Hafellia subnexa* Marbach. © Lichen lab., CSIR-NBRI



Image f. *Hafellia tetrapla* (Nyl.) Pusswald. © Lichen lab., CSIR-NBRI



Image g. *Leptogium askotense* D.D. Awasthi. © Lichen lab., CSIR-NBRI

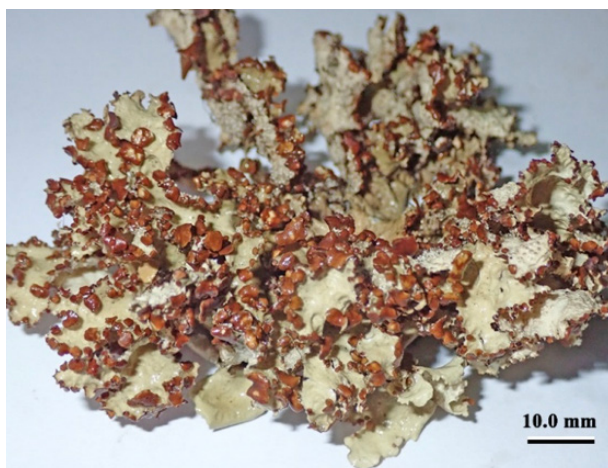


Image h. *Nephromopsis laii* (A. Thell & Randlane) Saag & A. Thell.
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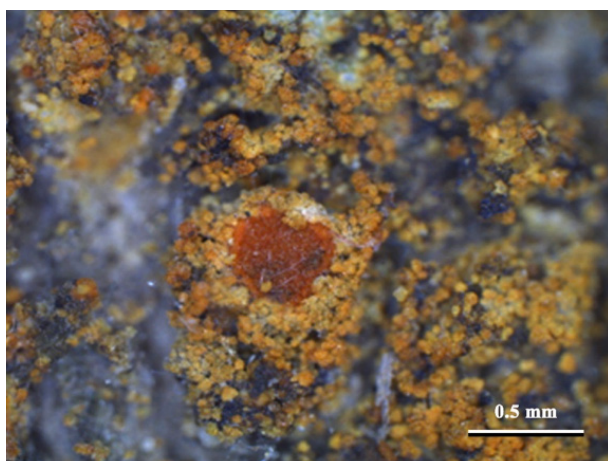


Image i. *Polycauliona phlogina* (Ach.) Arup, Frödén & Søbchting.
© Lichen lab., CSIR-NBRI

2010), Australia, Bhutan, New Guinea & New Zealand, and temperate regions of Northern America, central & southern Europe (Singh & Sinha 2010).

12. *Rinodina intermedia* Bagl., Comm. Soc. crittog. Ital. 1: 315 1863. (Physciaceae) (Image l).

Specimen examined: HBJU 16048, 10.vii.2017, India, J&K, Kishtwar district, KHANP, Marwah, on bark 33.669N, 75.703E, 2,400 m, Vishal Kumar & Y.P. Sharma.

Distribution: The species has a restricted distribution and is only known from Uttarakhand (Gupta et al. 2016) and West Bengal (Singh & Sinha 2010). The species is widely distributed in dry and warm temperate regions of northern hemisphere including Caribbean, Macaronesia, southern Europe, United Kingdom, Ecuador, Kenya, Africa, and South America (Mayrhofer et al. 2001).

13. *Rinodina oxydata* (A. Massal.) A. Massal., Geneacaena lichenum noviter proposita ac descripta: 19 1854. *Mischoblastia oxydata* A. Massal., Ricerche sull'autonomia dei licheni crostosi: 42 1852. (Physciaceae) (Image m).

Specimen examined: HBJU 16051, 17.vii.2018, India, J&K, Kishtwar district, KHANP, Palmar, on rock 33.456N, 75.685E, 2,510 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (Assam, Madhya Pradesh, Tamil Nadu, Uttarakhand, West Bengal (Singh & Sinha 2010; Gogoi et al. 2019)), southern Africa, Asia, Australia, Brazil (Kashik 2006), eastern & southern North America, Scandinavia, and Europe (Sheard 2010).

14. *Squamulea squamosa* (B. de Lesd.) Arup, Søbchting & Frödén, Nordic J Bot. 31: 56 2013. *Placodium squamosum* B. de Lesd., Annals Cryptog. Exot. 6: 123 1933. *Caloplaca squamosa* (B. de Lesd.) Zahlbr., Cat. Lich. Univers. 10: 629 1940. (Teloschistaceae) (Image n).

Specimen examined: HBJU 16079, 22.iv.2019, India, J&K, Kishtwar district, KHANP, Ekhala, on rock 33.449N, 75.741E, 1,810 m, Vishal Kumar & Y.P. Sharma.

Distribution: India (Uttarakhand) (Mishra & Upreti 2015), California and Arizona southwestern North America (Wetmore 2003).

ENUMERATION OF LICHENICOLOUS FUNGI

1. *Abrothallus microspermus* Tul., Annls Sci. Nat., Bot., sér. 3 17: 115 1852. *Abrothallus smithii* var. *microspermus* (Tul.) Linds., Quart. J. Microscop. Sci. 5: 34 1857. (Abrothallaceae) (Image o).

Specimen examined: HBJU 16058, 19.vii.2019, India, J&K, Kishtwar district, KHANP, Marwah, on twigs 33.669N, 75.700E, 2,550 m, Vishal Kumar & Y.P. Sharma.



Image j. *Pyxine cognata* Stirt. © Lichen lab., CSIR-NBRI

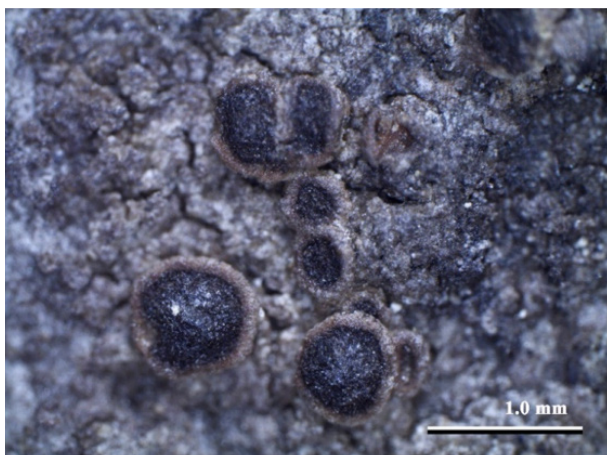


Image k. *Rinodina conradii* Körb. © Lichen lab., CSIR-NBRI

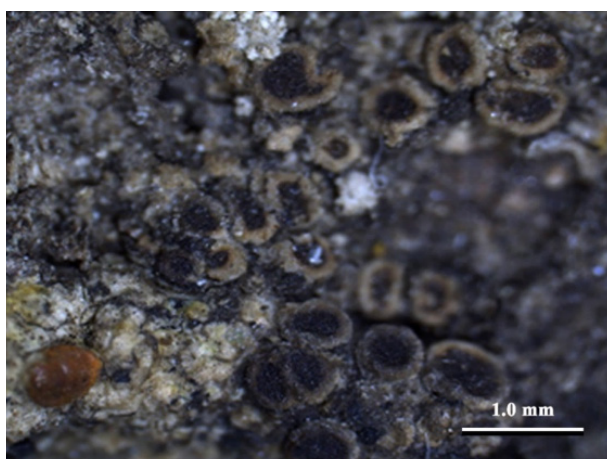


Image l. *Rinodina intermedia* Bagl. © Lichen lab., CSIR-NBRI

Description: Ascomata rounded, convex, black, 0.15–0.30 mm in diam., hymenium hyaline, hypothecium pale brown, Hymenium I–, K+ green. Asci 8-spored. Ascospores brown, 1-septate, 11–14.5 × 4.5–5.5 µm.

Host: *Punctelia neutralis* (Hale) Krog

Distribution: India (Arunachal Pradesh, Himachal Pradesh and Uttarakhand) (Joshi et al. 2018), Romania (Czarnota et al. 2018), Switzerland, Great Britain, southern Ural Mountains (Urbanavichene et al. 2013), North America (Cole & Hawksworth 2001, Diederich 2003, Kocourková et al. 2012), South Korea (Kondratyuk et al. 2013), and New Zealand (Longán & Gómez-Bolea 1999).

2. *Lichenocodium lecanorae* (Jaap) D. Hawksw., Bull. Br. Mus. nat. Hist., Bot. 6: 270 1979. *Coniosporium lecanorae* Jaap, Verh. bot. Ver. Brandenb. 47: 71 1905. (Abrothallaceae) (Image p).

Specimen examined: HBJU 16079, 21.iv.2019, India, J&K, Kishtwar district, KHANP, Sonder, on bark of *Cedrus deodara* 33.470N, 75.815E, 2,325 m, Vishal Kumar & Y.P. Sharma.

Description: Conidiomata pycnidia, scattered, blackish, ovoid, immersed to partially erumpent, 0.06–1.0 mm in diam., conidiophores absent, conidiogenous cells brown, conidia simple, brown, subglobose, 3.0–5.0 × 2.0–3.5 µm.

Host: *Lecanora* sp.

Distribution: India (Himachal Pradesh, Uttarakhand) (Joshi et al. 2016), Great Britain, Ireland, Canary Island, Spain (Hawksworth et al. 2010), and Ukraine (Darmostuk 2019).

DISCUSSION

The 16 species reported in the present study belong to 12 genera and eight families. Most of these species are crustose except for *Cladonia cervicornis* subsp. *verticillata* which is fruticose, while *Leptogium askotense*, *Nephromopsis laii* and *Pyxine cognata* are the foliose species. The study reports two interesting species of *Rinodina*, namely *R. conradii* and *R. intermedia* having 3-septate and submuriform ascospores respectively. Such species of *Rinodina* are rare in India, and previously, their distribution was confined to Uttarakhand and West Bengal. It is quite surprising that earlier workers overlooked both the species in the area, which is considered as the ‘hot spot’ of lichen diversity.

Further, among the 16 taxa reported as new to Jammu & Kashmir, the species *Buellia aeruginascens*,

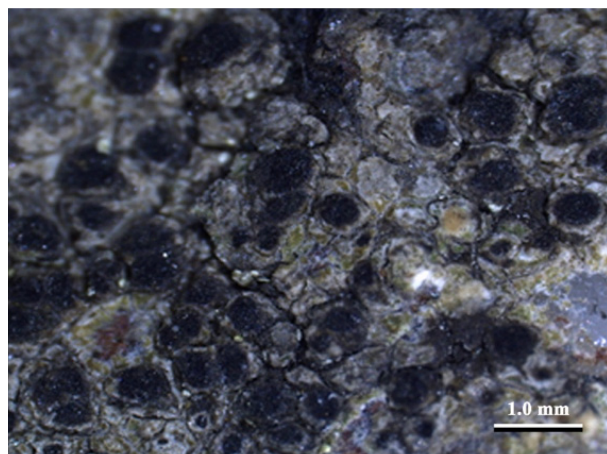


Image m. *Rinodina oxydata* (A. Massal.) A. Massal. © Lichen lab., CSIR-NBRI

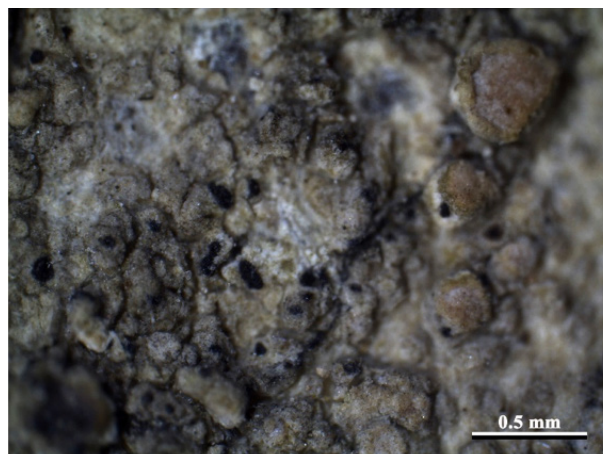


Image p. *Lichenocmium lecanorae* (Jaap) D. Hawksw. © Lichen lab., CSIR-NBRI

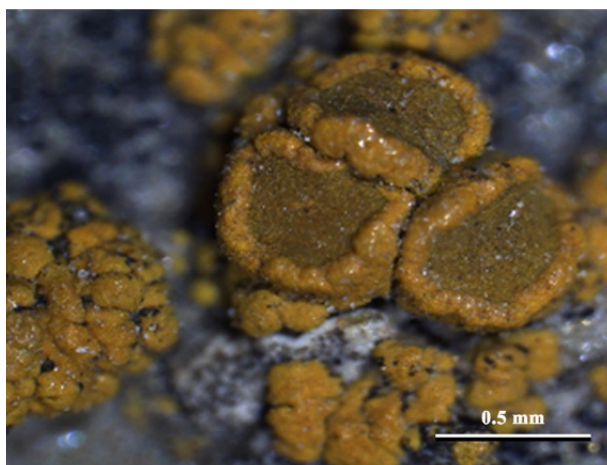


Image n. *Squamulea squamosa* (B. de Lesd.) Arup, Søchting & Frödén. © Lichen lab., CSIR-NBRI

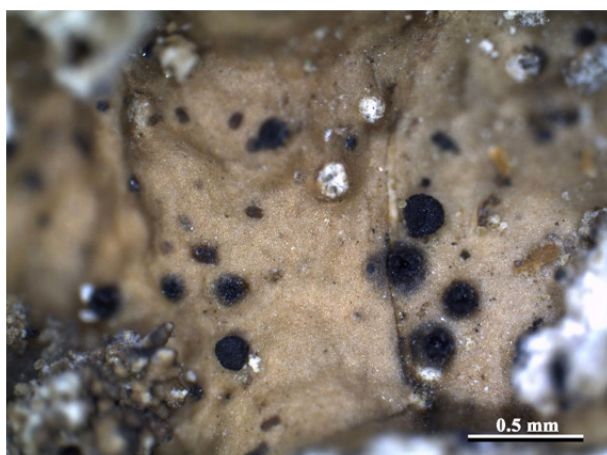


Image o. *Abrothallus microspermus* Tul. © Lichen lab., CSIR-NBRI

Hafellia curatellae, *Hafellia subnexa*, *Rinodina conradii* and *Rinodina oxydata* were previously reported from the northeastern Himalaya. The distribution of these species in western Himalaya reveals the continuous distribution of these species throughout the Himalayan belt. Although, *Nephromopsis laii* so far known only from eastern Himalaya but some of the specimens available at LWG indicate its occurrence in western Himalaya. Two species of lichenicolous fungi, *Abrothallus microspermus* and *Lichenocmium lecanorae*, extend their distribution within India, and *Punctelia neutralis* is observed as a new host for *Abrothallus microspermus*.

In the recent inventory of lichenized fungi for Jammu & Kashmir, Khare et al. (2020) listed 424 species, however, they missed the inclusion of four species (*Cetraria potaninii*, *Montanelia sorediata*, *Xanthoparmelia somloënsis*, and *X. taractica*) reported by earlier workers. Meanwhile, Kumar & Sharma (2020), while compiling the family Parmeliaceae reported five species as new to J&K from KHANP. After the inclusion of four species missed by Khare et al. (2020), five species reported by Kumar et al. (2020) and 14 species reported in the present study, the total number of lichenized fungi in Jammu & Kashmir rises to 447 species. Compared to other states within western Himalaya, this number is less, whereas Himachal Pradesh (ca. 520 species) and Uttarakhand (ca. 1,200 species) with similar climatic conditions are well-explored for lichen diversity. Similarly, in the case of lichenicolous fungi, after adding two new records, the total is raised to 68 species, while neighbouring Himalayan states such as Uttarakhand harbour 101 species and Himachal Pradesh records 32 species.

CONCLUSION

The frequent encountering of previously unreported species from KHANP indicates the unexplored diversity of lichen and lichenicolous fungi. The unique topography, climate, and prevalence of broadleaved as well as coniferous and mixed forest stands in KHANP are the plausible habitats which support luxuriant growth and proliferation of both lichenized and lichenicolous fungi. However, KHANP needs to be surveyed intensively, especially in the high altitudinal and inaccessible areas. A thorough survey would yield many more new additions to J&K as well as novel taxa to science.

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