


Studies on Lichens of Mizoram, Northeast India

A. R. Logesh¹ · M. Chinlambianga¹ · A. C. Shukla¹ · D. K. Upreti² 

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Abstract The paper enumerates 159 species of lichens recorded from the Mizoram state of northeast India. *Buellia aeruginascens*, *Chaenotheca chrysocephala*, *Diorygma reniforme*, *Gassicurtia acidobaeomyceta*, *Graphis granulosa*, *Hafellia demutans*, *Phyllopsora soralifera*, *Ramboldia soreliata*, *R. subnexa*, *Relicina sublanea*, *Stigmatochroma adaucta*, *S. gerontoides*, *S. kryptoviolascens*, *S. metaleptodes* are new records for Indian lichen biota. An inventory of lichen species together with detailed account of new records of lichens are provided in the present communication.

Keywords Lichenized fungi · New records · Indo-Burma hotspot · Northeastern India

Introduction

India has endowed with different phyto-geographical regions such as western and eastern Ghats, western and eastern Himalayas, Gangetic plains and north-eastern region. Lichen flora of India had been studied by different researchers since last century and recorded periodically [1–5]. A fairly good floristic account of lichens from most of the protected areas of the country are available. Lichens of

north-western Ghats, especially from Mahabaleshwar areas were worked out by Bajpai and Upreti [6] and Bajpai et al. [7]. The western Ghats and eastern Ghats of South India were studied extensively during the last decade [8–10] together with coastal areas [11–13]. A number of floristic studies were carried out in the Himalayan and Gangetic plains, especially the states of Himachal Pradesh, Uttarakhand and Uttar Pradesh were well explored by different workers [14–20].

Among the north-eastern states of India, the lichen flora of Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland and Sikkim is fairly well worked out [21–30]; however, a single account of the lichens from Mizoram is available [31]. Mizoram, located in the north-eastern part of India covers an area of approximately 21,087 sq. km., with more than 91 % of the evergreen forest vegetation. In the preliminary studies on lichens of Mizoram, 10 species were listed based on a few cursory collections from different parts of the state. During the recent field collections, more than 30 localities of Murlen National Park situated in north, east, west zones at different altitudes of Champhai district and some places of Aizawl and Mamit were explored systematically for collection of lichens.

Material and Methods

More than 500 lichen specimens were collected in six field trips during January 2012–September 2014. The collected specimens were identified based on their morphological, anatomical and chemical characters. The morphological characters were studied with the help of Leica S8APO stereo-zoom microscope while for anatomical studies Leica DM500 compound microscope was used. The sections were mounted in water for measurement of anatomical

✉ D. K. Upreti
upretidk@rediffmail.com

¹ Department of Horticulture Aromatic & Medicinal Plants, School of Earth Sciences & Natural Resource Management, Mizoram University, Aizawl 796009, Mizoram, India

² Lichenology Laboratory, Plant Diversity Systematics and Herbarium Division, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow 226001, Uttar Pradesh, India

structure and further lactophenol cotton blue was added for preservation. Chemical characters were studied using 5 % potassium hydroxide solution (K) and 1 % Lugol's solution (I), calcium hypochlorite (C) and para-phenylene diamine (PD) followed by thin layer chromatographic analysis (TLC) carried out in solvent system-A following the method of Walker and James [32]. The specimens were identified and authenticated with the help of Awasthi [33, 34], Kalb et al. [35, 36], Divakar and Upreti [37], Divakar et al. [38, 39], Lücking et al. [40], Marbach [41] and Mishra et al. [42]. The authenticated specimens were lodged in the herbarium of CSIR-NBRI (LWG).

Results and Discussion

New Records to India

Buellia aeruginascens (Nyl.) Zahlbr. *Cat. Lich. Univers.* 7: 331 (1931) (Fig. 1)

– *Lecidea disciformis* var. *aeruginascens* Nyl. *Bull. Soc. Linn. Normandie, Sér. 2* 2: 191 (1868)

Thallus crustose, corticolous, grey to whitish, areolate, UV–; apothecia round to sessile, up to 0.6 mm diam., disc flat, white pruinose; epihymenium brown, 10–20 µm width; hymenium 80–85 µm thick, not interspersed with oil; excipulum 65–70 µm width, light brown, dissolving in K, not forming crystals; hypothecium brown; asci consistently 8-spored; ascospores brown, 1-septate, 18–22 × 8–10 µm. Thallus K+ yellow, C–, KC–, PD+ yellow; stictic acid and atranorin present.

This species was earlier reported from the type locality in Chile, South America is a new record for Indian lichen flora.

Specimen examined: Murlen National Park (east). N 23°36'26.2", E 93°12'34.2" and 2092 alt. 23.09.2014. A.R.Logesh and M.Chinlapianga 14-021055 (LWG).

Chaenotheca chrysocephala (Turner ex Ach.) Th. Fr. *Lich. Arctoi* 3: 250 (1860) (Fig. 2)

– *Calicium chrysocephalum* Ach., *Methodus*, Suppl.: 15 (1803).

Thallus crustose, corticolous, granular to squamulose, shiny, deep yellow; photobiont *Trebouxia*; apothecia stalked, stalk 0.4–2.0 mm long and 0.4–0.8 mm diameter; capitulum disc yellow, pruinose, obconical, 0.2–0.3 mm diam.; asci cylindrical, one-celled, 12–18 × 2.0–3.5 µm; ascospores spherical to ellipsoid, 5–7 × 3.5–4 µm. Thallus K–, C–, KC–, PD–. No chemical substances.

The species has earlier been reported from north and central America, Europe, Scotland, British Isles, Australia, Asia and New Zealand. Awasthi [33] reported the occurrence of this species from Nepal. It is reported as new record for the Indian Flora.

Specimen Examined: Murlen National Park (West). N 23°46'49.7", E 93°39'11.8" and 1500 alt. 19.02.2014. M.Chinlapianga 14-019194 (LWG).

Diorygma reniforme (Fée) Kalb., Staiger & Elix, *Symb. Bot. Upsal.* 34(no. 1): 167 (2004) (Fig. 3)

– *Graphis reniformis* Fée, *Essai Crypt. Exot.* (Paris): 46 (1825) [1824].

Thallus crustose, corticolous, creamy white, with fine cracks; ascumata lirellate, branched, sessile, whitish, with well developed thalline margins, pruinose; hymenium not interspersed, 160–180 µm high, hyaline, I+ bluish violet; exciple basally carbonized; paraphyses anastomosing; asci one spored; ascospores muriform, hyaline, peripheral cells smaller than the central ones, 130–150 × 40–45 µm. K+ yellow turning into red crystals, C–, KC–, PD+ yellow. Salazanic, protocetraric and Norstictic acid present.

Diorygma reniforme was earlier known from Africa, South America and Thailand found growing on trees in moist forests between altitudes of 1400–1600 m. It is new record for the country found growing with other Graphidaceous lichens in moist evergreen forests at an altitude of 1800 m.

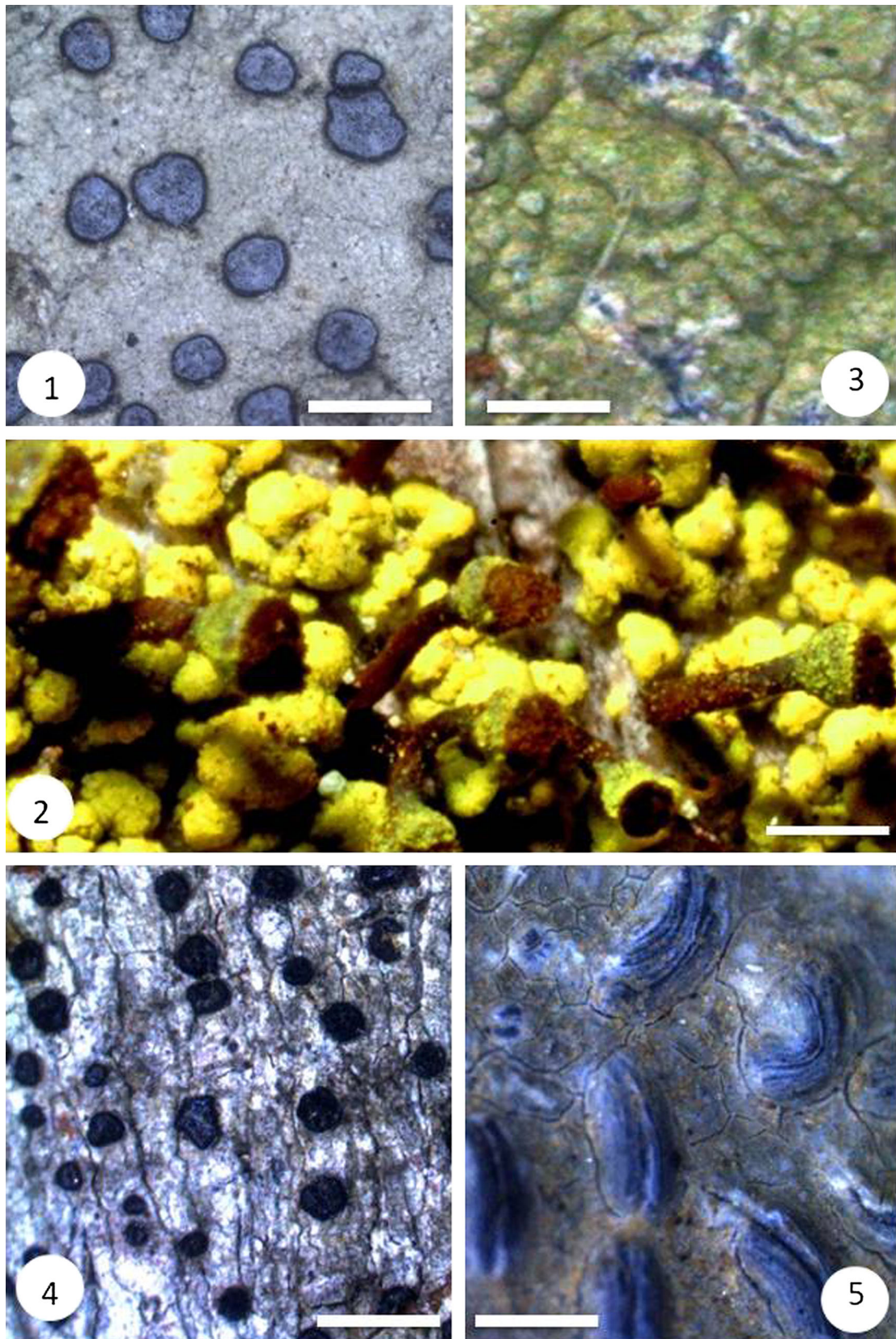
Specimen Examined: Murlen National Park (North) N 23°36'31.2", E 93°38'28.2" and 1795 m, 19.02.2014, M.Chinlapianga 14-021015 (LWG).

Gassicurtia acidobaeomyceta Marbach, *Bibliotheca Lichenol.* 74: 214 (2000) (Fig. 4)

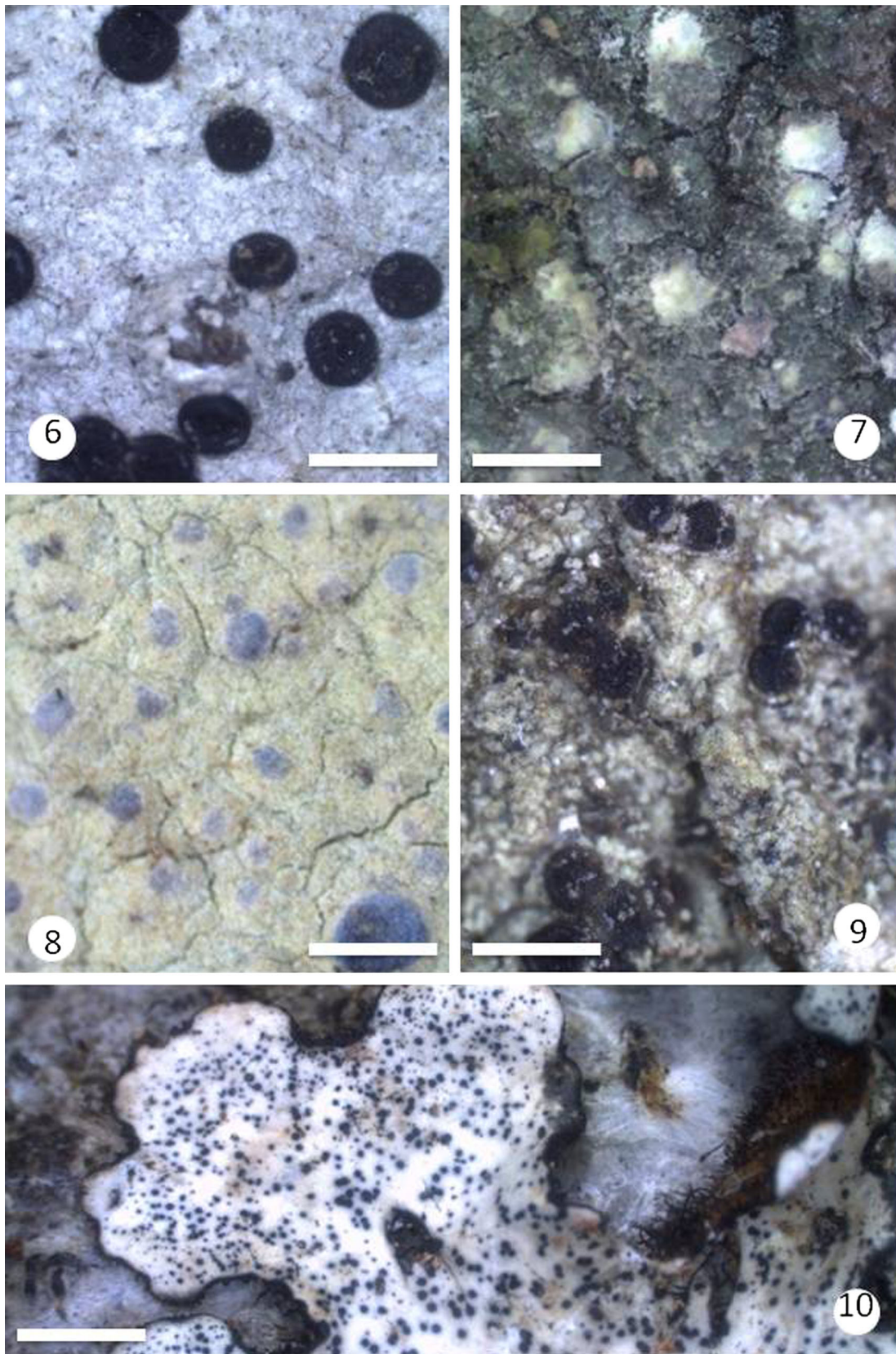
Thallus crustose, corticolous, areolate, brownish red to reddish; apothecia 0.2–0.5 mm in diam., sessile, disc flat, white pruinose; epihymenium pale brown, dissolving in K; hymenium not interspersed with oil droplets, 45–55 µm width, pale yellowish; excipulum 35–45 µm width, brown; asci 8-spored; ascospores 10–15 × 4.5–5 µm, 1-septate, thin septum. Thallus K+ yellow, C–, KC–, PD–. Atranorin, thiophanic acids present.

Earlier this species was known from Brazil and Hawaii up to 800 m altitude. It is a new record for India found growing on evergreen trees in moist places near stream.

Specimen Examined: Murlen National Park (East). N 23°36'26.2", E 93°12'34.2" and 2092 alt. 23.09.2014. A.R.Logesh and M.Chinlapianga 14-031428 (LWG).



Figs. 1–5 1 *Buellia aeruginascens*, 1 mm; 2 *Chaenotheca chrysocephala*, 0.5 mm; 3 *Diorygma reniforme*, 0.5 mm; 4 *Gassicurtia acidobaeomyceta*, 0.5 mm; 5 *Graphis granulosa*, 1 mm



Figs. 6–10 6 *Hafellia demutans*, 1 mm; 7 *Phyllopsora soralifera*, 1 mm; 8 *Ramboldia soreciata*, 0.5 mm; 9 *Ramboldia subnexa*, 2 mm; 10 *Relicina sublanea*, 1 mm

Graphis granulosa (Müll. Arg.) Lücking *Fieldiana, Bot.* 38 (no. 1549): 81 (2008) (Fig. 5)

– *Graphina granulosa* Müll. Arg., *Flora Regensburg* 69(20): 314 (1886).

Thallus crustose, corticolous, whitish grey; ascomata lirellate, lirellae, short and unbranched, sessile, distinctly verrucose with complete thalline margin, apically thin; labia striate; hymenium clear without oil; excipulum completely carbonized; asci one spored; ascospores regularly muriform, $80\text{--}100 \times 18\text{--}23 \mu\text{m}$. Thallus K–, C–, KC–, PD–; hypostictic acid present.

This species was earlier reported from The Netherlands and Jamaica. It is a new record for Indian lichen flora found growing on smooth bark trees forming extensive patches in association with other *Graphis* species.

Specimens Examined: Murlen National Park (East), N $23^{\circ}36'26.2''$, E $93^{\circ}12'34.2''$ & 2092 m alt. 23.09.2014., A. R. Logesh and M. Chinlapianga 14-031452 (LWG).

Hafellia demutans (Zahlbr.) Puswald, *Bibliothca. Lichenol.* 74: 259 (2000) (Fig. 6)

– *Buellia demutans* Zahlbr. *Cat. Lich. Univers.* 7: 348 (1931).

Thallus crustose, corticolous, smooth, white, UV–; apothecia round, sessile, disc flat without pruina, 0.4–0.7 mm in diam.; hymenium interspersed with oil; hypothecium carbonaceous; asci consistently 8 spored; ascospores $24\text{--}33 \times 13\text{--}15 \mu\text{m}$, 1-septate, thick walled. Thallus K+ yellow, C–, KC–, PD+; stictic acid and atranorin present.

This species was earlier recorded from North and South America, Australia and British islands. It is a new record for Indian lichen flora, found growing on rough bark at altitude of 1800 m.

Specimen Examined: Murlen National Park (East). N $23^{\circ}15'00.1''$, E $93^{\circ}39'21.9''$ & 1812 m alt. 20.09.2014. A.R.Logesh and M.Chinlapianga 14-021068 (LWG).

Phyllopsora soralifera Timdal *Lichenologist* 40 (4): 358 (2008) (Fig. 7)

Thallus squamulose, sorediate, closely adnate, rounded to elongate, sometimes indistinct, ascending, 0.1–0.3 mm wide, isidia absent, prothallus indistinct; soredia present on the squamules, cortex of type 2; apothecia absent. Thallus K–, C–, KC–, PD–; No chemical substances.

This species is close to *Phyllopsora catervisorediate* Mishra, Upreti and Nayaka, in sorediate condition of the squamules and cortex type 2, but *P. catervisorediate* differs in having atranorin as a secondary substance.

Specimen Examined: Murlen National Park (East). N $23^{\circ}36'26.2''$, E $93^{\circ}12'34.2''$ and 2092 alt. 23.09.2014. A.R.Logesh and M.Chinlapianga 14-031436 (LWG).

Ramboldia sorediate Kalb, *Bibliothca Lichenol.* 78: 161 (2001) (Fig. 8)

Thallus crustose, corticolous, distinctly areolate, greenish yellow, sorediate, soredia farinose; apothecia frequent, sessile, round, 0.2–0.5 mm diam., disc black, flat to convex; epihymenium brown, 5–10 μm width; hymenium hyaline, 35–45 μm thick; paraphyses sparingly branched, anastomosing, base interspersed with oil granules dissolve in K; ascospores ellipsoidal, $6\text{--}9 \times 2\text{--}4 \mu\text{m}$. Thallus K+ yellow, C–, KC–, PD–; thamnolic acid and traces of usnic acid present.

This species was earlier known from west Africa and Tasmania found growing on decorticated wood on branches in open, sclerophyll forest.

Specimen Examined: Murlen National Park (West). N $23^{\circ}08'10.9''$, E $93^{\circ}29'59.2''$ 1450 m alt. 19.02.2014. M. Chinlapianga 14-021032 (LWG).

Ramboldia subnexa (Stirt.) Kantvilas and Elix, *Bryologist* 97 (3): 301 (1994) (Fig. 9)

– *Lecidea subnexa* Stirt., *Trans. Glasgow Soc. Fld Nat.* 4: 94 (1878).

Thallus crustose, corticolous, greyish brown, areolate, lacking isidia and soredia; apothecia sessile, round, 1–1.5 mm diam., disc black; epihymenium golden brown, 10 μm thick; hymenium hyaline, 40–50 μm thick; hypothecium yellowish brown, 60–80 μm thick; paraphyses sparingly branched, septate, apices hyaline, not swollen, with abundant oil globules; ascospores $8\text{--}10 \times 3\text{--}4 \mu\text{m}$. Thallus K+ yellow, C–, KC–, PD–; thamnolic acid present.

This species was earlier reported from west Africa, Australia and Tasmania found growing on *Eucalyptus* woods, mainly at subalpine elevations. It is a new record for India found growing on rough bark of twigs.

Specimen examined: Murlen National Park (West). N $23^{\circ}36'20.8''$, E $93^{\circ}12'38.3''$ & 1625 m alt. 17.02.2014. M.Chinlapianga 14-021030 (LWG).

Relicina sublanea (Kurok.) Hale, *Phytologia* 28: 485 (1974) (Fig. 10)

– *Parmelia sublanea* Kurok., in Hale and Kurokawa, *Contr. U.S. natnl. Herb.* 36: 146 (1964).

Thallus foliose, corticolous, corticated on both sides, yellow, agglutinated, 1–2 mm wide; margins with bulbate

cilia, bulb inflated; lacking soredia and isidia; lower side brown; apothecia 1–3 mm diam. Medulla K–, C–, KC–, PD+ orange; protocetraric acid present.

This species was earlier reported from Sri Lanka, Philippines, Thailand, Australia and Papua New Guinea. It is a new record for India found growing on smooth bark of trees in association with other parmelioid species.

Specimens Examined: Murlen National Park (East), N 23°36'26.2", E 93°12'34.2" and 2092 m alt., 24.09.2014., A. R. Logesh and M. Chinlapianga 14-031478 (LWG).

Stigmatochroma adauca (Malme) Marbach, *Bibliothca Lichenol.* 74: 306 (2000) (Fig. 11)

– *Buellia adauca* Malme, Ark. Bot. 21A (no. 14): 7 (1927).

Thallus crustose, corticolous, grey, smooth, fissured to areolate; apothecia sessile, round to irregular, 0.5–0.8 mm diam., disc flat to convex, black, white pruinose, UV+; hymenium hyaline, not interspersed with oil; hypothecium carbonaceous; epithecium brown, 10–15 µm thick; paraphyses branched, non anastomosing; asci mostly 6-spored; ascospores brown, 1-septate, thin walled, 11–14 × 5–6 µm. Thallus K+ yellow turning into red crystals, C–, KC–, PD+ yellow; norstictic acid and atranorin present.

This species was earlier reported from Papua New Guinea, The Philippines, Malaysia, south America, New Zealand and Australia. It is a new record for India found growing on smooth bark trees.

Specimen examined: Murlen National Park (East), N 23°36'26.2", E 93°12'34.2" and 2092 m alt. 23.09.2014., A. R. Logesh and M. Chinlapianga 14-031426 (LWG).

Stigmatochroma gerontoides (Stirt.) Marbach, *Bibliothca Lichenol.* 74: 314 (2000) (Fig. 12)

– *Lecidea gerontoides* Stirt., Trans. Glasgow Soc. Fld Nat. 4: 165 (1876).

Thallus crustose, corticolous, creamy yellow to orange, slightly fissured to areolate, UV+ yellow; apothecia round to irregular, up to 0.4–0.8 mm in diam., yellow pruinose on the disc not at the margin, disc flat to convex, sessile; hymenium clear, 80–95 µm in thick; excipulum 35–45 µm thick, brown, forming red crystals in K; asci 8 spored; ascospores 1-septate, thin walled, 12–14 × 5–6 µm. Thallus K+ yellow–red, C–, KC–, PD+; norstictic acid and xanthonones present.

This species was earlier reported from Costa Rica and China. It is a new record for India found growing on the smooth barks of evergreen forests at an altitude of 1800 m.

Specimen examined: Murlen National Park (East), N 23°15'00.1", E 93°39'21.9" and 1812 m alt. 20.09.2014., A. R. Logesh and M. Chinlapianga 14-031437 (LWG).

Stigmatochroma kryptoviolascens Marbach, *Bibliothca Lichenol.* 74: 317 (2000) (Fig. 13)

Thallus crustose, corticolous, creamy white, fissured to areolate; apothecia round, 0.6–1 mm diam., sessile, flat disc, yellow pruinose, UV+; epihymenium golden brown; hymenium clear, hyaline, 70–80 µm thick, dark brown to carbonaceous; hypothecium dark brown; paraphyses branched, not anastomosing; asci 8-spored; ascospores 18–20 × 8–9 µm, 1-septate, thin walled. Thallus K+ red, C–, KC–, PD+; norstictic acid and atranorin present.

This species was earlier reported from Panama and Brazil. It is a new record for India found growing on the smooth barks of trees in evergreen forests at the altitude of 2000 m along with other Physciaceae members.

Specimen examined: Murlen National Park (East), N 23°36'26.2", E 93°12'34.2" and 2092 m alt. 23.09.2014., A. R. Logesh and M. Chinlapianga 14-021035 (LWG).

Stigmatochroma metaleptodes (Nyl.) Marbach, *Bibliothca Lichenol.* 74: 319 (2000) (Fig. 14)

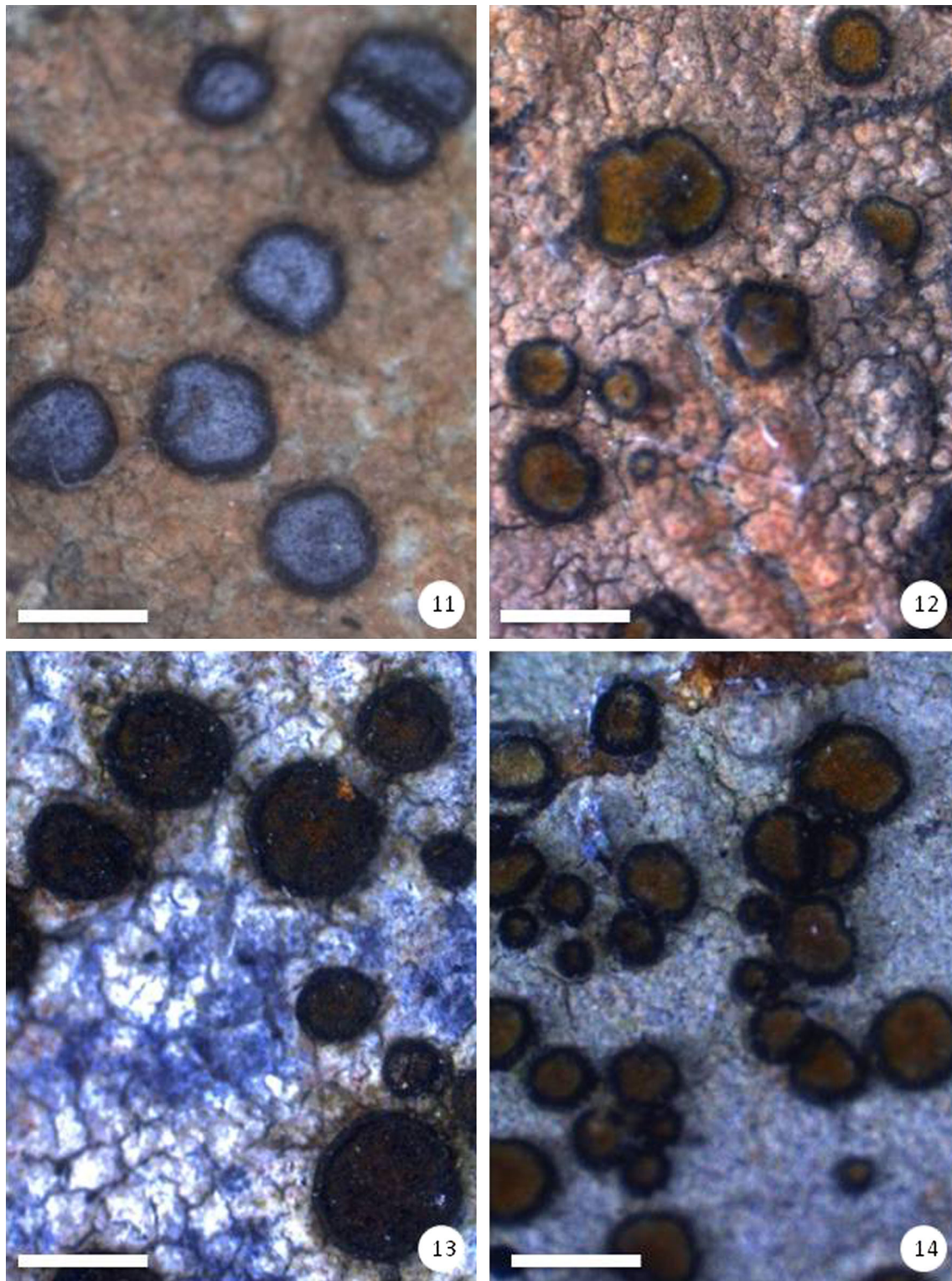
– *Lecidea metaleptodes* Nyl., Acta Soc. Sci. fenn. 26 (no. 10): 15 (1900).

Thallus crustose, corticolous, yellow, areolate; apothecia round to irregular, 0.3–0.5 mm diam., disc pruinose (greenish yellow); epihymenium dark brown, 20–25 µm thick; hymenium hyaline, not interspersed, 60–80 µm thick; excipulum carbonized, dark brown, 60–70 µm thick; paraphyses simple to sparingly branched, not anastomosing; asci 8-spored; ascospores brown, 1-septate, thick walled, 14–18 × 6–7 µm. Thallus K+ yellow–red, C–, KC–, P+ red; norstictic acid present.

This species was earlier reported from Brazil, Mexico, Costa Rica, New Zealand, The Philippines and Thailand. It is a new record for India found growing on the barks of trees in evergreen rain forests at an altitude of 2000 m.

Specimen Examined: Murlen National Park (East), N 23°39'11.2", E 93°19'56.2" and 2122 m alt. 20.09.2014., A. R. Logesh and M. Chinlapianga 14-021080 (LWG).

Identification of more than 500 specimens revealed the occurrence of 159 species belonging to 56 genera and 26 families of lichens (Table 1). The lichen family Parmeliaceae exhibits its dominance with 33 species and 7 genera followed by Physciaceae with 31 species and 9 genera.



Figs. 11–14 11 *Stigmatochroma adauca*, 1 mm; 12 *Stigmatochroma gerontoides*, 1 mm; 13 *Stigmatochroma kryptoviolascens*, 1 mm; 14 *Stigmatochroma metaleptodes*, 1 mm

Other dominant families of the area belong to Graphidaceae with 27 species and 10 genera followed by Parmeliaceae with 21 species and 6 genera. The genus

Heterodermia exhibit its dominance among the all the lichens having 13 species followed by *Usnea* with 12, *Graphis* with 9 and *Lecanora* with 8 species.

Table 1 Lichen flora of Mizoram

Family	Genus	S. no	Species	GF	Accn. No	Location		
Arthoniaceae	<i>Cryptothecia</i>	1	<i>Cryptothecia involuta</i> Stirton	Cr	14-019148	Sateek		
		2	<i>Cryptothecia lunulata</i> (Zahlbr.) Makh. and Patw	Cr	14-019193	MNP (W)		
		3	<i>Cryptothecia verruculifera</i> J.Ram, G.P.Sinha, Kr.P.Singh	Cr	14-021004	MNP (N)		
Cladoniaceae	<i>Cladonia</i>	4	<i>Cladonia coniocraea</i> (Flörke) Spreng.	Fr	14-019178	MNP (W)		
		5	<i>Cladonia fruticulosa</i> Kremp.	Fr	14-031446	MNP (E)		
Coccocarpaceae	<i>Coccocarpia</i>	6	<i>Coccocarpia palmicola</i> (Spreng.) Arvidss. and D.J.Halloway	Fo	14-021071	MNP (E)		
Collemaataceae	<i>Collema</i>	7	<i>Collema subconveniens</i> Nyl.	Fo	14-031405	MNP (E)		
		<i>Leptogium</i>	8	<i>Leptogium askotense</i> D.D.Awasthi	Fo	14-021078	MNP (E)	
			9	<i>Leptogium denticulatum</i> Nyl.	Fo	12-019393	MNP (S)	
Coniocybaceae	<i>Chaenotheca</i>	10	<i>Chaenotheca chrysocephala</i> (Turner ex. Ach.) Th. Fr.	Cr	14-019194	MNP (W)		
Ectolechiaceae	<i>Lopadium</i>	11	<i>Lopadium ionoexcipulum</i> Patw. and Makhija	Cr	14-019152	Sateek		
		12	<i>Lopadium leucoxanthum</i> (Spreng.) Zahlbr.	Cr	14-019184	MNP (W)		
Graphidaceae	<i>Chapsa</i>	13	<i>Chapsa leprocarpa</i> (Nyl.) A. Frisch	Cr	14-019151	Sateek		
		14	<i>Chapsa alborosella</i> (Nyl.) A. Frisch	Cr	14-031438	MNP (E)		
	<i>Diorygma</i>	15	<i>Diorygma heiroglyphicum</i> (Pers.) Staiger and Kalb	Cr	14-021017	MNP (W)		
		16	<i>Diorygma junghuhnii</i> (Mont. and Bosch) Kalb., Staiger and Elix	Cr	14-019185	Aibawk		
		17	<i>Diorygma megaspermum</i> B.O.Sharma and Makh.	Cr	14-019187	Sateek		
		18	<i>Diorygma reniforme</i> (Fée) Kalb., Staiger and Elix	Cr	14-021015	MNP (W)		
		<i>Fissurina</i>	19	<i>Fissurina dumastii</i> Fée	Cr	14-031440	MNP (E)	
			<i>Glyphis</i>	20	<i>Glyphis cicatricosa</i> Ach.	Cr	14-031447	MNP (E)
				<i>Graphis</i>	21	<i>Graphis arecae</i> Vain.	Cr	14-031435
		22	<i>Graphis assimilis</i> Nyl.		Cr	14-031464	MNP (E)	
		23	<i>Graphis caesiella</i> Vain		Cr	14-031462	MNP (E)	
		24	<i>Graphis granulosa</i> (Müll. Arg.) Luecking		Cr	14-031452	MNP (E)	
		25	<i>Graphis insulana</i> (Muell. Arg.) Luecking		Cr	14-031454	MNP (E)	
		26	<i>Graphis lineola</i> Ach.		Cr	14-031429	MNP (E)	
		27	<i>Graphis proserpens</i> Vain.		Cr	14-031453	MNP (E)	
		28	<i>Graphis schiffneri</i> Zahlbr.		Cr	14-019198	Sateek	
		29	<i>Graphis scripta</i> (L.) Ach.		Cr	14-019197	Aibawk	
		<i>Hemithecium</i>	30		<i>Hemithecium aphanes</i> (Mont. and Bosch.) M.Nakan and Kashiw.	Cr	14-031463	MNP (E)
			31		<i>Hemithecium divaricoides</i> (Räsänen) V. Tewari and Upreti	Cr	14-021006	Sateek
	32		<i>Hemithecium pyrrochroa</i> (Mont. and Bosch.) V.Tewari and Upreti		Cr	14-021026	MNP (W)	
	<i>Myriotrema</i>	33	<i>Myriotrema caelestinum</i> (Fée) Hale		Cr	14-019190	Sateek	
		34	<i>Myriotrema microporum</i> (Mont.) Hale		Cr	14-031477	MNP (E)	
	<i>Phaeographis</i>	35	<i>Phaeographis kalbii</i> Staiger		Cr	14-021005	Sateek	
		36	<i>Phaeographis dendroides</i> (Leight.) Müll. Arg.		Cr	14-031526	MNP (E)	
	<i>Sarcographa</i>		37		<i>Sarcographa labyrinthica</i> (Ach.) Müll. Arg.	Cr	14-019188	Sateek
	<i>Thecaria</i>	38	<i>Thecaria austroindica</i> (D.D.Awasthi and Upreti) K.Singh and G.P.Sinha	Cr	14-021046	MNP (E)		
		39	<i>Thecaria quassiiicola</i> Fée	Cr	14-019189	Sateek		
		Haematommaceae	<i>Haematomma</i>	40	<i>Haematomma puniceum</i> (Sw.) A.Massal.	Cr	14-019162	MNP (W)
	41			<i>Haematomma watii</i> (Stirt.) Zahlbr.	Cr	14-031401	MNP (E)	
Lecanoraceae	<i>Lecanora</i>	42	<i>Lecanora achroa</i> Nyl.	Cr	14-021022	MNP (W)		
		43	<i>Lecanora alba</i> Lumbsch	Cr	14-021009	MNP (W)		
		44	<i>Lecanora chlarotera</i> Nyl.	Cr	14-021013	MNP (W)		
		45	<i>Lecanora concilianda</i> Vainio	Cr	14-021011	MNP (W)		
		46	<i>Lecanora coronulans</i> Nyl.	Cr	14-031488	MNP (E)		
		47	<i>Lecanora fimbriatula</i> Stirton	Cr	14-031485	MNP (E)		
		48	<i>Lecanora helva</i> Stizenb.	Cr	14-031486	MNP (E)		
		49	<i>Lecanora tropica</i> Zahlbr.	Cr	14-019147	Sateek		
		<i>Ramboldia</i>	50	<i>Ramboldia manipurensis</i> (K.Singh) Kalb et al.	Cr	14-021045	MNP (E)	
			51	<i>Ramboldia russula</i> (Ach.) Kalb et al.	Cr	13-019380	MNP (S)	
			52	<i>Ramboldia soledata</i> Kalb.	Cr	14-021030	MNP (N)	
			53	<i>Ramboldia subnexa</i> (Stirt.) Kantvilas and Elix	Cr	14-021032	MNP (W)	

Table 1 continued

Family	Genus	S. no	Species	GF	Accn. No	Location
Lecideaceae	<i>Lecidea</i>	54	<i>Lecidea granifera</i> (Ach.) Vain.	Cr	14-021049	MNP (E)
Lobariaceae	<i>Lobaria</i>	55	<i>Lobaria retigera</i> (Bory) Trevis	Fo	14-031404	MNP (E)
Pannariaceae	<i>Pannaria</i>	56	<i>Pannaria emodi</i> P.M.Jørg	Fo	14-021070	MNP (E)
	<i>Parmeliella</i>	57	<i>Parmeliella papillata</i> P.M.Jørg	Fo	14-031439	MNP (E)
Parmeliaceae	<i>Hypotrachyna</i>	58	<i>Hypotrachyna cirrhata</i> (Fr.) Divakar, A. Crespo, Sipman, Elix and Lumbsch	Fo	14-031427	MNP (E)
		59	<i>Hypotrachyna nepalensis</i> (Taylor) Divakar, A. Crespo, Sipman, Elix and Lumbsch	Fo	14-019182	MNP (W)
		60	<i>Hypotrachyna imbricatula</i> (Zahlbr.) Hale	Fo	12-019394	MNP (S)
		61	<i>Hypotrachyna sublaevigata</i> (Nyl.) Hale	Fo	12-019384	MNP (S)
	<i>Myelochroa</i>	62	<i>Myelochroa perisidians</i> (Nyl.) Elix and Hale	Fo	14-019158	MNP (W)
		63	<i>Myelochroa xantholepis</i> (Mont. and Bosch.) Elix and Hale	Fo	14-019192	MNP (W)
	<i>Parmotrema</i>	64	<i>Parmotrema hababianum</i> (Gyeln.) Hale	Fo	14-031425	MNP (E)
		65	<i>Parmotrema indicum</i> Hale	Fo	14-019149	Sateek
		66	<i>Parmotrema ravum</i> (Krog and Swins.) Serus.	Fo	14-019142	Sateek
		67	<i>Parmotrema reticulatum</i> (Taylor) Choisy	Fo	14-019172	MNP (W)
		68	<i>Parmotrema saccatlobum</i> (Taylor) Hale	Fo	14-031480	MNP (E)
		69	<i>Parmotrema stuppeum</i> (Taylor) Hale	Fo	14-021029	MNP (W)
		70	<i>Parmotrema tinctorum</i> (Nyl.) Hale	Fo	14-019155	MNP (W)
		71	<i>Parmotrema tsavoense</i> (Krog. and Swinsc.) Krog. and Swinsc.	Fo	14-031528	MNP (E)
	<i>Relicina</i>	72	<i>Relicina sublanea</i> (Kurok.) Hale	Fo	14-031478	MNP (E)
		73	<i>Relicina sydneyensis</i> (Gyeln.) Hale	Fo	14-021003	MNP (W)
	<i>Relicinopsis</i>	74	<i>Relicinopsis malaccensis</i> (Nyl.) Elix and Verdon	Fo	14-031527	MNP (E)
	<i>Remototrachyna</i>	75	<i>Remototrachyna adducta</i> (Nyl.) Divakar and A. Crespo	Fo	14-019160	MNP (W)
		76	<i>Remototrachyna awasthii</i> (Hale and Patw.) Divakar and A. Crespo	Fo	14-019159	MNP (W)
		77	<i>Remototrachyna crenata</i> (Kurok.) Divakar and A. Crespo	Fo	14-021072	MNP (E)
		78	<i>Remototrachyna rhabdiformis</i> (Kurok.) Divakar and A. Crespo	Fo	14-019164	MNP(N)
	<i>Usnea</i>	79	<i>Usnea aciculifera</i> Vain.	Fr	13-019390	MNP (S)
		80	<i>Usnea baileyi</i> (Stirton) Zahlbr.	Fr	14-031497	MNP (E)
		81	<i>Usnea bornmuelleri</i> J. Steiner	Fr	14-019144	Sateek
		82	<i>Usnea fragilis</i> Stirt.	Fr	14-021020	MNP (N)
		83	<i>Usnea galbinifera</i> Asahina	Fr	13-019400	MNP (S)
		84	<i>Usnea himantodes</i> Stirton	Fr	14-031519	MNP (E)
		85	<i>Usnea longissima</i> Ach.	Fr	13-019399	Chawlhmun
		86	<i>Usnea orientalis</i> Motyka	Fr	14-021010	MNP (W)
		87	<i>Usnea pangiana</i> Stirton	Fr	14-031491	MNP (E)
		88	<i>Usnea pectinata</i> Taylor	Fr	14-031494	MNP (E)
		89	<i>Usnea stigmatoides</i> G. Awasthi	Fr	14-021019	MNP (N)
		90	<i>Usnea undulata</i> Stirton	Fr	14-031493	MNP (E)
Pertusariaceae	<i>Pertusaria</i>	91	<i>Pertusaria albescens</i> (Huds.) M.Choisy and Werner	Cr	14-021023	Sateek
		92	<i>Pertusaria amara</i> Nyl.	Cr	14-031416	MNP (E)
		93	<i>Pertusaria leucosorodes</i> Nyl.	Cr	14-021087	MNP (E)
		94	<i>Pertusaria multipunctata</i> (Turner) Nyl.	Cr	14-031419	MNP (E)
		95	<i>Pertusaria pustulata</i> (Ach.) Duby	Cr	14-031417	MNP (E)
		96	<i>Pertusaria quassiae</i> Fée	Cr	14-021021	MNP (W)
Phlyctidaceae	<i>Phlyctis</i>	97	<i>Phlyctis karnatakana</i> S.Joshi and Upreti	Cr	14-031445	MNP (E)
		98	<i>Phlyctis polyphora</i> Stirton	Cr	14-019191	MNP (W)

Table 1 continued

Family	Genus	S. no	Species	GF	Accn. No	Location		
Phyciaceae	<i>Amandinea</i>	99	<i>Amandinea placodimorpha</i> (Vainio) Marbach	Cr	14-031407	MNP (E)		
	<i>Buellia</i>	100	<i>Buellia aeruginascens</i> (Nyl.) Zahlbr.	Cr	14-021055	MNP (E)		
		101	<i>Buellia morehensis</i> K.Singh and S.R.Singh	Cr	14-021042	MNP (E)		
	<i>Dirinaria</i>	102	<i>Dirinaria aegialita</i> (Afz. In Ach.) Moore	Fo	14-021088	MNP (E)		
		103	<i>Dirinaria confluens</i> (Fr.) D.D.Awasthi	Fo	14-019177	MNP (W)		
		104	<i>Dirinaria papillulifera</i> (Nyl.) D.D.Awasthi	Fo	14-021039	MNP (E)		
		105	<i>Gassicurtia acidobaemyceta</i> Marbach	Cr	14-031428	MNP (E)		
	<i>Hafellia</i>	106	<i>Hafellia curatellae</i> (Malme) Marbach	Cr	14-031408	MNP (E)		
	<i>Heterodermia</i>	107	<i>Hafellia demutans</i> (Stirton) Puswald	Cr	14-021068	MNP (E)		
		108	<i>Heterodermia albidiflava</i> (Kurok.) Awas.	Fo	14-019143	Sateek		
		109	<i>Heterodermia boryii</i> (Fée) Kr.P.Singh and S.R.Singh	Fo	14-031443	MNP (E)		
		110	<i>Heterodermia comosa</i> (Eschw.) Follmann and Redón	Fo	14-019183	MNP (W)		
		111	<i>Heterodermia dactyliza</i> (Nyl.) Swinsc. and Krog	Fo	12-019376	MNP (S)		
		112	<i>Heterodermia diademata</i> (Taylor) D.D.Awasthi	Fo	14-021094	MNP (E)		
		113	<i>Heterodermia flabellata</i> (Fée) D.D.Awasthi	Fo	14-031424	MNP (E)		
		114	<i>Heterodermia hypochraea</i> (Vain.) Swinsc. and Krog	Fo	14-021092	MNP (E)		
		115	<i>Heterodermia isidiophora</i> (Nyl.) D.D.Awasthi	Fo	14-021073	MNP (E)		
		116	<i>Heterodermia japonica</i> (Sato) Swinsc. and Krog	Fo	14-019179	MNP (W)		
		117	<i>Heterodermia obscurata</i> (Nyl.) Trevis	Fo	14-021095	MNP (E)		
		118	<i>Heterodermia podocarpa</i> (Bél.) D.D.Awasthi	Fo	12-019388	MNP (S)		
	119	<i>Heterodermia speciosa</i> (Wulf.) Trevis	Fo	14-021076	MNP (E)			
	120	<i>Heterodermia togashi</i> (Kurok.) D.D.Awasthi	Fo	14-019170	MNP (W)			
	<i>Physcia</i>	121	<i>Physcia aipolia</i> (Ehrh. ex. Humb.) Fürnr.	Fo	14-021058	MNP (E)		
		122	<i>Physcia dilatata</i> Nyl	Fo	14-031472	MNP (E)		
		123	<i>Physcia integrata</i> Nyl.	Fo	14-021098	MNP (E)		
		124	<i>Physcia stellaris</i> (L.) Nyl.	Fo	14-031473	MNP (E)		
	<i>Pyxine</i>	125	<i>Pyxine subcinerea</i> Stirt.	Fo	14-021096	MNP (E)		
	<i>Stigmatochroma</i>	126	<i>Stigmatochroma adaucta</i> (Malme) Marbach	Cr	14-031426	MNP (E)		
		127	<i>Stigmatochroma gerontoides</i> (Stirton) Marbach	Cr	14-031437	MNP (E)		
128		<i>Stigmatochroma kryptoviolascescens</i> Marbach	Cr	14-021035	MNP (E)			
129		<i>Stigmatochroma metaleptoides</i> (Nyl.) Marbach	Cr	14-021080	MNP (E)			
Porinaceae		<i>Porina</i>	130	<i>Porina americana</i> Fée	Cr	14-031411	MNP (E)	
	131		<i>Porina subcutanea</i> Ach.	Cr	14-021057	MNP (E)		
Porpidiaceae	<i>Mycobilimbia</i>	132	<i>Mycobilimbia hunana</i> (Zahlbr.) D.D.Awasthi	Cr	12-019387	MNP (S)		
Pyrenulaceae	<i>Anthracothecium</i>	133	<i>Anthracothecium interlatens</i> Aptroot	Cr	14-019138	Sateek		
		134	<i>Anthracothecium macrosporum</i> (Hepp.) Müll. Arg.	Cr	14-021067	MNP (E)		
		135	<i>Anthracothecium prasinum</i> (Eschw.) R.C.Harris	Cr	14-019139	Sateek		
	<i>Pyrenula</i>	136	<i>Pyrenula approximans</i> (Kremp.) Müll. Arg.	Cr	14-019134	Sateek		
		137	<i>Pyrenula complanata</i> (Mont.) Trevis	Cr	14-019146	Sateek		
		138	<i>Pyrenula mastophoroides</i> (Nyl.) Zahlbr.	Cr	14-019135	Sateek		
		139	<i>Pyrenula thailandica</i> Aptroot	Cr	14-019176	Sateek		
		140	<i>Pyrenula zeylanica</i> Upreti and A.Singh	Cr	14-021044	MNP (E)		
		Ramalinaceae	<i>Bacidia</i>	141	<i>Bacidia fusconigrescens</i> (Nyl.) Zahlbr.	Cr	14-021091	MNP (E)
				142	<i>Bacidia laurocerasi</i> (Delise ex Duby) Vain.	Cr	14-021090	MNP (E)
143	<i>Bacidia medialis</i> (Tuck. ex Nyl.) Zahlbr.			Cr	12-019385	MNP (S)		
<i>Phyllopsora</i>	144		<i>Phyllopsora albicans</i> Müll. Arg.	Sq	14-021007	MNP (W)		
	145		<i>Phyllopsora corallina</i> (Eschw.) Müll. Arg.	Sq	14-021065	MNP (E)		
	146		<i>Phyllopsora soralifera</i> Timdal	Cr	14-031436	MNP (E)		
	147	<i>Phyllopsora</i> sp.	Cr	14-019165	MNP (W)			
<i>Ramalina</i>	148	<i>Ramalina conduplicans</i> Vain.	Fr	14-019166	MNP (W)			
	149	<i>Ramalina hossei</i> Vain.	Fr	14-031444	MNP (E)			
	150	<i>Ramalina sinensis</i> Jatta	Fr	14-031441	MNP (E)			
Roccellaceae	<i>Chiodecton</i>	151	<i>Chiodecton leptosporum</i> Müll. Arg.	Cr	14-021056	MNP (E)		

Table 1 continued

Family	Genus	S. no	Species	GF	Accn. No	Location
Stereocaulaceae	<i>Lepraria</i>	152	<i>Lepraria lobificans</i> Nyl.	L	14-021031	MNP (W)
		153	<i>Lepraria incana</i> (L.) Ach.	L	12-019395	MNP (S)
Tapelariaceae	<i>Trapelia</i>	154	<i>Trapelia coarctata</i> (Turner ex Sm.) M.Choisy	Cr	12-031529	Ngaizal
Teloschistaceae	<i>Caloplaca</i>	155	<i>Caloplaca cerinelloides</i> (Erichs.) Poelt	Cr	14-031414	MNP (E)
		156	<i>Caloplaca amarkantakana</i> Y.Joshi and Upreti	Cr	14-031418	MNP (E)
Trypetheliaceae	<i>Laurera</i>	157	<i>Laurera meristospora</i> (Mont. and Bosch.) Zahlbr.	Cr	14-019167	Aibawk
		158	<i>Trypethelium tropicum</i> (Ach.) Mull. Arg.	Cr	14-019136	Sateek
Verrucariaceae	<i>Normandina</i>	159	<i>Normandina pulchella</i> (Borrer) Nyl	Sq	14-031476	MNP (E)

GF growth form, Accn No accession number, Cr crustose, Fo foliose, Fr fruticose, L leprose, Sq squamulose, MNP murlen national park

Singh and Sinha [5] mentioned the occurrence of *Cladonia fruticulosa* Kremp. and *Cladonia submultiformis* Asahina, only two species of lichens from the state. Chinlamianga et al. [31] further added 10 species of lichens to the list based on lichen specimens collected from different regions of the state. Since most of the earlier studies on lichens of the state were based on cursory collections, therefore a more systematic approach for exploration in the state initiated from Murlen National Park in the present study. The north-eastern region of India is well known for its rich and diverse plant resources including lichens. More than 1200 species of lichens so far are reported from Arunachal Pradesh (480 sp.), Assam (150 sp.), Manipur (295 sp.), Meghalaya (184) and Nagaland (304) based on the checklist of lichens of India [5]. So far records of lichens from the state of Tripura are not known.

Out of all the recorded species of lichens from Mizoram, 67 species are first addition to the northeastern region of India. *Coccocarpia palmicola*, *Lobaria retigera*, *Everniastrum cirrhatum*, *Everniastrum nepalense*, *Parmotrema reticulatum*, *Heterodermia diademata* and *Usnea baileyi* exhibit their widespread distribution in the studied area similar to all the northeastern states. The state of Arunachal Pradesh exhibit maximum similarity with the flora of Mizoram as 60 species are common in both the states. The states of Nagaland and Manipur share 48 and 46 species common with Mizoram respectively, while Assam and Meghalaya share only 24 and 23 species respectively [5].

Being situated in a remote, with difficult terrain and having less anthropogenic pressure, the studied area showed luxuriance of macrolichens genera such as *Usnea*, *Everniastrum*, *Parmotrema*, *Ramalina* and *Heterodermia*, together with crustose lichen genera *Graphis* and *Pyrenula*. Certain taxa having their type locality in the northeastern region are also reported in the present study such as *Ramboldia manipurensis* (K. Singh) Kalb (earlier described as *Catillaria manipurensis* K. Singh), *Graphis assimilis* Nyl. The lichen flora of the studied area showed its affinity vis-vis Sino-Japanese elements as most of the Graphidaceous, Usnioid lichen taxa are similar to that of China and Japan [43, 44].

The secondary metabolites synthesized in lichens are unique and most of them are not produced by any other group of plants. Most of the lichen secondary metabolites showed biological activity against plant and human pathogens. Usnic acid, majorly available in all species of the genus *Usnea* is reported be an excellent antibiotic, also available in market in the name 'Usno' and 'Binan' [45]. Moreover, lichens are used in preparing dyes [46] and food additives [47]. A number of lichens are used in folk and herbal medicine [48]. Recent studies on lichens revealed that nanoparticles produced from lichens have remarkable antimicrobial properties and excellent source of green molecules [49, 50].

In the present study, it was observed that *Usnea baileyi* and *Heterodermia diademata* exhibit their luxuriant growth in the area and have varied array of chemical compounds which can be used for future bioprospection studies.

Conclusion

Occurrence of 159 species from a small region clearly indicates the rich potential of lichen diversity of Mizoram. More intensive and extensive exploration of lichens in the remaining unexplored regions of the state such as Mamit, Saiha, Lunglei districts will definitely further add the number of lichen species in the present inventory. The states of Meghalaya, Assam, Manipur together with Mizoram and Tripura need further systematic, exploration of lichens for better understanding of the lichen diversity from northeastern region of the country.

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Conflict of interest The authors declare that they have no conflict of interest.

References

- Singh A (1964) Lichens of India. Bull Nat Bot Gdns Lucknow 93:1–356
- Awasthi DD (1965) Catalogue of lichens from India, Nepal, Pakistan and Ceylon. Beih Nov Hedw 17:1–137
- Awasthi DD (1977) A general resume of the lichen flora of India. Bull Bot Surv India 19(1–4):301–306
- Awasthi DD (2000) Lichenology in Indian subcontinent. A supplement to a handbook of lichens. Bishen Singh Mahendra Pal Singh, Dehradun
- Singh KP, Sinha GP (2010) Indian lichens: annotated checklist. Botanical Survey of India, Kolkata
- Bajpai R, Upreti DK (2011) New records of lichens from Mahabaleshwar and Koyna areas of Satara district, Maharashtra, India. Geophytology 40(1–2):61–68
- Bajpai R, Upreti DK, Nayaka S, Dubey U (2012) Lichen flora in and around Mahabaleshwar, Satara district, Maharashtra with *Lecanora expallens* Ach., as new record to Indian Lichen flora. Phytotaxonomy 12:123–130
- Nayaka S, Upreti DK (2002) Lichens flora of Sharavati river basin, Shimoga district, Karnataka, India, with six new records. J Econ Taxon Bot 27:627–648
- Upreti DK, Joshi Y, Divakar PK, Lumsch HT, Nayaka S (2008) Notes on some interesting lichens from Western Ghats in India. Phytotaxonomy 8:113–116
- Shyamkumar R, Thajuddin N, Upreti DK (2011) Diversity of lichens in Kollihills of Tamil Nadu, India. Int J Biodivers Conserv 3(2):36–39
- Jagadeesh Ram TAM, Sinha GP, Singh KP (2012) Lichen flora of sundarbans biosphere reserve. Bishen Singh Mahendra Pal Singh, West Bengal
- Logesh AR, Upreti DK, Kalaiselvam M, Nayaka S, Kathiresan K (2012) Lichen flora of Pichavaram and Muthupet mangroves (Southeast Coast of India). Mycosphere 3(5):884–888
- Nayaka S, Ingle KK, Bajpai R, Rawal JR, Upreti DK, Trivedi S (2013) Lichens of Gujarat state, India with special reference to coastal habitats. Curr Res Environ Appl Mycol 3(2):222–229
- Rawat S, Upreti DK, Singh RP (2010) Lichen diversity in Valley of Flowers National Park, Western Himalaya, Uttarakhand, India. Phytotaxonomy 10:112–117
- Upreti DK, Joshi Y, Nayaka S, Joshi S (2010) New records of squamulose lichens from western Himalayas. Geophytology 38(1–2):85–91
- Joshi S, Upreti DK, Das P (2011) Lichen biodiversity across elevational gradient in Pindari Glacier valley of Uttarakhand, India. J Funct Environ Bot 1(2):122–132
- Nayaka S, Upreti DK (2011) An inventory of lichens in Uttar Pradesh through bibliographic compilation. Uttar Pradesh State Biodiversity Board Bulletin, Lucknow, pp 25–35
- Nayaka S, Upreti DK, Khare R (2011) Diversity and distribution of lichen in Katarniaghat Wildlife Sanctuary, Uttar Pradesh. J Ind Bot Soc 90(3&4):360–366
- Mishra GK, Joshi S, Upreti DK, Punetha N, Dwivedi A (2011) An enumeration of lichens from the Pithoragarh district of Uttarakhand, India. Geophytology 39(1–2):23–39
- Joshi S, Upreti DK (2012) Lichen distribution in Milam Glacier valley of Pithoragarh district in Uttarakhand, India. Nelumbo 54:193–206
- Awasthi DD, Singh SR (1977) Five new taxa of saxicolous lichens from Meghalaya, India. Nor J Bot 24:1–8
- Singh KP (1981) Microlichens from Manipur, India. Geophytology 11:242–256
- Singh KP (1981) Macrolichens from Manipur, India. Biol Mem 6:145–168
- Singh KP, Sinha GP (1994) Lichen flora of Nagaland. Bishen Singh Mahendra Pal Singh, Dehradun
- Sinha GP, Singh KP (2005) Macrolichens of Sikkim. Botanical Survey of India, Kolkata
- Rout J, Rongmei R, Das P (2005) Epiphytic lichen flora of a pristine habitat (NIT campus) in Southern Assam, India. Phytotaxonomy 5:117–119
- Rout J, Das P, Upreti DK (2010) Epiphytic lichen diversity in a reserve forest in south Assam, northeast India. Trop. Ecol. 51(2):281–288
- Pinokiyo A, Singh KP, Singh JS (2008) Diversity and distribution of lichens in relation to altitude within a protected biodiversity hot spot, north-east India. The Lichenologist 40(1):47–62
- Bajpai R, Nayaka S, Upreti DK (2011) Distribution of some lichens on four trees in east and south districts of Sikkim. Biozones 3(1&2):406–419
- Dubey U, Upreti DK, Rout J (2007) Lichen flora of Along town, West Siang district, Arunachal Pradesh. Phytotaxonomy 7:21–26
- Chinlampaingam M, Logesh AR, Dubey U, Shukla AC, Upreti DK (2013) Preliminary studies on lichen flora of Mizoram. Sci Tech J 1(1):22–25
- Walker FJ, James PW (1980) A revised guide to the microchemical technique for the identification of lichen products. Bull Britt Lichenol Soc 46:13–29
- Awasthi DD (1991) A key to the microlichens of India, Nepal and Sri Lanka. Biblioth Lichenol 40:1–337
- Awasthi DD (2007) A compendium of the Macrolichens from India, Nepal and Sri Lanka. Bishen Singh Mahendra Pal Singh, Dehradun
- Kalb K, Staiger B, Elix JA (2004) A monograph of the lichen genus *Diorygma*—a first attempt. Symb Bot Ups 34:1–49
- Kalb K, Staiger B, Elix JA, Lange U, Lumsch HT (2008) A new circumscription of the genus *Ramboldia* (Lecanoraceae, Ascomycota) based on morphological and molecular evidence. Nov Hedw 86(1–2):23–42
- Divakar PK, Upreti DK (2005) Parmelioid lichens in India (a revisionary study). Bishen Singh Mahendra Pal Singh, Dehra Dun
- Divakar PK, Crespo A, Nuñez-Zapata J, Flakus A, Sipman HJM, Elix JA, Lumsch HT (2013) A molecular perspective on generic concepts in the *Hypotrachyna* clade (Parmeliaceae, Ascomycota). Phytotaxa 132(1):21–38
- Divakar PK, Lumsch HT, Ferencova Z, Prado RD, Crespo A (2010) *Rematotrachyna*, A newly recognized tropical lineage of lichens in the *Hypotrachyna* clade (Parmeliaceae, Ascomycota), originated in the Indian subcontinent. Am J Bot 97(4):579–590
- Lücking R, Archer AW, Aptroot A (2009) A world-wide key to the genus *Graphis* (Ostropales: graphidaceae). The Lichenologist 41(4):363–452
- Marbach B (2011) Artificial key to Marbach's tropical *Buelia* sensu lato with short diagnoses. <http://www.bgbm.org/sipman/keys/Trobuellia.htm>. Accessed 03 January 2015
- Mishra GK, Upreti DK, Nayaka S, Haridas B (2011) New taxa and new reports of *Phyllopsora* (Lichenized Ascomycotina) from India. Mycotaxon 115:29–44
- Wetmore, Clifford M (2003). Keys to the lichens of China. Retrieved from the University of Minnesota digital conservancy, <http://hdl.handle.net/11299/164294>
- Harada H, Okamoto T, Yoshimura I (2004) A checklist of lichens and lichen-allies of Japan. Lichenology 2(2):47–165
- Boustie J, Tomasi S, Grube M (2011) Bioactive lichen metabolites: alpine habitats as an untapped source. Phytochem Rev 10:287–307
- Shukla P, Upreti DK, Nayaka S, Tiwari P (2014) Natural dyes from Himalayan lichens. Indian J Tradit Knowl 13(1):195–201
- Upreti DK, Divakar PK, Nayaka S (2005) Commercial and ethnic use of lichens in India. Econ Bot 59(3):269–273

48. Nayaka S, Upreti DK, Khare R (2010) Medicinal lichens of India. In: Trivedi PC (ed) Drugs from plants. Avishkar Publishers, Jaipur
49. Singh BN, Prateeksha Pandey G, Jadaun V, Singh S, Bajpai R, Nayaka S, Naqvi AH, Rawat AKS, Upreti DK, Singh BR (2015) Development and characterization of a novel Swarna-based herbo-metallic colloidal nano-formulation—inhibitor of *Streptococcus mutans* quorum sensing. RSC Adv 5:5809–5822
50. Singh BN, Upreti DK, Singh BR, Pandey G, Verma S, Roy S, Naqvi AH, Rawat AKS (2014) Quercetin sensitizes fluconazole-resistant *Candida albicans* to induce apoptotic cell death by modulating quorum sensing. Antimicrob Agents Chemother 59(4):2153–2168