



New additions of macrolichens to the lichen flora of Arunachal Pradesh, India in Eastern Himalaya

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Abstract

Lichen exploration of West Kameng district and Tawang district of Arunachal Pradesh state, India located in the Eastern Himalayas reveal seventy nine lichens represented primarily by foliose (73%), a few fruticose (15%), dimorphic (8%), leprose (2%) and crustose (1%) types. Of these, seventeen species, one fruticose, sixteen foliose growth forms, belonging to 12 genera and 5 families are recorded as new additions to the lichen flora of Arunachal Pradesh state. The lichens were sampled at an elevation ranging from 1618 meter to 4509 meter. The diagnostic features of new additions to macrolichens of Arunachal Pradesh based on the phytogeographic affinities and distribution of species is briefly described.

Keywords – Foliose – Fruticose – Elevation – Distribution

Introduction

Lichens are the symbiotic association between a fungus (mycobiont) and an alga (phycobiont) or cyanobacteria (cyanobiont). They comprise a unique group which are among the most significant indicators of environment and also sensitive towards habitat variation (Wolseley et al. 1994, Rai et al. 2011). India is blessed with rich lichen biodiversity contributing 15% of total global lichen flora (Singh & Sinha 1997, Upreti 1998). Most of the parts of the country are still unexplored and lichenologists are trying to explore new records of lichens from India. Recently *Polymeridium cinereonigricans* (Vain.) R.C. Harris, *P. pleurothecium* R.C. Harris and *P. submuriforme* Aptroot are recorded as new to India (Ingle et al. 2017). A total of 49 species belongs to 26 genera and 14 families of lichens species are recorded recently from the mangrove forests of Bhitarkanika Wildlife Sanctuary and National Park (Odisha) for the first time (Panda et al. 2017). Lichens along with cyanobacteria contribute a significant role for forest nitrogen fixation and also have various industrial applications. Lichens are being used in several ways by different communities of ethnic people. The ethnic use of seven species of lichens belonging to four families is recently recorded from Himalayan country Nepal (Devkota et al. 2017). Secondary metabolites produced by such organisms are of great relevance to medical science (Rout et al. 2005). Lichens are also used for pollution monitoring (Rout 2007) and in dating rocks. With realization of potential impacts of global climate shifts, the lichen flora of polar and alpine regions have assumed greater significance. The vegetation of Arunachal Pradesh has been categorized into six broad types, viz.: tropical,

subtropical, temperate, sub-alpine, alpine and secondary forests (Kaul & Haridasan 1987). Research related to lichen diversity in North-Eastern region of the country is only beginning to get momentum in the last couple of decades or so (Singh & Pinokiyo 2004, Pinokiyo et al. 2008, Rout et al. 2005, Rout 2007, Rout et al. 2010, Rout et al. 2013, Sinha & Jagadeesh 2011, Daimari et al. 2014, Upreti et al. 2015, Dey et al. 2015, Devi et al. 2015, Logesh et al. 2017). Arunachal Pradesh, a state in the North East India is one of the most high lichen diversity region of India. Much of the area in the state, including the Himalayan foothills and the Patkai hills, are home to Eastern Himalayan broadleaf forests (Upreti 1997). Lichen survey in Arunachal Pradesh was initiated by Awasthi (1961). Other lichenologist such as Upreti 1985a, Upreti 1985b, Rout et al. 2004a, Rout et al. 2004b, Dubey & Rout 2007, Dubey 2009, Bajpai et al. 2016, Singh et al. 2018, Sinha et al. 2018 including Awasthi 1982, have also made important contributions to the study of lichens of Arunachal Pradesh. However several areas in the state still remained unexplored. Hence, an extensive field exploration was made covering West Kameng and Tawang districts of the state of Arunachal Pradesh leading to some new additions to the lichen flora of the state.

Materials & Methods

The study has been carried out in West Kameng and Tawang districts of western part of the state of Arunachal Pradesh (Fig. 1). The West Kameng district (area 7,422 km²) lies between 26°54' to 28°01' N and 91°30' to 92°40' E. The district is bordered by Tibet region in the north, Tawang and East Kameng districts in the northwest and east, respectively. The southern boundary adjoins Sonitpur and Darrang districts of the state of Assam and Bhutan as international border in the West. The district is mostly mountainous. The vegetation types range from tropical to alpine between altitudinal ranges of 500 meter to 6000 meter. The Tawang district (area 2,172 km²) lies between 27°25' to 27°52' N and 91°16' to 91°59' E. It is surrounded by Tibet in the north, Bhutan in the south-west and Sela ranges separate it from West Kameng district in the east. The vegetation type ranges from temperate to alpine covering altitude of 1500 meter to 6000 meter. Five study sites in each district, *viz.* Dirang, Sangti, Bartse, Tsangeso, Sela in West Kameng district and another five *viz.*, Negroteng, Pangang Teng Tso (PTTTSO), Bangajang, Nagula, Bumla in Tawang district were selected (Table 1). The study sites were chosen so as to represent ten progressively different elevations varying from Dirang to Bumla.

The study sites were stratified into three different vegetation with regard to the elevation such as Oak-Rhododendron mixed vegetation (1600-2500 meter), Rhododendron-rich middle subalpine forest (2500-3500 meter) and higher altitude alpine grassland with abies vegetation (3500-4500 meter). The specimens were collected from different substrata such as soil, rock, shrubs, tree trunks and twigs from different localities of West Kameng and Tawang districts of the state during September 2012 and November 2013. The collected specimens were properly dried, labeled and investigated morphologically, anatomically and chemically. Standard keys of Awasthi 2007, Divakar & Upreti 2005 were used for the identification. The morphology was studied using a Labo Med Digi Zoom dissecting microscope, and the anatomical details were studied using a Leica TM DM 500 optical microscope. The color spot tests (K, C, KC, P test) and Thin Layer Chromatography (TLC) (Culberson & Kristiansen 1970, Culberson 1972, Santesson 1973, Awasthi 1988, 1991) were performed. The chromatogram was developed using the solvent system A (toluene: dioxane: acetic acid::180: 60: 80 ml). Identified samples were deposited in the Department of Ecology and Environmental Science, Assam University, Silchar, Assam (AUS). A voucher specimen of each taxa has also been submitted to the herbarium of National Botanical Research Institute (NBRI), Lucknow (LWG), India. Few species were categorized as new addition to lichen flora of Arunachal Pradesh based on the annotated checklist (Singh & Sinha 2010) and some of the recent reports on Indian lichens (Bajpai et al. 2016, Singh et al. 2018, Sinha et al. 2018).

Results

A total of 79 species belonging to 32 genera and 18 families of lichen have been identified from West Kameng and Tawang District of Arunachal Pradesh (Table 2). Three species belonging

to 2 genera and 1 family of fruticose lichens and five species belonging to 4 genera and 3 families of foliose lichens are identified common from both the districts. Seventeen species belonging to twelve genera and five families were identified as new additions to the lichen flora of Arunachal Pradesh. The Parmeliaceae family was the most dominant in the area. Both the districts exhibited luxuriant growth of foliose lichens with 54 species of this type. Nagula was found to be the most lichen rich area during the course of the present study (Fig.4).

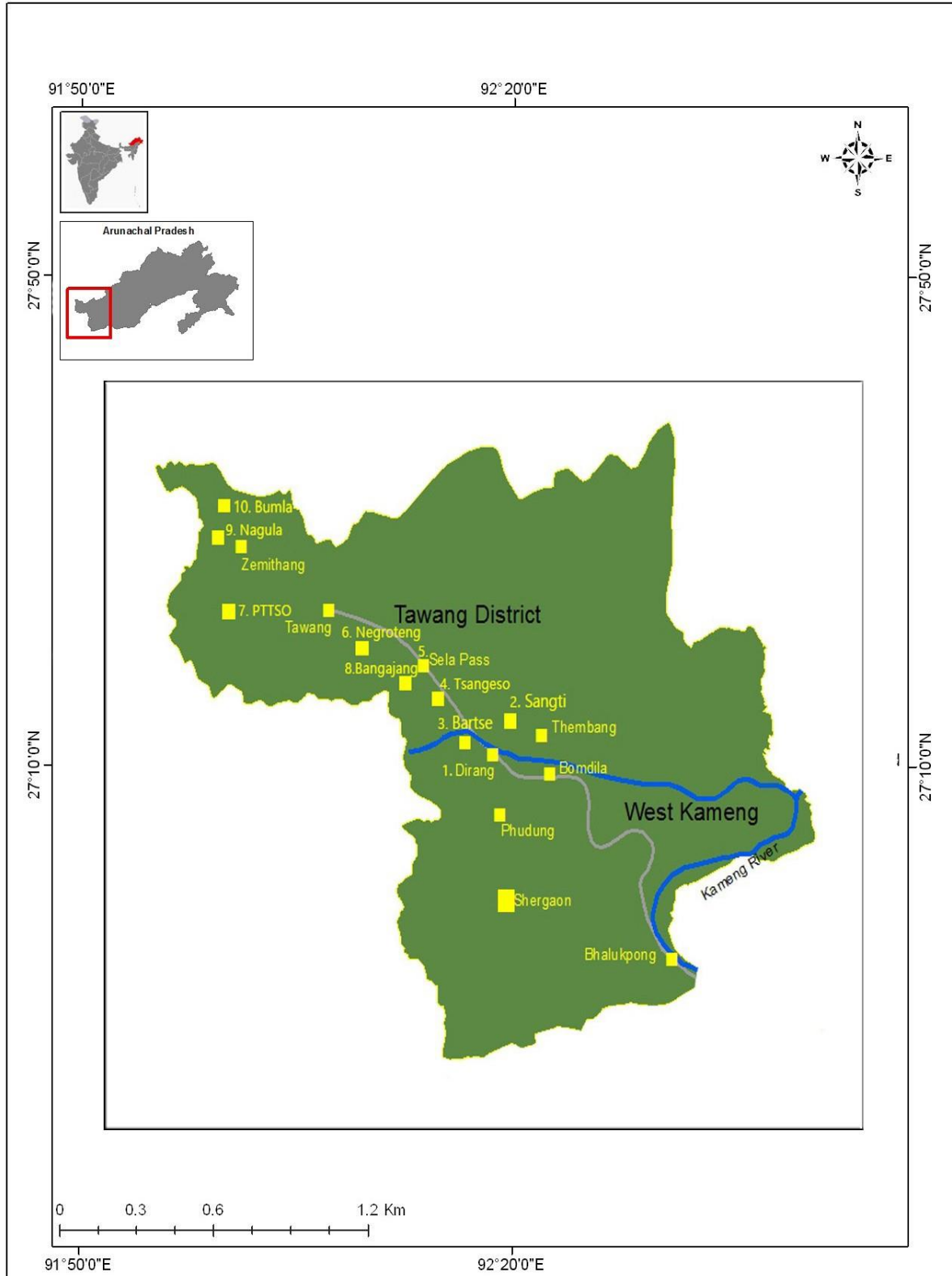


Fig. 1 – Map showing sites (1-10) of lichen collection in West Kameng and Tawang district

Table 1 Lichen collection sites and their elevation.

District	Collection sites	Latitude (N)	Longitude (E)	Elevation (m)	Temp (°C)
West Kameng	1. Dirang	27°25'24.0''	92°18'10.8''	1602	20
	2. Sangti	27°26'01.2''	92°07'12.2''	2330	18
	3. Bartse	27°17'57.8''	92°15'32.6''	2727	17
	4. Tsangeso	27°43'14.1''	91°49'18.5''	3715	18
	5. Sela	27°29'0.7''	92°06'39.6''	3837	18
Tawang	6. Negroteng	27°30'30.0''	92°00'05.2''	3802	20
	7. PTTSO	27°38'17.2''	91°51'25.2''	3916	14
	8. Bangajang	27°29'54.5''	92°01'17.2''	4146	8
	9. Nagula	27°41'33.3''	91°51'07.5''	4290	10
	10. Bumla	27°43'14.3''	91°53'31.2''	4509	10

Taxonomy

Bryoria tenuis (Dahl) Brodo & D. Hawksw. (Family: Parmeliaceae) Fig. 2.1

Thallus erect to decumbent, to 8 cm long, often dying at base; dark brown to black in basal region, paler brown towards apices, branched; main branch to 0.5 mm in diam; lateral spinules present; pseudocyphellae fissural, usually dark; isidia, soredia and isidioid spinules absent. Apothecia absent in Indian specimens.

Basionym – *Alectoria tenuis* Dahl, Meddl. Groenl. 150(2): 144.1950. Type: Greenland, Julianehaab District. Igalikfjord. Eqaqut, 9 Aug. 1937. *E. Dahl* (O-holotype)

Known distribution – distributed in the temperate regions of India (Uttaranchal and West Bengal-Darjeeling District), in boreal and arctic regions of Europe and North America.

Material examined – India, Arunachal Pradesh, Tawang, PTTSO, substratum-tree twig; 24 Sept. 2012; R. Debnath; AUS/JR-RD/APPT/12-11, 12-017720(LWG); Negroteng; 23 Sept. 2012; R. Debnath; AUS/JR-RD/APN/12-06, 12-017723(LWG); LWG Accession no: 29490, 29489

Cetrelia collata (Nyl.) W.Culb. & C.Culb. (Family: Parmeliaceae) Fig. 2.2

Thallus to 15 cm across; lobes to 25 mm wide; upper side pale brownish, with wider than 1 mm diam. pseudocyphellae; lacking isidia and soredia; lower side black, punctate or not, with few rhizines.

Basionym – *Platysma collatum* Nylander, Flora 70: 134. 1887. Type: China, Yunnan, Delavay 1590(H-NYL 36116-holotype).

≡ *Cetraria collate* (Nyl.) Muller Argoviensis, Nuov. Giorn. Bot. Ital. 24: 192.1892.

Known distribution – reported from temperate regions of India (Sikkim), Nepal, China.

Material examined – India, Arunachal Pradesh, West Kameng, Sela; substratum-tree bark; 23 Sept. 2012; R. Debnath; AUS/JR-RD/APSE/12-11; 12-017727(LWG).

Cetrelia olivetorum (Nyl.) W. Culb. & C.Culb. (Family: Parmeliaceae) Fig. 2.3

Thallus to 14 cm across; lobes to 18 mm wide; upper side tan to brownish with small, upto 0.5 mm wide pseudocyphellae; lobe margins with farinose; lower side black, rarely punctate, with few rhizines.

Basionym – *Parmelia olivetorum* Nylander, Nat. Sallsk.Fauna Fl. Fenn. Forhandl. N.S. 5: 180. 1866. Type: Switzerland (H-ACH-1327-lectotype).

Known distribution – widespread in temperate regions of India (Uttaranchal), Nepal, China, Japan, Europe and North America.

Material examined – India, Arunachal Pradesh, West Kameng, Bartse; substratum: tree bark; 22 Sept. 2012; R. Debnath; AUS/JR-RD/APB/12-07, 12-017797(LWG).

Dermatocarpon vellereum Zschacke (Family: Verrucariaceae) Fig. 2.4

Thallus usually monophyllus, to 12 cm across, umbilicate, rather thick, leathery; upper side light brownish to brownish red, white to dark pruinose; lower side black, with dense, thick, stumpy, coralloid rhizinomorphs. Perithecia pale red; ascospores ellipsoid, 9-12 x (5-) 6-9 μ m.

≡ *Dermatocarpon rhizinosum* Choisy, Bull. Soc. Bot. France 78: 455.1931. non *D. rhizinosum* (Mull. Arg.) Zahlbr.

Known distribution – widespread in subtropical to lower temperate regions of India (Himachal Pradesh, Jammu & Kashmir, Maharashtra, Rajasthan-Mt. Abu. Tamil Nadu-Nilgiri & Palni Hills, Uttaranchal), Nepal, China and Eastern Europe.

Material examined – India, Arunachal Pradesh, Tawang, Bumla; substratum-rock; 26 Sept. 2012; R. Debnath; AUS/JR-RD/APUL1/12-01(AUS), 12-017754(LWG); adjacent areas of Nagula lake; substratum-rock; 12 Nov. 2013; R. Debnath; AUS/JR-RD/AP/13-55.

Everniastrum neocirrhatum (Hale & Wirth) Hale. (Family: Parmeliaceae) Fig. 2.5

Thallus to 19 cm across; lobes 0.5-1.5(-2.5) mm wide; upper side grey, lacking isidia and soredia; lower side brown black, with short scattered rhizines. Apothecia to 10 mm in diam.; ascospores(14-)16-22 x (6-) 8-10 μ m.

Basionym – *Parmelia neocirrhata* Hale & Wirth, Phytologia 22: 37.1971.

≡ *Cetrariastrum neocirrhatum* (Hale & Wirth) W. Culberson & C. Culberson. Bryologist 84: 289.1981.p.288.fig.10.

Known distribution – distributed in India (Nagaland), Mexico.

Material examined – India, Arunachal Pradesh, Tawang, adjacent areas of Nagula Lake; substratum-tree bark; 25 Sept. 2012; R. Debnath; AUS/JR-RD/APNL/12-47, 12-017783(LWG); West Kameng, Dwangbu, Sangti; substratum-tree bark; 9 Nov. 2013; R. Debnath; AUS/JR-RD/AP/13-20, AUS/JR-RD/AP/13-68.

Hypogymnia alpina D.D.Awasthi. (Family: Parmeliaceae) Fig. 2.6

Thallus adnate, branched; lobes to 1.5 mm wide, apically somewhat swollen; upper side grey-brown to blackish, lacking soredia and isidia. Apothecia goblet shaped, 2 mm in diam; ascospores 5-10 x 4-6 μ m.

Known distribution – reported from India (Sikkim, Uttarakhand).

Material examined – India, Arunachal Pradesh, Tawang, Bumla; substratum- tree bark; 26 Sept. 2012; R. Debnath; AUS/JR-RD/APTL/12-02, 12-017777(LWG); Tawang, Bumla; substratum-tree bark; 13 Nov. 2013; AUS/JR-RD/AP/13-32, 15-025646(LWG).

Hypogymnia enteromorpha (Ach.) Nyl. Nylander. (Family: Parmeliaceae) Fig. 2.7

Thallus branched, lobes compact to discrete, lacking adventitive branchlets; upper side grey-white to yellowish grey; isidia and soredia absent; Apothecia pedicellate and to 20 mm in diam; ascospores 6.5-8.3 x 3.8-5 μ m.

Basionym – *Parmelia enteromorpha* Acharius.Meth. Lich.: 252.1803; Bitter 1901: 233, tab. 11. Fig. 11.

Known distribution – reported from alpine regions of India (Sikkim), Japan, Korea, Tasmania and North America.

Material examined – India, Arunachal Pradesh, Tawang, adjacent areas of Nagula lake; substratum-tree bark; 25 Sept. 2012; R. Debnath; AUS/JR-RD/APNL/12-42, 12-017759(LWG)

Hypogymnia pseudohypotrypa(Asahina)A.Singh. (Family: Parmeliaceae) Fig. 2.8

Thallus branched; lobes to 6 mm wide; upper side yellowish grey to grey-brown; isidia and soredia absent; Apothecia pedicellate, to 15 mm in diam.

Basionym – *Parmelia pseudohypotrypa* Asahina in Nuno, J. Jap.Bot. 39: 89.1964.

Known distribution–reported from upper temperate regions of India (Sikkim, West-Bengal-Darjeeling District), China and Tibet.

Table 2 Species composition of lichens from West Kameng and Tawang district of Arunachal Pradesh during the study period.

Species	Sub	GF	DI	SA	BS	TS	NE	SE	PT	BA	NA	BU
1 <i>Acrosyphus sphaerophoroides</i> Lev.	T	Fr.									+	
2 <i>Bryoria asiatica</i> (Du Rietz) Brodo & D. Hawksw.	C	Fr.		+								
3 <i>Bryoria confusa</i> (D.D.Awasthi) Brodo & D.Hawksw.	C	Fr.										+
4 <i>Bryoria himalayana</i> (Mot.) Brodo & D.Hawksw.	C	Fr.								+		
5 <i>Bryoria tenuis</i> (Dahl) Brodo & D.Hawksw.*	C	Fr.					+		+			
6 <i>Candelaria</i> sp.	T	F									+	
7 <i>Canomaculina subsumpta</i> (Nyl.) Elix	C	F										+
8 <i>Cetrelia cetrarioides</i> (Del. ex Duby) W. Culb. & C.Culb.	C	F				+						
9 <i>Cetrelia collata</i> (Nyl.) W. Culb. & C. Culb.*	C	F						+				
10 <i>Cetrelia braunsiana</i> (Mull. Arg.) W. Culb. & C.Culb.	C	F			+							
11 <i>Cetrelia olivetorum</i> (Nyl.) W. Culb. & C. Culb.*	C	F			+							
12 <i>Cladonia coccifera</i> (L.) Willd.	T	D							+			
13 <i>Cladonia pyxidata</i> (L.) Hoffim.	T	D									+	
14 <i>Cladonia rangiferina</i> (L.) Waber ex F.H. Wigg.	T	Fr.									+	
15 <i>Cladonia stellaris</i> (Opiz) Pouzar & Vezda	T	Fr.									+	
16 <i>Cladonia yunnana</i> (Vain) Abbayes ex J.C. Wei & Y.M. Jiang	T	D									+	
17 <i>Coccocarpia erythroxyli</i> (Spreng.) Swinsc. & Krog	T	F	+		+							
18 <i>Coccocarpia palmicola</i> (Spreng.) Arvidss. & D.J. Galloway	C	F	+									
19 <i>Crysothrix candelaris</i> (L.) J.R. Laundon	S	L									+	
20 <i>Dermatocarpon vellereum</i> Zschacke*	S	F										+
21 <i>Everniastrum cirrhatum</i> (Fr.) Hale	C	F	+	+		+		+	+			
22 <i>Everniastrum neocirrhatum</i> (Hale & Wirth) Hale*	C	F									+	
23 <i>Everniastrum nepalense</i> (Taylor) Hale	C	F						+		+		
24 <i>Flavopunctelia flaventior</i> (Stirton) Hale	C	F				+						
25 <i>Heterodermia boryi</i> (Fee) Kr.P. Singh & S.R.Singh	C	F				+	+					
26 <i>Heterodermia diademata</i> (Taylor) D.D.Awasthi	B	F		+								
27 <i>Heterodermia leucomelos</i> (L.) Poelt	B	F			+							
28 <i>Heterodermia pseudospeciosa</i> (Kurok.) W. Culb.	B	F	+		+							
29 <i>Heterodermia speciosa</i> (Wulf.) Trevis.	B	F	+									

Table 2 Continued.

	Species	Sub	GF	DI	SA	BS	TS	NE	SE	PT	BA	NA	BU
30	<i>Hypogymnia alpina</i> D.D. Awasthi*	B	F										+
31	<i>Hypogymnia enteromorpha</i> (Ach.) Nyl.*	B	F									+	
32	<i>Hypogymnia physodes</i> (L.) Nyl.	B	F					+					
33	<i>Hypogymnia pseudobitteriana</i> (D.D.Awasthi) D.D.Awasthi	B	F					+					
34	<i>Hypogymnia pseudohypotrypa</i> (Asahina) A.Singh*	B	F		+								
35	<i>Hypogymnia thamsoniana</i> (Mull. Arg.) D.D. Awasthi*	B	F		+								
36	<i>Hypogymnia vittata</i> (Ach.) Gasil.	C	F		+		+			+			
37	<i>Hypotrachyna infirma</i> (Kurok.) Hale	C	F			+							
38	<i>Leptogium cyanescens</i> (Rabenh.) Korb.	C	F	+									
39	<i>Leptogium denticulatum</i> Nyl.	C	F		+								
40	<i>Leptogium trichophorum</i> Mull. Arg.	C	F						+				
41	<i>Lepraria</i> sp.	T	L									+	
42	<i>Lethariella cladonioides</i> (Nyl.) Krog	T	Fr.								+		
43	<i>Lobaria retigera</i> (Bory) Trev.	C	F	+	+							+	
44	<i>Melanelia stygia</i> (L.) Essl.	S	F									+	
45	<i>Myelochroa metarevoluta</i> (Asahina) Elix & Hale*	S	F									+	
46	<i>Nephromopsis nephromoides</i> (Nyl.) Ahti & Randl.	C	F			+							
47	<i>Nephromopsis pallescens</i> (Schaer.) Park	C	F			+							
48	<i>Parmelinella chozoubae</i> (Kr. P.Singh & Sinha) Elix & Pooprang*	S	F	+									
49	<i>Parmelaria subthomsonii</i> D.D.Awasthi	C	F	+									
50	<i>Parmotrema praesorediosum</i> (Nyl.) Hale*	C	F							+			
51	<i>Parmotrema reticulatum</i> (Taylor) Choisy	C	F	+		+							
52	<i>Parmotrema saccatilobum</i> (Taylor) Hale*	C	F									+	
53	<i>Parmotrema tinctorum</i> (Despr. ex Nyl.) Hale	C	F			+							
54	<i>Peltigera collina</i> (Ach.) Schrad.*	T	F								+		
55	<i>Peltigera polydactylon</i> (Neck.) Hoffm.	T	F	+									
56	<i>Peltigera rufescens</i> (Weiss) Humb.	T	F								+		
57	<i>Physcia caesia</i> (Hoffm.) Furnr.*	C	F									+	
58	<i>Ramalina hossei</i> Vain.	C	Fr.	+									

Table 2 Continued.

	Species	Sub	GF	DI	SA	BS	TS	NE	SE	PT	BA	NA	BU
59	<i>Ramalina sinensis</i> Jatta	C	Fr.	+									
60	<i>Rhizocarpon geographicum</i> (L.) DC.	S	Cr.									+	
61	<i>Stereocaulon alpinum</i> Laurer	T	D								+		
62	<i>Stereocaulon foliolosum</i> Nyl. var. botryophorum (Mull. Arg.) I.M. Lamb	T	D									+	
63	<i>Stereocaulon himalayense</i> D.D.Awasthi & I.M.Lamb	T	D									+	+
64	<i>Sticta nylanderiana</i> Zahlbr.*	C	F		+								
65	<i>Sticta weigelii</i> (Ach.)Vain.	C	F	+									
66	<i>Sulcaria sulcata</i> (Lev.) Bystr. ex Brodo & D.Hawksw.	C	Fr.	+									
67	<i>Thamnolia vermicularis</i> (Sw.) Schaer. var. vermicularis	T	Fr.									+	
68	<i>Umbilicaria indica</i> Frey var. indica	S	F								+	+	+
69	<i>Umbilicaria vellea</i> (L.) Ach. em. Frey*	S	F									+	
70	<i>Usnea aciculifera</i> Vain.	C	F	+					+				
71	<i>Usnea bismolliuscula</i> Zahlbr.	C	F		+								
72	<i>Usnea cineraria</i> Mot.	C	F		+								
73	<i>Usnea dendritica</i> Stirt.	C	F		+								
74	<i>Usnea himantodes</i> Stirt.	C	F								+		
75	<i>Usnea longissima</i> Ach.	C	F		+		+	+					
76	<i>Usnea misamisensis</i> (Vain.) Mot.	C	F				+						
77	<i>Usnea orientalis</i> Mot.	C	F							+	+		
78	<i>Usnea thamsonii</i> Stirt.	C	F		+		+			+			
79	<i>Usnea fragilis</i> Stirt.	C	F								+		

Note: Sub-Substratum, GF-Growth Form, C-Corticolous, T-Terricolous, S-Saxicolous, F-Foliose, Fr.-Fruticose, Cr.- Crustose D-Dimorphic, L-Leprose; BA-Bangajang, BS-Bartse, BU-Bumla, DI-Dirang, NA-Nagula Lake, NE-Negroteng, PT-PTTSO, TS-Tsangeso, SA-Sangti & SE-Sela.

*New additions to the lichen flora of Arunachal Pradesh

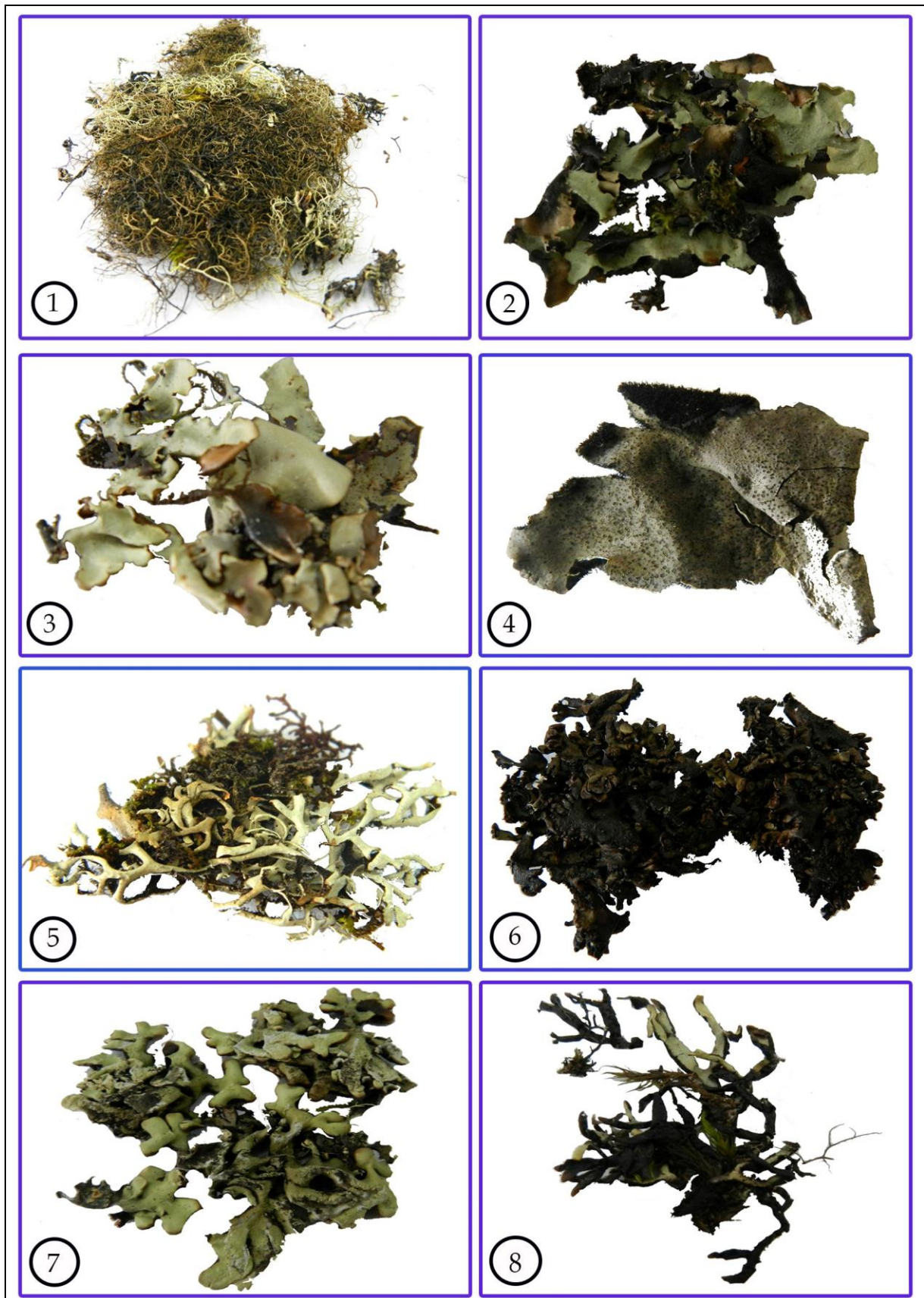


Fig. 2 – New additions of lichens to Arunachal Pradesh. 1 *Bryoria tenuis* (Dahl) Brodo & D. Hawksw. 2 *Cetreliella collata* (Nyl.)W. Culb. & C. Culb. 3 *Cetreliella olivetorum* (Nyl.)W. Culb. & C.Culb. 4 *Dermatocarpon vellereum* Zschake. 5 *Everniastrum neocirrhatum* (Hale & Wirth) Hale. 6 *Hypogymnia alpina* D.D. Awasthi. 7 *Hypogymnia enteromorpha* (Ach.) Nyl. 8 *Hypogymnia pseudohypotrappa* (Asahina) A. Singh.

Material examined – India, Arunachal Pradesh, West Kameng, Sangti; substratum-tree bark; 23 Sept. 2012; R. Debnath; AUS/JR-RD/APS/12-32, 12-017757(LWG); Tawang, PTTSO; substratum-tree bark; 11 Nov. 2013; R. Debnath; AUS/JR-RD/AP/13-02, LWG Accession no: 29530

Hypogymnia thomsoniana (Mull. Arg.) D.D.Awasthi. (Family: Parmeliaceae) Fig. 3.9

Thallus to 6 cm across, branched; lobes to 3 mm wide; upper side ashy brown to copper-brown, with pycnidia; isidia and soredia absent; Apothecia immature.

Basionym – *Parmelia thomsoniana* Muller Argoviensis, Flora 74: 379.1891.

Known distribution – Reported from India (Sikkim).

Material examined – India, Arunachal Pradesh, West Kameng, Sangti; substratum- tree bark; 23 Sept. 2012; R. Debnath; AUS/JR-RD/APS/12-25, 12-017790(LWG).

Myelochroa metarevoluta (Asahina) Elix & Hale. (Family: Parmeliaceae) Fig. 3.10

Thallus adnate, to 4 cm across; lobes to 4 mm wide; upper side whitish grey, postulate-sorediate; lower side rhizinate; medulla yellow. Apothecia and pycnidia not known.

Basionym – *Parmelia metarevoluta* Asahina. J. Jap. Bot. 35: 97.1960. fig.1.

Known distribution – reported from India (Manipur, Meghalaya, Sikkim), China, Japan and North America.

Material examined – India, Arunachal Pradesh, Tawang, adjacent areas of Nagula Lake; substratum-rock; 25 Sept. 2012; R. Debnath; AUS/JR-RD/APNL/12-611(AUS), 12-017772(LWG); Tawang, adjacent areas of Sela lake; substratum-rock; 10 Nov. 2013; R. Debnath; AUS/JR-RD/AP/13-79, 15-025663(LWG); LWG Accession no: 32048

Parmelinella hozoubae (Kr. P. Singh & Sinha) Elix & Pooprang.(Family: Parmeliaceae) Fig. 3.11

Thallus adnate, to 5 cm across; lobes sublinear, to 4 mm wide, truncate, ciliate in axils; upper side grey, lacking isidia and soredia; lower side black. Apothecia laminal; ascospores (9-) 13-17 x (5-) 7-12µm.

Basionym – *Parmelina hozoubae* Kr. P. Singh & Sinha, Nord. J. Bot. 13: 463.1993, p. 464.fig.1: and Singh & Sinha 1994: 267, p. 256, Pl. 16, fig. 6.

≡ *Parmelina metarevoluta* (Asahina) Hale. Phytologia 28: 483. 1974; Hale 1976d: 36.p. 37. fig.17 b.

Known distribution – reported from India (Nagaland), Thailand.

Material examined – India, Arunachal Pradesh, West Kameng, Dirang; substratum-tree bark; 22 Sept. 2012; R. Debnath; AUS/JR-RD/APK/12-01, 12-017739(LWG); LWG Accession no: 29514

Parmotrema praesorediosum(Nyl.) Hale. (Family: Parmeliaceae) Fig. 3.12

Thallus adnate, to 10 cm across; lobes 5-8 mm wide, eciliate; upper side grey to darker, emaculate, soralia usually marginal, linear or crescent-shaped; soredia granular; lower side centrally black. Apothecia to 4 mm in diam., imperforate; ascospores 15-21 x 7-10 µm.

Basionym – *Parmelia praesorediosa* Nylander, Sert. Lich. Trop. Labaun, Singapore: 18. 1891: Hale 1965: 258, Pl. 5, fig. 19: D. Awasthi 1976: 215, Pl. 12, fig. 3.

≡ *Parmelia neglecta* Asahina, J. Jap. Bot. 17: 71.1941.

Known distribution – reported from tropical to lowermost temperate regions (Andhra Pradesh, Assam, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Orissa, Rajasthan-Mt Abu, Sikkim, Tamil Nadu- Nilgiri and Palni Hills, Uttaranchal, West Bengal-Jalpaiguri District), Nepal, Sri Lanka, SE Asia, Indonesia and Fiji, Africa. North, Central and South America, Australia, Papua Guinea and New Calendonia.

Material examined – India, Arunachal Pradesh, Tawang, PTTSO; substratum- tree bark; 24 Sept.2012; R. Debnath; AUS/JR-RD/APPT/12-16, 12-017743(LWG)



Fig. 3 – New additions of lichens to Arunachal Pradesh. 9 *Hypogymnia thamsoniana* (Mull. Arg.) D.D. Awasthi. 10 *Myelochroa metarevoluta* (Asahina) Elix & Hale. 11 *Parmelinella chozoubae* (Kr. P. Singh & Sinha) Elix & Pooprang. 12 *Parmotrema praesorediosum* (Nyl.) Hale. 13 *Parmotrema saccatilobum* (Taylor) Hale. 14 *Peltigera collina* (Ach.) Schard. 15 *Physcia caesia* (Hoffm.) Furnr. 16 *Sticta nylanderiana* Zahlbr. 17 *Umibilicaria vellea* (L.) Ach. Em. Frey.

- Parmotrema saccatilobum*** (Taylor) Hale. (Family: Parmeliaceae) Fig. 3.13
 Thallus to 10 cm across; lobes 4-10 mm wide, involute-tubular (saccate), eciliate; upper side grey, emaculate, cracked at centre, isidiate; isidia granular to filiform; Indian specimens sterile.
 Basionym – *Parmelia saccatiloba* Taylor, London J. Bot. 6:174.1847; Hale 1965: 262; D. Awasthi 1976: 219, Pl.9, fig 3.
 Known distribution – widespread in tropical and subtropical regions of India (Andaman Islands, Assam, Goa, Sikkim, Nagaland, Uttaranchal, West Bengal-Calcutta and Darjeeling District), China, Taiwan, Singapore, Australia, Fiji, Pacific islands.
 Material examined – India, Arunachal Pradesh, Tawang, adjacent areas of Nagula lake; substratum-tree bark; 25 Sept. 2012; R. Debnath; AUS/JR-RD/APNL/12-612, 12-017771(LWG); LWG Accession no: 29501
- Peltigera collina*** (Ach.) Schard. (Family: Peltigeraceae) Fig. 3.14
 Thallus adnate, to 3 cm across; lobes 4-6(-12) mm wide; upper side yellowish-brown, scabrid, tomentose, marginally soraliolate with granular soredia; Indian specimens sterile.
 Basionym – *Lichen collinus* Acharius. Lich. Svec. Prodr.: 162.1798.
 ≡ *Peltigera scutata* (Dicks.) Duby, fide: Thomson Amer. Midl. Nat. 44: 16.1950.
 Known distribution – reported from subtropical to lower temperate regions of India (Sikkim, Tamil Nadu-Nilgiri and Palni Hills, Uttaranchal), China, Central Europe and North America.
 Material examined – India, Arunachal Pradesh, West Kameng, Sangti; substratum-rock; 23 Sept. 2012; R. Debnath; AUS/JR-RD/APS/12-40(AUS).
- Physcia caesia*** (Hoffm.) Furnr. (Family: Physciaceae) Fig. 3.15
 Thallus 5–7 cm across; lobes 3 mm wide; upper side whitish grey to darker, white-maculate; soralia terminal on short lobes, capitate to lip-shaped. Apothecia to 1.5 mm in diam.
 Basionym – *Lichen caesius* Hoffmann. Enumeratio Lich.: 65. 1784
 ≡ *Physcia wainioi* Rasanen.Medd. Soc. Fauna Fl. Fenn. 46: 166.1921.
 Known distribution – reported from upper temperate regions of India (Jammu & Kashmir, Manipur, Rajasthan, Uttaranchal), Nepal, Europe and N. America.
 Material examined – India, Arunachal Pradesh, Tawang, adjacent areas of Nagula Lake; substratum-rock; 25 Sept. 2012; R. Debnath; AUS/JR-RD/APNL/12-56, 12-017731(LWG); LWG Accession no: 29509
- Sticta nylanderiana*** Zahlbr. (Family: Lobariaceae) Fig. 3.16
 Thallus horizontal, loosely adnate, to 14 cm across; lobes 3-30 mm wide; upper side pale grey to darker, lacking isidia and soredia; lower side pale brown to brown, cyphellate: cyphellae initially minute, later 0.4-2 mm in diam., saucer shaped.
 ≡ *Sticta damaecornis* **S. platyphylla* Nylander. Syn. Lich. 1: 357.1860, non Massalongo ex anno 1853. Type: (Nepal. Himalaya) alt. 12000ft. (=3600). *Hooker f. & Thomson* 1963(H-NYL 37652-lectotype).
 Known distribution – widespread in temperate regions of India (Himachal Pradesh, Manipur, Sikkim, Nagaland, Tamil Nadu and Uttaranchal), Bhutan, Nepal and China.
 Material examined – India, Arunachal Pradesh, Tawang, PTTSO; substratum-tree bark; 24 Sept. 2012; R. Debnath; AUS/JR-RD/APPT/12-11, 12-017755(LWG); Tawang, PTTSO; substratum-tree bark; 11 Nov. 2013; R. Debnath; AUS/JR-RD/AP/13-62; LWG Accession no: 29535.
- Umbilicaria vellea***(L.) Ach. (Family: Umbilicariaceae) Fig. 3.17
 Thallus monophyllous, umbilicate, 2.5-12 cm across, rigid; margin entire to incised; upper side grey to blackish grey, smooth, areolate, pruinose; lower side black, to brownish black; Apothecia rare, to 3 mm in diam.
 Basionym – *Lichen velleus* Linnaeus, Sp. Pl.: 1150. 1753.

Known distribution – reported from temperate regions of India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand), Africa, Bhutan, Europe, Nepal, Sri Lanka, cosmopolitan in northern arctic regions and New Zealand.

Material examined – India, Arunachal Pradesh, Tawang, adjacent areas of Nagula Lake; substratum-rock; 25 Sept. 2012; R. Debnath; AUS/RD/APNL/12-64, 12-017736(LWG).

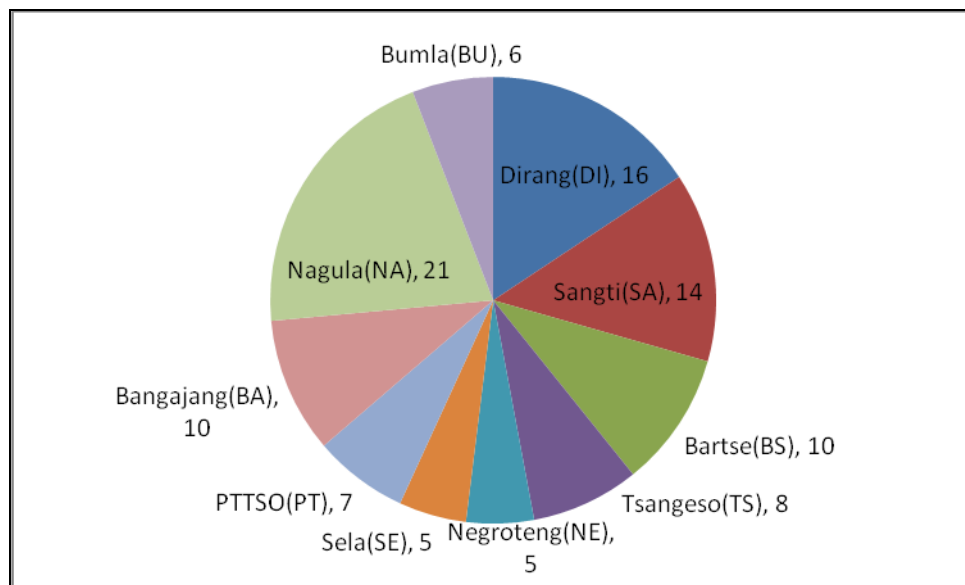


Fig. 4 – Number of species from different study sites

Discussion

The high elevation, ample sunlight, low temperature and less human disturbances provide suitable environment for the growth of macrolichens. Foliose and fruticose lichens need adequate light condition for their growth. According to James et al. 1977, Broad 1989, Wolseley & Pryor 1999, the fruticose lichens are most light sensitive. Based on the annotated checklist (Singh & Sinha 2010), recent reports of Bajpai et al. 2016, Singh et al. 2018, Sinha et al. 2018 the present research led to 17 species belonging to 12 genera and 5 families as new additions to the lichen flora of Arunachal Pradesh.

Note added at proof stage

While the manuscript was under review, few more works (Bajpai et al 2016, Singh et al 2018, Sinha et al 2018) on the lichen diversity of the state appeared and accordingly the present list of new additions to the lichen flora are based on these reports.

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