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Lichens of the Mahabaleshwar Panchgani Ecosensitive zone (MPESZ), Maharashtra, India

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Lichens are by definition symbiotic organisms composed of a fungal partner, the mycobiont and one or more photosynthetic partners, the photobiont, that may be either a green alga or a cyanobacterium. Lichens are regarded as an example of controlled parasitism, because the fungus seems to obtain most of the benefits and the photobiont may grow more slowly in the lichenized state than when free-living (Ahmadjian 1993).

They dominate other groups of organisms in as much as 8% of the earth's surface (Ahmadjian 1993, 1995). The associated entity grows at an average rate of 1–5 mm per year and persists for tens or hundreds of years on their substratum. In the tropics and subtropics some rapidly growing lichens even colonize the surface of leaves as epiphylls.

The growth forms of lichens are usually conspicuous and among the terrestrial autotrophs of the world, lichens exhibit intriguing variation in miniature. They are categorized primarily based on their morphology and size into three major types, viz., crustose (crust like), foliose (leaf like) and fruticose (shrubby). The lichens belonging to the former category are called microlichens and the latter two are referred to as macrolichens. They colonize a great variety of substrates such as rocks, soil, humus, wood substrates as tree trunks, branches and logs, animal shells, bones, insect backs, synthetic materials as plastic taps and substrates derived from mineral sources such as bricks, cement, concrete roofs and walls and glass and iron, amongst others (Brightman & Seaward 1978; Hale 1983; Sipman 1994; Schroeter & Sancho 1996).

Many of the lichen species have proved economically very beneficial and continue to hold significant commercial implications particularly in cosmetic and perfumery industries. A large number of chemicals called lichen substances unique to lichens have made them useful as a source of dyes, medicines, agrochemicals and other exploitable compounds. They play an important role in the mineral cycling patterns of their ecosystem, particularly if cyanolichens are the dominant components.

The Western Ghats have attracted the attention of naturalists for nearly a century in course of the studies on the biological material of their interests or in their discussions on the biogeography of the Indian biota. The complex topography of the Western Ghats with a wide range of microclimatic and soil conditions have resulted in a mosaic of plant communities and animal associations unique to itself. Besides being biologically rich in genera and species the Western Ghats is rich in endemics too. Many new and endemic lichen species have also been reported from this region (Makhija et al. 2004; Dube et al. 2005; Makhija et al. 2005; Makhija et al. 2006; Chitale & Makhija 2008; Chitale et al. 2008; Chitale et al. 2009;

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Makhija et al. 2009; Dube & Makhija 2010; Singh & Sinha 2010; Bajpai & Upreti 2011; Chitale et al. 2011; Bajpai et al. 2012;). Lateritic plateaus and basalt outcrops are a special habitat seen in the northern Western Ghats. They are known for high endemism and dominance of certain function groups such as carnivorous plants (Watve 2013). They are seen at altitude above 900m in the Western Ghats.

During the previous surveys undertaken for documentation of lichen diversity of the region, rocky plateaus of laterite as well as basalt were seen to have abundance of saxicolous lichens. Though the saxicolous lichen species of India have been studied by Indian and foreign lichenologists, they are available in the form of scattered publications and all are dealing mainly with the taxonomy (Awasthi 1965, 1988, 1991, 2000; Schubert & Klement 1966; Patwardhan & Badhe 1972; Degelius 1974).

In view of this, the present paper documents lichens of Mahabaleshwar-Panchgani Ecosensitive Zone (MPESZ) in the northern Western Ghats, and reports the diverse lichen forms and their preferred substrates.

Study area: MPESZ lies roughly between 17^{0}55'N–73^{0}40'E & 17.00^{0}N–73.82^{0}E. The lateritic plateaus, better known as the tablelands, have been studied by many geologists and geographers (Widdowson & Cox 1996; Widdowson 1997; Ollier & Sheth 2008). The area was a famous hill station since the British period and botanically very well known due to the work of Blatter (1909), Razi (1952), Puri & Mahajan (1960), Deshpande et al. (1993, 1995). However, the focus of these studies was on angiosperms. Old records of lichens of the region are available, but needed to be updated. New records of lichens from Mahabaleshwar and Koyna region have been recently published (Bajpai & Upreti 2011; Bajpai et al. 2012). Lichenology group from Agharkar Research Institute has consistently reported many lichens from this region (Dube et al. 2005; Chitale 2007; Chitale et al. 2008; Chitale & Makhija 2008; Chitale et al. 2009; Dube & Makhija 2010; Chitale et al. 2011). However, this is the first ever checklist of the lichens of this region, and describes the prevalent forms with their microhabitat needs.

MPESZ area is dominated by semi-evergreen forests of Memecylon-Syzygium-Actinodaphne series as described by Pascal (1988). Much of the hill slopes are biotically modified and dominated by *Catunaregam spinosa, Scutia myrtina* and *Carissa congesta* thickets. Herbaceous vegetation dominates open areas in the monsoon period (June–September). Five tablelands are located within the Panchgani Municipal Corporation limits, and another fourteen plateaus are reported

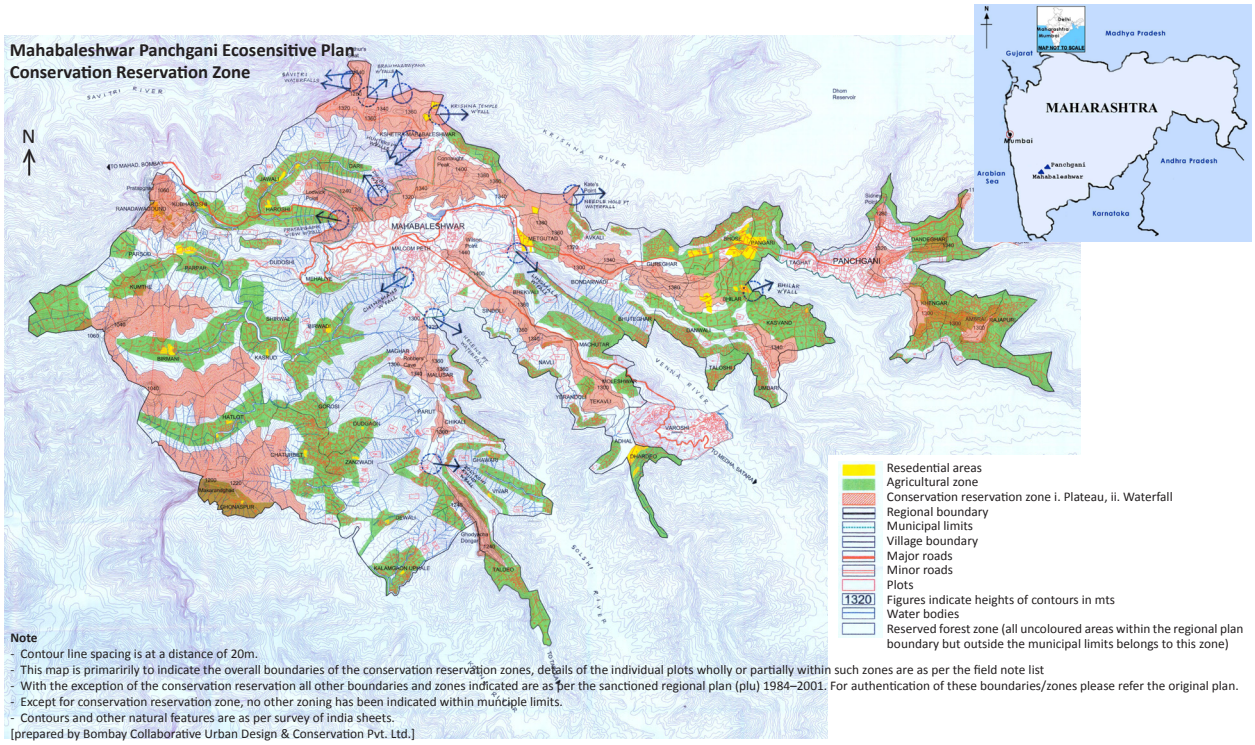

Figure 1. Study area. © The Bombay Environmental Action Group (BEAG)

Image 1. Wilson Point

Image 2. Table Land-Panchgani

from Mahabaleshwar proper. Notable amongst these is the Wilson Point (Image 1) with an altitude of about 1000–1400 m, which is the highest point in the region. All these plateaus are declared conservation zones as per the development plan of the region and tablelands of Panchgani are natural heritage sites (Image 2). Tetali et al. (2000) and Mishra & Singh (2001) have described more than 20 endemic and threatened flowering plants from this region.

Methods: Primary data on MPESZ lichens was collected during 2001–2010 as a part of surveys for Maharashtra lichens and studies on microlichens (Chitale 2007). The floristic surveys covered dry as well as wet seasons, diverse habitats (forests, scrublands and rocky plateaus). Lichen specimens were collected using standard field survey techniques and reference specimens are deposited in Agharkar Research Institute lichen repository (Ajrekar Mycological Herbarium - AMH). Ecological notes regarding substrate, forms, abundance were recorded on field.

All the specimens collected were studied for their morphology, anatomy and chemistry and identified at Agharkar Research Institute (ARI) using the most recent literature available on lichen taxonomy.

Secondary data was collected from previously published literature from the study area (listed above) which was mostly about new records and lichen descriptions. Earlier lichen collections from ARI lichen repository were also scanned to make a complete regional checklist of species reported so far.

Results and Discussion: A list of species of lichens reported from MPESZ is given Table 1. They include, 25 families represented by 43 genera and about 129 species which is 5.6% of the total lichens known from India. Of these, 110 species are exclusively corticolous (bark or twig dwelling), 20 species are saxicolous (rock dwelling), three species are muscicolous and only one species is exclusively terricolous. Lichens can also be categorized as macrolichens, including, foliose lichens (49 spp.); fruticose (3 spp.); squamulose (4 spp.), leprose (3 spp.) and microlichens i.e. crustose lichens (72 spp.).

So far only five lichen species have been recorded from the Panchgani Plateau but the number is likely to increase as currently exploratory, ecological studies have been started as part of DST-Fast-track Scheme. Some species probably form their origin here, e.g., *Diorygma megasporum* Kalb, Staiger & Elix, *Diorygma panchganiense* Makhija, Chitale & B.O. Sharma. (Makhija et al. 2009). Observations also show that excessive trampling and disturbance has eroded lichen flora from the main parts of Panchgani tableland, while the peripheral part of the plateau has a better preserved lichen crust. Therefore, it is necessary to study and then plan protection measures to protect this unique lichen diversity of these unique plateaus.

Schubert & Klement (1966) in their study tour to northern and central India have collected several lichens from these areas of which 16 species are recorded from Maharashtra. Degelius (1974) in his monograph on the lichen genus *Collema* have reported five saxicolous species from Maharashtra (Satara District, near Panchgani). Three species of the genus *Rhizocarpon* have so far been recorded from Maharashtra—*Rhizocarpon concentricum* (Davies) Beltram, *Rhizocarpon distinctum* Th. Fr., *Rhizocarpon obscuratum* (Ach.) Massal. (Singh, 1980)—but the material on which the record of earlier known species are based was not available for study. Chitale Gayatri and Dube Archana during 2001–2007 have taxonomically explored the state of Maharashtra and also the MPESZ area for their doctoral studies and have published new species (Chitale 2007; Dube 2007). Unfortunately *Rhizocarpon* genus was not recollected.

Table 1. List of lichen species recorded in MPESZ with description of growth form and substrate

	Taxa	Family	Growth forms	Substrate
1	*Anisomeridium albisedum* (Nyl.) R. C. Harris	Monoblastiaceae	Crustose	Corticolous
2	*Arthothelium albescens* Patw. & Makhija	Arthoniaceae	Crustose	Corticolous
3	*Arthothelium nigrodiscum* Patw. & Makhija	Arthoniaceae	Crustose	Corticolous
4	*Arthothelium subruanum* Makhija & Patw.	Arthoniaceae	Crustose	Corticolous
5	*Aspicilia calcarea* (L.) Sommerf.	Megasporaceae	Crustose	Saxicolous
6	*Bacidia alutacea* (Kremp.) Zahlbr.	Ramalinaceae	Crustose	Corticolous
7	*Bacidia fusconigrescens* (Kremp.) Zahlbr.	Ramalinaceae	Crustose	Corticolous
8	*Bacidia personata* Malme	Ramalinaceae	Crustose	Corticolous
9	*Bacidia rubella* (Hoffm.) Massal.	Ramalinaceae	Crustose	Corticolous
10	*Buellia panchganiensis* Makhija & Dube (Table Land, Panchgani)	Caliceaceae	Crustose	Saxicolous
11	*Buellia tabularis* Makhija & Dube (Table Land, Panchgani)	Caliceaceae	Crustose	Saxicolous
12	*Caloplaca abuenis* Joshi & Upreti	Teloschistaceae	Crustose	Saxicolous
13	*Caloplaca amarkantakana* Joshi & Upreti	Teloschistaceae	Crustose	Saxicolous
14	*Caloplaca cupulifera* (Vain.) Zahlbr.	Teloschistaceae	Crustose	Saxicolous
15	*Caloplaca flavorubescens* (Huds.) J.R.Laundon (Table Land, Panchgani)	Teloschistaceae	Crustose	Corticolous
16	*Caloplaca pollinii* (A.Massal.) Jatta	Teloschistaceae	Crustose	Corticolous
17	*Cladonia scabriuscula* (Delise) Nyl.	Cladoniaceae	Fruticose	Corticolous
18	*Collema conglomeratum* Hoffm. Var. *crassiusculum* (Malme) Degel.	Collemataceae	Foliose	Corticolous
19	*Collema furfureolum Mull. Arg.*	Collemataceae	Foliose	Saxicolous
20	*Collema leptaleum* Tuck. var. *biliosum* (Mont.) Degel.	Collemataceae	Foliose	Corticolous
21	*Collema polycarpon* Hoffm. var. *polycarpon*	Collemataceae	Foliose	Saxicolous
22	*Collema pulcellum* Ach. var. *subnigrescens* (Mull. Arg.) Degel.	Collemataceae	Foliose	Corticolous
23	*Collema tenax* var. *tenax* (Sw.) Ach.	Collemataceae	Foliose	Saxicolous
24	*Cryptothecia lunulata* (Zahlbr.) Makhija & Patw.	Arthoniaceae	Crustose	Corticolous
25	*Diorygma "microsporum"* ad int.	Graphidaceae	Crustose	Corticolous
26	*Diorygma "patwardhanii"* ad int.	Graphidaceae	Crustose	Corticolous
27	*Diorygma albocinerascens* Makhija, Chitale & B.O. Sharma	Graphidaceae	Crustose	Corticolous
28	*Diorygma albovirescens* Makhija, Chitale & B.O. Sharma	Graphidaceae	Crustose	Corticolous
29	*Diorygma excipuloconvergentum* Makhija, Chitale & B.O. Sharma	Graphidaceae	Crustose	Corticolous
30	*Diorygma junghuhnii* (Mont. & Bosch) Kalb. in Kalb	Graphidaceae	Crustose	Corticolous
31	*Diorygma megaspermum* Makhija, Chitale & B.O. Sharma	Graphidaceae	Crustose	Corticolous
32	*Diorygma megasporum* Kalb, Staiger & Elix	Graphidaceae	Crustose	Corticolous
33	*Diorygma megistosporum* Makhija, Chitale & B.O. Sharma	Graphidaceae	Crustose	Corticolous
34	*Diorygma panchganiense* Makhija, Chitale & B.O. Sharma	Graphidaceae	Crustose	Corticolous
35	*Diploschistes* cf. *rampoddensis* (Nyl.) Zahlbr. (Table Land, Pgani)	Thelotremataceae	Crustose	Saxicolous
36	*Endocarpon subrosettum* A. Singh & Upreti	Verrucariaceae	Crustose	Saxicolous
37	*Fissurina cingalina* (Nyl.) Staiger	Graphidaceae	Crustose	Corticolous
38	*Graphis duplicata* Ach.	Graphidaceae	Crustose	Corticolous
39	*Graphis lineola Ach.*	Graphidaceae	Crustose	Corticolous
40	*Graphis nigroglauca* Leight.	Graphidaceae	Crustose	Corticolous
41	*Graphis parilis* Kremph.	Graphidaceae	Crustose	Corticolous
42	*Graphis platycarpa* Eschw.	Graphidaceae	Crustose	Corticolous
43	*Graphis polystriata* Makhija, A. Dube, Adaw. & Chitale	Graphidaceae	Crustose	Corticolous
44	*Graphis proserpens* Vain.	Graphidaceae	Crustose	Corticolous

	Taxa	Family	Growth forms	Substrate
45	*Graphis* sp. 1	Graphidaceae	Crustose	Corticolous
46	*Graphis subserpentina* (Nyl.) Mull Arg.	Graphidaceae	Crustose	Corticolous
47	*Graphis treblocarpa* (Bel.) Nyl.	Graphidaceae	Crustose	Corticolous
48	*Graphis tsunodae Zahlbr.*	Graphidaceae	Crustose	Corticolous
49	*Hemithecium nakanishianum* (Patw. & C.R. Kulkarni) Makhija & Dube	Graphidaceae	Crustose	Corticolous
50	*Hemithecium norsticticum* Makhija & Dube	Graphidaceae	Crustose	Corticolous
51	*Hemithecium pyrrhochroa* (Mont. & Bosch.) V. Tewari & Upreti	Graphidaceae	Crustose	Corticolous
52	*Heterodermia albicans* (Pers.) Swinscow & Krog L	Physciaceae	Foliose	Corticolous
53	*Heterodermia angustiloba* (Miill. Arg.) Awasthi	Physciaceae	Foliose	Corticolous
54	*Heterodermia boryii* (Fee) K.P. Singh & S.R. Singh	Physciaceae	Foliose	Corticolous
55	*Heterodermia diademata* (Taylor) Awasthi	Physciaceae	Foliose	Corticolous
56	*Heterodermia hypocaesia* (Yesuda D.D. Awasthi	Physciaceae	Foliose	Corticolous
57	*Heterodermia incana* (Stirton) Zahlbr.	Physciaceae	Foliose	Corticolous
58	*Heterodermia japonica* (Sato) Swinscow & Krog	Physciaceae	Foliose	Corticolous
59	*Heterodermia leucomelos* (L.) Poelt	Physciaceae	Foliose	Corticolous
60	*Heterodermia podocarpa* (Bel.) Awasthi	Physciaceae	Foliose	Corticolous
61	*Heterodermia pseudospeciosa* (Kurok.) W. Culb.	Physciaceae	Foliose	Corticolous
62	*Heterodermia* sp.	Physciaceae	Foliose	Corticolous
63	*Heterodermia speciosa* (Wulfen) Trevisan	Physciaceae	Foliose	Corticolous
64	*Hypotrachyna awasthi* Hale & Patw.	Parmeliaceae	Foliose	Corticolous
65	*Lecanora alba* Lumbsch	Lecanoraceae	Crustose	Corticolous
66	*Lecanora allophana* (Ach.) Röhl.	Lecanoraceae	Crustose	Corticolous
67	*Lecanora andina* Rasanen	Lecanoraceae	Crustose	Corticolous
68	*Lecanora austrointumescens* Lumbsch & Elix	Lecanoraceae	Crustose	Corticolous
69	*Lecanora cenisia* Ach.	Lecanoraceae	Crustose	Corticolous
70	*Lecanora cf. imshaugii* Brodo	Lecanoraceae	Crustose	Corticolous
71	*Lecanora chlarotera* Nyl.	Lecanoraceae	Crustose	Corticolous
72	*Lecanora expallens* Ach.	Lecanoraceae	Crustose	Corticolous
73	*Lecanora interjecta* Mull. Arg.	Lecanoraceae	Crustose	Corticolous
74	*Lecanora lavidofusca* Mull. Arg.	Lecanoraceae	Crustose	Corticolous
75	*Lecanora sp*. 1 (Table Land, Pgani)	Lecanoraceae	Crustose	Corticolous
76	*Lepraria coriensis* (Hue) Sipman	Stereocaulaceae	Leprose	Corticolous
77	*Lepraria lobificans* Nyl.	Stereocaulaceae	Leprose	Saxicolous
78	*Lepraria* sp.	Stereocaulaceae	Leprose	Corticolous
79	*Leptogium azureum* (Sw.) Mont.	Collemataceae	Foliose	Corticolous or Saxicolous
80	*Leptogium burnetiae* C.W. Dodge var. *hirsutum* (Sierk) P.M. Jorg.	Collemataceae	Foliose	Corticolous/ Muscicolous/ Saxicolous
81	*Leptogium chloromelum* (Sw.) Nyl.	Collemataceae	Foliose	Corticolous
82	*Leptogium cochleatum* (Dicks.) P.M. Jorg. & P. James	Collemataceae	Foliose	Corticolous
83	*Leptogium cyanescens* (Ach.) Korb.	Collemataceae	Foliose	Corticolous/ Muscicolous
84	*Leptogium denticulatum* Nyl.	Collemataceae	Foliose	Corticolous/ Muscicolous
85	*Leptogium gelatinosum* (With) J.R. Laundon	Collemataceae	Foliose	Corticolous
86	*Leptogium indicum* D.D. Awasthi & Akhtar	Collemataceae	Foliose	Corticolous
87	*Leptogium javanicum* Mont.	Collemataceae	Foliose	Corticolous/ Saxicolous

	Taxa	Family	Growth forms	Substrate
88	*Leptogium phyllocarpum* (Pers.) Mont.	Collemataceae	Foliose	Corticolous
89	*Leptogium propaguliferum* Vain.	Collemataceae	Foliose	Corticolous
90	*Leptogium subazureum* Dube & Makhija	Collemataceae	Foliose	Corticolous
91	*Leptogium ulvaceum* (Pers.) Vain	Collemataceae	Foliose	Terricolous
92	*Lopezaria isidiza* (Makhija & Nagarkar) Aptroot & Sipman	Ramalinaceae	Crustose	Corticolous
93	*Micarea* sp.	Pilocarpaceae	Crustose	Corticolous
94	*Mycomicrothelia hemispherica* (Mull. Arg.) D. Hawksw.	Arthopyreniaceae	Crustose	Corticolous
95	*Myelochroa aurulenta* (Tuck.) Elix & Hale	Parmeliaceae	Foliose	Corticolous
96	*Pallidogramme commutabilis* (Kremp.) Chitale & Makhija	Graphidaceae	Crustose	Corticolous
97	*Parmeliella brisbanensis* (Knight.) P.M. Jorg. & D.J. Galloway	Pannariaceae	Crustose-squamulose to foliose	Corticolous
98	*Parmelinella simplicior* (Hale) Elix & Hale	Parmeliaceae	Foliose	Corticolous
99	*Parmelinella wallichiana* (Tayl.) Elix & Hale	Parmeliaceae	Foliose	Corticolous
100	*Parmotrema sanctiangelii* (Lynge) Hale	Parmeliaceae	Foliose	Corticolous
101	*Parmotrema tinctorum* (Nyl.) Hale	Parmeliaceae	Foliose	Corticolous/ Saxicolous
102	*Pertusaria alutacea* (Kremph.) Zahlbr.	Pertusariaceae	Crustose	Corticolous
103	*Pertusaria cf. depressa (Fee) Mont. Et Bosch*	Pertusariaceae	Crustose	Corticolous
104	*Pertusaria corallina* (L.) Arnold	Pertusariaceae	Crustose	Corticolous
105	*Pertusaria pertusa* (L.) Tuck.	Pertusariaceae	Crustose	Corticolous
106	*Pertusaria quassiae* (Fée) Nyl.	Pertusariaceae	Crustose	Corticolous
107	*Phaeophyscia endococcina* var. *endococcinoides* (Poelt) Essl.	Physciaceae	Foliose	Corticolous
108	*Phaeophyscia hispidula* (Ach.) Moberg	Physciaceae	Foliose	Corticolous
109	*Phaeophyscia pyrrophora* (Poelt) Awasthi & Joshi	Physciaceae	Foliose	Corticolous
110	*Phlyctis karnatakana* S. Joshi & Upreti	Phlyctidaceae	Crustose	Corticolous
111	*Phyllopsora corallina* (Eschw.) Mull. Arg.	Biatoraceae	Squamulose,	Corticolous
112	*Physcia abuensis* D.D. Awasthi & S.R. Singh	Physciaceae	Foliose	Corticolous
113	*Physcia integrata* Nyl.	Physciaceae	Foliose	Corticolous
114	*Physcia tribacoides* Nyl.	Physciaceae	Foliose	Corticolous
115	*Physcia undulata* Moberg	Physciaceae	Foliose	Corticolous
116	*Porina* sp.	Porinaceae	Crustose	Corticolous
117	*Pyrenopsis* sp.	Lichinaceae		
118	*Pyxine cocoes* var. *cocoes* (Swartz) Nyl.	Physciaceae	Foliose	Corticolous
119	*Pyxine cocoes* var. *prominula* (Stirt.) D.D. Awasthi	Physciaceae	Foliose	Corticolous
120	*Pyxine petricola* var. *petricola* Nyl.	Physciaceae	Foliose	Corticolous
121	*Remototrachyna awasthi* (Hale & Patw.) Divakar & Crespo	Parmeliaceae	Foliose	Corticolous
122	*Rimelia reticulata* (Taylor) Hale & A. Fletcher	Parmeliaceae	Foliose	Corticolous
123	*Staurothele clopima* (Wahlenb.) Th. Fr.	Verrucariaceae	Crustose -squamulose	Saxicolous
124	*Staurothele fissa* (Taylor) Zack.	Verrucariaceae	Crustose-squamulose	Saxicolous
125	*Thelotrema monosporum* Nyl.	Thelotremoid -Graphidaceae	Crustose	Corticolous
126	*Trapelia placiodiodes* Coppins & James	Tapelariaceae	Crustose	Saxicolous
127	*Usnea complanata* (Mull. Arg.) Motyka	Parmeliaceae	Fruticose	Corticolous
128	*Usnea ghattensis* G. Awasthi	Parmeliaceae	Fruticose	Corticolous
129	*Verrucaria acrotella* Ach.	Verrucariaceae	Crustose	Saxicolous

Image 3. ***Usnea ghattensis***

But there is a hope of finding it on these outcrops with thorough explorations, as they are saxicolous species (rock dwelling).

Many of these species are likely to be endemic to the special habitats in this region. They are most vulnerable to extinction as they occur in narrow geographical areas and it is extremely important to document the existing vegetation and study the effect of biotic pressures on it.

Natural habitats in MPESZ are gradually degrading due to increasing human pressures. The protection offered by ecosensitive zone category or natural heritage tag or conservation zone declaration has slowed down the habitat depletion caused by land-use change and rapid urbanization. However, increasing pressure for fuelwood, grazing, insensitive tourism are serious threats to natural biodiversity. Lichen flora, is sensitive to even mild disturbance of their habitats and hence needs special protection. The role of lichens as pioneer species in a habitat, as indicator taxa and complex biological symbionts needs to be emphasized. It is urgently necessary that steps are taken to halt the process and thereby conserve the diversity of species characteristic and endemic to these areas. It is hoped that this review of MPESZ lichens attracts attention to this lesser-known but ecologically significant group of organisms and appropriate conservation measures are urgently taken. However, increasing pressure for fuelwood, grazing, insensitive tourism are serious threats to natural biodiversity (Image 3).

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