SYSTEMATIC INVESTIGATIONS AND BIOPROSPECTION OF LICHENS FROM MURLEN NATIONAL PARK, MIZORAM

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I, M.Chinlampianga, hereby declare that the subject matter of the thesis entitled "Systematic investigations and Bioprospection of Lichens from Murlen National Park, Mizoram" is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge, to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/ Institutes.

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Contents

4.1 Systematic investigation

1. *Amandinea placodiomorpha* (Vainio) Marbach [Plate: 1/A]
2. *Anthracothecium macrosporum* (Hepp.) Müll. Arg [Plate: 1/B]
3. *Arthothellium albescens* Patwa & Malch [Plate: 1/C]
4. *Arthothelium verruculosum* Patwa & Malch [Plate: 1/D]
5. *Bacidia fusconigrescens* (Nyl.) Zalhbr. [Plate: 2/A]
6. *Bacidia inundata* (Fr.) Korb. [Plate: 2/B]
7. *Bacidia laurocerasi* (Delise ex Duby) Zahlbr. [Plate: 2/C]
8. *Bacidia medialis* (Tuck. in Nyl.) Zahlbr. [Plate: 2/D]
9. *Buellia aeruginascens* (Nyl.) Zalhbr. [Plate: 3/A]
10. *Caloplaca amarkantakana* Y.Joshi & Upreti [Plate: 3/B]
11. *Caloplaca cerinelloides* (Erichs.) Poelt [Plate: 3/C]
12. *Chaenotheca chrysocephala* (Turner ex. Ach.) Th. [Plate: 3/D]
13. *Chapsa alborosella* (Nyl.) A. Frisch [Plate: 4/A]
14. *Chiodecton leptosporum* Müll. Arg. [Plate: 4/B]
15. *Cladonia coniocraea* Flörke) Spreng [Plate: 4/C]
16. *Cladonia fruticulosa* Kremp. [Plate: 4/D]
17. *Coccocarpia palmicola* (Spreng.) Arvid. & D.J. Gallo. [Plate: 5/A]
18. *Collema subconveniens* Nyl., [Plate: 5/B]
19. *Cryptothecia lumulata* (Zahlbr.) Makhija & Patw. [Plate: 5/C]
20. *Cryptothecia verruculifera* Jagadeesh, G. P. Sinha & Kr. P. Singh [Plate: 5/D]
21. *Diorygma heiroglyphicum* (Pers.) Staiger & Kalb [Plate: 6/A]
22. *Diorygma junghuhnii* (Mont. & Bosch) Kalb, Staiger & Elix, [Plate: 6/B]
23. *Diorygma reniforme* (Fée) Kalb., Staiger & Elix [Plate: 6/C]
24. *Dirinaria aegialita* (Afz. in Ach.) Moore [Plate: 6/D]
25. *Dirinaria confluens* (Fr.) D.D. Awasthi [Plate: 7/A]
26. *Dirinaria papillulifera* (Nyl.) D.D. Awasthi [Plate: 7/B]
27. *Everniastrum cirrhatum* (Fr.) Hale ex Sipman [Plate: 7/C]
28. *Everniastrum nepalense* (Taylor) Hale [Plate: 7/D]
29. *Fissurina dumastii* (Fée) Sprengel [Plate: 8/A]
30. *Gassicurtia acidobaeomyceta* Marbach [Plate: 8/B]
31. *Glyphis cicatricose* Ach. [Plate: 8/C]
32. *Graphis arecae* Vain. [Plate: 8/D]
33. *Graphis assimilis* Nyl. [Plate: 9/A]
34. *Graphis duplicata* Ach., [Plate: 9/B]
35. *Graphis gramulosa* (Müll. Arg.) Lucking [Plate: 9/C]
36. *Graphis insulana* (Muell. Arg.) [Plate: 9/D]
37. *Graphis lineola* Ach. [Plate: 10/A]
38. *Graphis proserpens* Vain. [Plate: 10/B]
39. *Haematomma puniceum* (Sw. ex Ach.) Massal., [Plate: 10/C]
40. *Haematomma watii* (Stirt.) Zahlbr. [Plate: 10/D]

List of Figures

Fig. 3.13 (a-c): Map of protected area of Mizoram, (b) Lichen collection sites in the study area and (c) forest vegetation type of Murlen National Park

Fig. 3.14: Unscaled map showing different sites sampling for lichen collection in the Study area, Murlen National Park

Fig. 3.15(A-F): Different types of fruticose thalli:

(A) *Rocella montagnei* with marginal soralia
(B) *Bryoria himalayana*
(C) *Evevnia mesomorpha*
(D) *Ramalina sp.*
(E) *Usnea* sp.
(F) *Usnea longissima*

Fig. 3.16(a-e) : Different morphological character of podecia in *Cladonia*

(a). Podecial cup opens and asciopen
(b) Podecial cup without corticated plane with cavity white squamulose
(c) Podecial cups with apothecia and corticated plane
(d) Marginally prolirelate podecial cups
(e) Podecia with centre proleratum

Fig.3.17 (a-g) : Different morphological character of podecia in *Cladonia*

(a) Decorticated podecia with basal squamules (b) Sparingly branched podecia,
(c) Sorediate podecia with macrosquamules (d) Farinose sorediate
(e) Podecia corticated base (f) soredia with microsquamules
(g) Longitudinal fissures and open end of podecia

Fig. 3.18 (A-K): Morphological characters for the segregation of Parmeloid taxa

(A) Punctate pseudocyphellae
(B) Effigurate pseudocyphellae
(C) Reticulate maculate
(D) Effigurate maculate and robust cilia
(E) Simple cilia evenly distributed
(F) Bulbate cilia
(G) Tuttled cilia
(H) Rhizines
    (i) Simple hyphal
    (ii) Hyphal rhizines in bundles
    (iii) Simple
    (iv) Squamously branched
    (v) Dichotomously branched
(I) Labiom sorelia
(J) Terminal Sorelia
(K) Isidia
    (i) Simple
    (ii) branched

(iii) Coralloid
(iv) Globose

Fig. 3.19 (A&B): Anatomy of Thallus

A. (i) C.S. of thallus showing cortex isidia

(ii) V.S of thallus of foliose

B. (i) Ascocarp cover and ostiole types in pyrenocarpous lichen(completely covered)

(ii) Ascocarp hat covered
(iii) Ascocarp naked
(iv) Ostiole papilate
(v) Ascocarp ulbicate
(vi) Ostiole depressed

Fig- 3.20 (A&B): A. Different anatomical charaters of lirellae of graphidaceous taxa

(i) Exciple open, labia convergent, entire
(ii) Exciple open, labia convergent, sulcate
(iii) Exciple open, labia divergent, entire
(iv) Exciple closed labia convergent entire

B (a-h): Different types of anatomical character of isidium in lichens

Fig- 3.21(A-K): Different types of spore of lichens

(A) Rinodina
(B) Anthracothecium
(C) Archopyrenia
(D) Pyrenula
(E) Graphis
(F) Bacidia
(G) Diplochistes
(H) Pertusaria (1-2 spored)
(I) Pertusaria (4-8 spored)
(J) Lecanora
(K) Caloplaca

Fig- 3.22: Schematic diagram of biosynthetic pathway for major groups of lichens natural products

Fig- 3.23 (A&B): A. Lichen chemical substance present in *Diorygma sp* through TLC, and

B. substances present in *Sarcographa* species of lichen detected through TLC

Fig- 3.24 (A & B): Constituents of secondary metabolites in Graphidaceous members of lichens detected in TLC

Fig- 3.25: Flowchart for method of extraction of metabolites from whole lichen thallus Mizoram

List Tables

Abbreviations

AD	=	Anno Domini (in the Christian era)
Aq.	=	Aqueous
BC	=	Before Christ
(bac.)	=	use in bacteria
(bot.)	=	use in botany
+	=	present; positive reaction
-	=	absent; negative reaction
±	=	in *lichen chemistry*, plus or minus or present or absent more or less or with or without or in *species description*
?	=	used as an indication of doubt as to the position of a name when originally published
µm	=	micrometer (mille micron)
µl	=	microliter
alt.	=	altitude
cf., cfr.	=	*confer*; compare (with)
cm	=	centimeter
comb. nov.	=	*combination nova*; new combination
conc. HCl	=	concentrated hydrochloric acid
C	=	aqueous solution of calcium hypochlorite
diam.	=	diameter
dist.	=	district
dup	=	duplicate
E	=	East
e.g.	=	*exempli gratia*; for example
ed./eds.	=	editor/editors
edn.	=	edition
Equals sign [=]	=	taxonomic synonym
et al.	=	*et alii / et aliorum*; and of others

Exclamation mark (!)	=	specimen seen by the author.
f.	=	*forma* (form)
ff.	=	after a page number reference, and following pages (e.g. p. 240ff.)
fig., figura/figs.	=	figure/figures
fil., filius	=	son
ft.	=	feet
Hyphen [-]	=	used to link together two words/numerals
HPLC	=	High Performance Liquid Chromatography
i.e.	=	*id est* (that is)
ib., ibid., ibidem	=	(obsol.) the same, in the same place
I	=	iodine
I.C.B.N.	=	International Code of Botanical Nomenclature
K	=	aqueous solution of Potassium hydroxide
Km	=	Kilometer
l.c., loc. cit.	=	*loco citato* (in the place cited; used to avoid the repetition of a bibliographic reference already given)
LCB	=	Lactophenol Cotton Blue
LWG	=	Lucknow Botanic Garden (National Herbarium Repository)
m	=	meter
MEC	=	Minimum Effective Concentration
MNP	=	Murlen National Park
mm	=	millimeter.
MSGIT	=	Modified Spore Germination Inhibition Technique
Mt./Mts.	=	mount/mounts.
MTCC	=	Microbial Type Culture Collection
Mtn./Mtns.	=	mountain/mountains
N	=	North
nm	=	nanometer

nom. provis.	=	*nomen provisiorum*; provisional name
p./pp.	=	prescribed pages/page
p.p.	=	*pro parte*
Pd	=	aqueous solution of *para*-Phenylenediamine
PDA	=	Potato Dextrose Agar
pl.	=	plate
pl./pls.	=	plate/plates
q.v.	=	*quod vide* (which see)
Rf	=	Retention factor
s.d.	=	*sine description*; without description
s.da.	=	(unoff.) *sine dies*; without date
s.lat.	=	*sensu lato*: in the wide sense
S	=	South
s.s., s. str.	=	*sensu stricto*; in the strict sense
sp. (pl. spp.)	=	species
sp. aff.	=	*species affinis*; species related to
sp. nov.	=	*species nova*; a new species
sp./spp.	=	species (singular/plural)
ssp.	=	subspecies
t., tab.	=	*tabula*; table
T	=	Type, typus (collection)
TEM	=	Transmission Electron Microscopy
TLC	=	Thin Layer Chromatography
UV	=	Ultra Violet
var.	=	*varieties*; variety
viz	=	*videlicet*; namely
W	=	West
WWF	=	World Wildlife Fund

Chapter 1

INTRODUCTION

Chapter : **1**

1. INTRODUCTION

1.1 Definition and classification of lichens

The word Lichens (pronounced as "Lie kens") is a Greek origin, and was first used by Theophrastus (370-285 BC) - the father of Botany, to denote the superficial growth on the bark of olive trees. Tournefort (1700 AD) proposed lichen as one of the genera of plant entities. The dual nature of lichen was first propounded in 1867 by Simon Schwendener, a Swiss Botanist, till lichen was thought to be simple organism between algae and fungi. However, the advent of microscopes in the beginning of 18th century enabled detailed anatomical studies of lichens, which revealed their special dual character consisting of algal and fungal partners. This led to a series of more refined definitions. A number of definitions of lichens are provided in contem-porary literature (Hawksworth and Hill 1984, Gilbert 2004, Lawrence 2005). Scholler (1997) described how in the 18th century lichens on the bark of trees and rocks were recognised as physically joined algae and filaments of fungi. Indeed, this dual character of lichens was recorded as comprising algae and fungi living in a symbiotic relationship. This symbiotic description provided a more specific explanation of the living

arrangement between both partners. Lichens play a significant role in structure and function of ecosystem. More precisely, lichen is described as an ecologically obligate, stable mutualism between an exhabitant fungal partner and an inhabitant population of extracellularly located unicellular or filamentous algal or cyanobacterial cells (Kirk *et al.* (2001). The study of lichens still remain neglected in the world, although they are colonized together with mosses form dominant organism in ecosystem covering over 10% of the earth terrestrial habits, particularly at high elevations (Nash and Egan, 1988).

Lichens do not have independent scientific names; the fungal and photosynthetic partners each have separate names, and names given to lichens are considered as referring to the fungal partner alone. The classification of lichens is therefore integrated into the system of Fungi. Current nomenclature is consistent with the recognition of lichens as a nutritional rather than a taxonomic group. The nomenclature of fungi including lichen–forming fungi is governed by the international code of botanical nomenclature (Kirk *et al.* (eds.) 2001).

1. 2 Dual nature and symbiotic association

Lichens are the most remarkable composite symbiotic organisms made up from members of as many as three kingdoms (Hale, 1983). They are able to do so successfully by mutually benefiting between the two quite different organisms; a photosynthetic green alga (Kingdom: Protista) or a less often a cyanobacteria (Kingdom: Monera) and a fungus (Kingdom: Fungi). Lichen is a combination of two organisms, an alga and a fungus, living together in symbiotic association. The algal component in the lichen is called phycobiont or photobiont while fungus as mycobiont. The phycobiont and the mycobiont loose their original identity during the association and the resulting entity (Lichen) behave as a single organism, both morphologically and physiologically. Hence the lichen is called as a composite organism. In lichen thallus (body) the mycobiont predominates with 90% of the thallus volume and provides shape, structure and colour to the lichen with partial contribution from the algae. Whatever is visible from outside in a lichen thallus is the fungal part, which holds algal cell within. Hence the lichens are placed within kingdom Mycota (Fungi). The fungi present in lichen are called as lichenized fungi. Among the 20,000 lichen species known in the world 95% belongs to the ascomycetes group of fungi while basidiomycetes and deuteromycetes groups are represented by only 3% and 2% of species respectively.

Lichens are completely different from the mosses and liverworts with which they often grow. The upper surface of many lichens bears special structures which appear as miniature pots, or volcanoes with a minute pore at the tip. Some are brightly coloured, others more muted, and many are black. All these structures are known as 'fruit bodies' as they forcibly discharge tiny spores, which become airborne. Spores need to meet the right algal partner before they can form a new lichen therefore this type of reproduction is unreliable. Many lichens increase their chance of successful reproduction by producing special parts that become detached and grow into a new plant (propagules) containing both alga and fungus. The most common are powdery structures (soralia) that develop as pustules on the upper surface. These release small clumps of algal cells (soredia) held together by a web of fungal threads (hyphae). The other structures for vegetative reproduction, also unique to lichens, are isidia and they contain both alga and fungus (Gilbert 2004).

1.3 Habit (growth forms) and habitat

Lichens grow on any substratum that provides a convenient anchorage to hold to them. This may be on soil (terricolous), humus (humicolous), stones, rocks, brick (saxicolous), lime plaster (Calcicolous), leaves (foliicolous),on bark or tree trunk (corticolous), on twigs (ramicolous), on decaying or dead wood (lignicolous), on moss (muscicolous) and other man made substratum like iron pipes, asbestos sheet, lime or cement plaster and glass panes. Sometimes lichens also grow on some insects and animals. Lichens which are bigger in size and shape can be easily recognized as leaf like (foliose) and thread like (fruticose) commonly called macrolichens, while taxa which forms a crust over the substratum and are quite smaller in size are categorized under microlichens. Based on the type of substrate, the corticolous (bark inhabiting) lichens exhibit their dominance followed by saxicolous (rock inhabiting) and terricolous (soil inhabiting) species in the country. Among the different altitudinal zones the temperate regions exhibit the luxuriant growth of lichens followed by alpine and tropical regions.

1.4 Richness of lichen in different vegetation zone

Apart from altitudinal variation the vegetation and forest types of higher plants also play important role in determining the type of lichen flora of the region. Based on the forest type six different lichen vegetation zones of the country are : Moist tropical evergreenforest, cold deserts in the Himalayas, South Peninsular region, Mid Eastern Indian and Peninsular Plateau, Dry and arid

regions and Indo-gangetic plains of central India, Coastal regions of India and Andaman and Nicobar Island. The cold deserts in the Himalayas exhibit some unique group of plants including lichens having restricted distribution only in such habitats. The Himalayan region in India is exhaustively explored for lichen wealth in the past and the lichen flora of different Himalayan states is well worked out. Since most of the substrate exhibit dense growth of different species of lichens growing in close association, forming mixed patches, sometimes over looked by the collectors during collection.

Eastern Himalaya, one of the main centres of speciation is also a 'Hot Spot' of biodiversity. This rich diversity with many endemic species (102) is in fact a poor record of lichens diversity in India, as many more areas, especially mountains and the forest canopies are yet to be explored [Negi & Gadgil (1996); Negi (1999a); Negi and Upreti (2000)].

In Indian context, the knowledge accumulated so far shows that the 3 regions namely, Eastern Himalaya, Western Ghats and Western Himalaya have rich and luxuriant lichen flora. The main reason of remarkable diversity of life forms in a single country (may be known as one continent) is the great diversity of ecosystems, which it has supported down the ages. Almost every major type of habitat is to be found here from areas of the coldest to the hottest climatic conditions, from the highest elevation down to the sea level. The Himalayan belt constitutes a complex mountain range, which extended about 2400 km from east to west. Each range revealed innumerable vast diverse topographical situation suitable for the luxuriant growth of a number of higher plants and lower plants including lichens. The flowering plants are well worked out while knowledge of non-flowering plants such as lichens is meager. There has been awakening of interest in Indian lichens in preceding years. To facilitate future research in the field of pharmacology, ecology, ecophysiology, pollution and bio-monitoring studies, conservation, etc. systematic of lichen taxonomy is identified as one of the important areas to work out.

Approximately 20,000 species of lichens are known from the world and India represents more than 10% of the species. Singh and Sinha, (2010) reported that the Indian lichens flora comprises about 2303 species under 305 genera and 74 families widely distributes in tropical, subtropical, temperature and alpine regions of India. They reported that the lichen family Parmeliacease is the largest family in India comprised of 345 species followed by Graphidiaceae, Thelotremataceae,

Pyrenulaceae, Caliciaceae and Lecanoraceae represented with 279, 131, 123, 103 and 99 species respectively. The largest lichen genera in India is crustose lichen genus *Graphis* which contains 111 species followed by genera such as *Pyrenula*, *Lecanora*, *Caloplaca*, represented by 90, 83 and 65 while *Usnea* and *Porina* are represented by 60 species (Singh and Sinha, 2010).

In temperate regions of India the corticolous lichen dominates over saxicolous and terricolous lichens. The ground flora under coniferous forest at lower temperate areas remains mostly dry thus favour scanty to poor growth of soil lichens. The evergreen temperate forest and coniferous forest of upper temperate regions provide a moist shady environment suitable for species of *Lobaria*, *Peltigera*, *Stereocaulon* and *Cladonia* to colonize on soil among mosses. The common crustose soil lichen genera of the region are *Caloplaca*, *Diploschistes*, *Diplotomma* and *Pertusaria*. Most of the alpine region in the Himalayas exhibit dominant growth of the terricolous communities of lichens. Fruticose species of lichen genera such as *Cladonia rangiferina* and *Cladonia* aggregate grow luxuriantly in moist slope in alpine regions. The cold desert in the Himalayas also exhibit good growth of terricolous lichens

The lichens growing on other plants are called epiphytic. Lichens can also grow on under water rocks, but not freely in water or on ice. They are widely distributed in almost all the phytogeographical regions of the world. The growth forms of lichens are usually conspicuous on the substrate, forming grey, green, brown and orange patches. Requisite moisture, light and altitude, unpolluted air and undisturbed perennial substratum often favour growth and abundance of lichens. Apart from altitudinal variation the vegetation and forests types of higher plants also play important role in determining the type of lichen flora of the region. Based on the altitudinal variations lichen flora of India can be summarized as below:

1. Moist tropical evergreen forests lichens: This region includes north-eastern Indian region, part of Assam and West Bengal. The species of *Leptogium, Collema* (Cyanolichens) together with member of lichen family Physciaceae (*Heterodermia, Dirinaria* and *Phaeophyscia*) and *Parmeliaceae* prefer such habitats.
2. South Peninsular region: The 'Shola' forests growing in patches in the south Peninsular region provide a favourable habitat for good growth of both micro and macrolichen genera as all the trees equally and sufficiently exposed to rain, sunlight and wind currents.

3. Mid Eastern Indian and Peninsular Plateau: The broad leaf deciduous forests trees in the mid eastern Indian and Peninsular Plateau exhibit moderate number of crustose and squamulose lichens together with few foliose forms. Hard, dry bark pealing out nature of trees is common inhibitory factors responsible for poor diversity of lichens in the area.

1.5 Economic uses of Lichens

Since ancient times lichens have a household item in India (Kumar and Upreti, 2001). Lichen produce a diverse range of chemical products and several species of lichens enjoyed a good position in ancient and traditional system of medicine like Ayurveda and Unani. Still a number of species of lichens are used by the different ethnic groups all over the world. The lichens are utilized for different purposes depending on their nutritive, medicinal, decorative, brewing, distilling, dyeing, cosmetics and perfumery properties. Recently, lichen has attracted attention because they contain compounds that can be used as medicinal agents or as neutraceuticals in functional foods. *U. esculenta* has been used in traditional preventatives and remedies for bloody vomit and diarrhea, skin disease, epilepsy, and yellow jaundice (Jang *et. al.,* 2003). A part from diversity, the economic use of lichens is well known in the world as well as India from several decades. The lichens also have been well known as valuable plant resources and are still used as medicine, food, fodder, perfume, species, dye and environmental monitoring studies. The economic importance of lichens is discussed below:

1.5.1 Lichen as food

The species of lichen genus *Umbilicaria* in Japan are eaten as salad called "Iwatake". They are rich in carbohydrates and fats. Species of *Cladonia, Stereocaulon,* Usnea and Ramalina are eaten mixed with flour, as they are considered as good source of carbohydrates. Many lichen *(Lecanora esculerata)* found in various parts of the world covering the soil, is gathered by the Tartars and earth-bread is prepared from it. *Centraria islandica,* commonly known as "Iceland Moss" is used as human food. After collection and removal of certain bitter principals by allowing them to diffuse into cold water, the thallus is dried. The decoction of this dried thallus which forms a demulcent drink with milk is believed to be highly nutritious.

Parmelia abessinica available in large quentities in the market of south Deccan Plateau, particularly in Bellary, is used as food material and as condiment. In Sikkim, *Parmelia cirrhata* a

very commonly growing lichen of that area is eaten as a vegetable after boiling and frying it in fat. *Leptogium denticulatum,* common foliose lichen used by 'Adi' tribe of Arunachal Pradesh.
The local 'Adi' people collect the lichen from soil, rock and tree trunk, wash it properly and boil with water.The soup and boiled thallus which becomes jelly like after boiling is used as vegetable.

1.5.2 Lichen as spices

In Indian bazaar, lichens are sold by the name of "Chharilia: which consist of a mixture of two or three species of *Parmelia*, *Usnea longissima* Ach, *Ramalina subcomplanata* Nyl, and *Herterodermia tremulans* (Mull. Arg.) W. Culb. were used as spices. These lichens provide a special fragrance to meat, pulse and other important vegetables.In view of the high protein content and the interesting amino acids composition together with ergosterol and inorganic constituents of iron and calcium, *Dermatocarpon moulinsii* (20% crude protein), *Lobaria isidiosa* (20% crude protein), *Rocella montagneii* (14% crude protein) and *Parmelia tinctorum* (14%crude protein) appear to have good food value.

1.5.3 Lichens as fodder

Lichens are important food for animals in the arctic regions. During winter the reindeer and caribou supplement their normal diet of sedges andwillow twigs with lichens, most common species of *Usnea* and *Cetraria*. Sheep in the Libyan deserts are reported to graze on the subfoliose lichens *Lecanora esculenta*. This forms a thick loose crust on soil and rocks and usually eaten by the sheeps.

In alpine meadows, the commonly growing species of lichens are common source of food for the land snails and termites. Lichens provide a protective environment for a number of invertebrates. Lichenophagous insects, such as bark lice, springtails and moth caterpillars, possess mandibulate mouth parts, with which they bite of the lichen and chew it. *Ramalina*, *Parmelia* and *Usnea* on twings of bushes are favored by the musk deer during scarcity. In south India, Rocella montagnei Bel, luxuriantly grows on plants and is used as a common fodder for animals. Several new lichens species and varieties especially of *Rhizocarpon*, have been described, which are actually no more than well known species damaged by snails and mites.

1.5.4 Lichens use in Medicines

Lichens were held in high regard by medicinal practitioners in medieval times and their use has persisted to this day. In various pharmacopoeias, lichens are listed purely on the basis of their folklore medicinal use. Several species of lichens enjoyed as good position in ancient and traditional systems of Indian medicine like Ayurveda and Unani.

Lichens are valuable plant resources and are used as medicines, food, fodder, dyes perfumes, spices, ornamental uses, and for various other purposes. More than one thousand primary and secondary metabolites with identified structures are currently known in lichens (Molnár and Farkas, 2010). The use of lichens in medicine is based on the fact that they contain unique and varied biologically active substances, mainly with antimicrobial actions. These substances are used in lichen chemotaxonomy (i.e., their classification in terms of chemical features), and they are known to possess potential sources of natural antibiotics. Lichen metabolites exert a wide variety of biological actions including antibiotic, antimycotic, antiviral, anti-inflammatory, analgesic, antipyretic, antiproliferative, and cytotoxic effects [Huneck, (1999); Manojlovic, *et al*., (2002); Manojlovic, *et al*., (2010); Shukla, *et al*., (2010)]. Lichens have been found to contain a variety of secondary lichen substances with strong antioxidant activity. Even though these manifold activities of lichen metabolites have now been recognized, their therapeutic potential has not yet been fully explored and thus remains pharmaceutically unexploited. Ranković, *et al.,* (2008) reported the antimicrobial properties of acetone, methanol, and aqueous extracts of the lichens *Lasallia pustulata*, *Parmelia sulcata*, *Umbilicaria crustulosa*, and *Umbilicaria cylindrica*. In Indian context, out of the present 2000 lichen species so far known, hardly less than 1% of the species are screened out for their biological activity. More than 50% lichen species known from the world exhibit presence of peculiar antibiotic substances. In India species of *Parmelia* are extensively used in traditional medicinal systems are being extensively used in traditional medicinal systems and are being extensively collected (Kumar and Upreti, 2001).

More than 50% lichen species known from the world exhibit presence of peculiar antibiotic substances. It is estimated that over 13,500 fungal species may take part in lichen symbiosis, many of which are obligate and they are prolific producers of secondary metabolites, with over 350

characterized (Hawksworth, 1988).Until now several hundred secondary metabolites, including depsides, depsidones, naphthoquinones, anthraquinones, pulvinates, chromones, and dibenzofurans, have been detected in lichens (Hale, 1983). Slow growth, and often harsh living conditions, makes production of protective metabolites a necessity to lichens and many secondary constituents are believed to serve as antigrowth, antimicrobial or antiherbivore agents (Hale, 1983; Rankovic *et. al.,* 2008). Secondary lichen metabolites show a wide range of potentially useful biological activities (Shahi *et. al.,* 2001). Most lichen substances with antibiotic activity are phenolic metabolites (e.g. usnic acid and the anthraquinone endocrocin) (Hale 1983).

Lichens produce some characteristic anthraquinone derivatives, which have yet to be found in higher plants (Sochting, 1997; Sochting, 2001). Anthraquinones and xanthones are also important constituents of plants, microorganisms and insects. They are ingredients of many medicines of plant origin since they possess a broad spectrum of biological activities, including anti-bacterial, anti-inflammatory, anti-tumorous, purgative, astringent, anti-viral, antioxidant and antifungal (Manojlovic *et. al.,* 2002).

1.6 Scope of the present work

India is unique in its biota and one of the most diverse in the world ranging from the cold arctic zone of the Himalayas to the tropical areas of the Southern Western Ghats. The great diversity inthis region may be due to the vast geographical area extending over many degrees of latitude, varied topography, climatic zones and position of the country at the junction of many biogeographical regions and subregions. There are about 2000 species of lichens so far reported from the temperate and subtemperate regions of Himalayas, regions of Western Ghats and Eastern Himalaya. Among these, Western Ghats hold about 800 species of lichen including both micro and macro forms. Only a fragmentary work has been done from east part of Himalayan region including Mizoram. A detailed inventory of the lichens and their special habitats is inevitable for understanding the lichen flora of the area and their diversity.

The vast topographical and climatic diversity of India has endowed it with a rich lichen flora, both in luxuriance and species diversity. In spite of constant endeavour in exploration and survey during the last five decades the knowledge about lichens remains incomplete. Vast areas of the country are still unexplored lichenologically (Awasthi, 1983). Even many floristically rich areas like

North-Eastern India, considered to be the "Botanical Eden" and remains *terra-incognito* from the lichenological point of view (Karjilal *et al.*,1934-40; Rao, 1974; Balakrishnan, 1981; Balakrishnan, 1983; Haridarsan & Rao,1985-1987; Kataki, 1986; Rao and Hazra,1986; Jamir and Rao,1988). It is therefore, essential to investigate the unexplored and under-explored areas to know the diversity and to develop suitable conservation measures.

Further, literature reveals that in North Eastern Parts, especially in Mizoram; no such research work has been undertaken on lichens so far. The expected findings of the present research work will not only be helpful to know the lichen's morphology, pattern of diversity, distribution and their bio-chemical profiling as well as their proper documentation and conservations, before they last forever. This would also be baseline information for the future studies, and encourage the researcher and policy makers.

1.7 Aims & Objectives

The present research work was concentrated on Murlen National Park, Champhai district, Mizoram, India; with the following objectives:

1. To collect and categorize important lichens from 'Murlen National Park'

2. To study the morphological and bio-chemical characteristics of the collected Lichen species for identification, and their proper documentation in National Repository / CSIR-NBRI, Lucknow

3. To investigate the bioactivity test of selected lichens against common pathogenic Microorganisms

Chapter

2

REVIEW OF LITERATURE

Chapter: 2

2. REVIEW OF LITERATURE

2.1 World scenario

The foremost account of lichen taxa under the genus comprising 80 species was published under the 24th class of cryptogamie algae in species Plantarum by Linnaeus (1753). Acharius, a Sweddidh Botanist, referred to as father of Lichenology, coined several terms for the structures peculiar to lichen and describe many new genera and numerous new species from the basis of external morphology in his monumental works *Methodica Lichenium, lichenographia Universalis* and synopsis *methodica lichenium* (Archarius, 1803, Archarius, 1810 and Archarius, 1814).

Different aspects of lichens are well worked out in the European countries. A number of floristic accounts of lichens from various regions of the world are available. Well documented floristic accounts of lichen of most of the European, American and Australian regions were also available (Purvis *et. al.,* 1992; Brodo *et. al.,* 2001). Most of the studies carried out with the intention to identify the lichenological rich sites for its conservation (Peterson and Cune, 2003; Cune *et. al.,* 2000), while few studies aimed at conservation of selected rare, endangered and useful in the

assessment of the distribution and ecology of common epiphytic lichens (Bruteig, 1993), composition of lichens in different types of vegetation and their substrate preference of lichen communities was reported by Halonen (1991).

The floristic composition of epiphytic lichen communities is determined by substratum qualities such as age (of the part of the tree where the lichen is growing), bark texture and bark chemistry, and by habitat condition such as age and history of the woodland, forest productivity, aspect and climate (Barkman, 1958; Brodo.1974; Rose, 1974; Gustaffson *et al.,* 1992; Selva 1994; Holien, 1998). Epiphytic lichen vegetation has been studied mist extensively because of its links with biomonitoring studies.

After the important studies by Ochsner (1928), Hilitzer (1925) and Almborn (1948, 1955), the fundamental monograph of Barkman (1958) constituted an important reference point, not only for syntaxonomy, but also for further ecological and phytologeographical studies. The monographs of Wirth (1972) and Roux (1981) are two fundamental contributions, concerning silicicolous and calcicolous lichen vegetation respectively. For epigaeic lichen vegetation there are a number of European studies (Roger, 1972; Ritschel, 1974; Crespo and Barreno, 1978). Further, Ahti and Oksanen (1990) presented a comprehensive monograph covering a wider area of arctic and boreal zone.

In the last two decades, after extensive studies on the lichen floras in the different regions of the world, the lichen communities have increased by many folds. Some of the remarkable studies are: Seaward (1988) defined lichens as an ecosystem and its interaction with other organisms; Cune (1990) compared species abundance of lichen to its individual species biomass; Nimis (1991) analyzed developments and problems dealing with lichen community studies; Armstrong (1991) studied distribution of lichens across direction gradient; Mikhalova and Vorobeichik (1999) studied dimensional and age structure of population of epiphytic lichen species under condition of atmospheric pollution; Cune (2000) used lichen communities as indicator of forest health; however, Wolf *et al.* (2002) reviewed methods for monitoring the biodiversity (community composition and species diversity) of forest lichen.

Lucking (2003) compared Takhtajan's floristic region of the word based on vascular plant distribution to foliicolous lichen biogeography; Neitlich *et al.* (2003) used lichen as to assess resource contamination, biodiversity and sustainability in the context of forest health. Peterson and Mc Cune

(2003) described the varying lichen community of different hotspot types and how the hotspots communities differ from more typical young and old forest stands. The composition of the epiphytic community differs predictably according to height and aspects on the trunk have also been studied by Hale (1952); John (1992); Rose (1974). Eversman (1982) performed studies on epiphytic lichens of a Ponderosa pine forest on Southeastern Montana in four vegetation type reported that the majority of lichen cover and diversity on the tree trunks was on the lowest 50cm, diversity and covers increases with ascending moisture levels.

A number of workers have described distributional and successional pattern of lichens on tree bark of some temperate deciduous and other in boreal coniferous species were studied by Degelius (1964), Degelius (1978); Kershaw (1964); Harris (1971); Stone (1989). Somermea, 1972, Yarranton, 1972; Gough, 1975. Eversman *et al.* 1987; Hyvarinen *et al.*, (1992). Hale (1983) classified corticolous lichen communities in different federation in England. Various species of Graphis, *Pertusaria*, *Lecanora* and *Pyrenula* are often abundant ad confined to this federation called Graphidion. This is a federation of shade loving lichen found on smooth bark trees in the more temperate parts of Britain and Europe. Hale (1983) suggested that these are the lichen communities of temperate forests and are hardly representative of the great range of habitats available to the lichens on the world level. *Pannarian* with other genera are exclusively to *Lobarian* federation and is sensitive to pollution. The characteristics habitat for this federation is moss covered tree trunks in sheltered woods. *Arthopyrenia*, *Lecanora* and *Opegrapha* are classified as Olivaceion federation, are the communities on smooth bark and is favoured by well lighted habitats and eventually replaced by Graphidion in shady situation. The ecological community of *Lobaria*, *Pulmonaria* and *Parmelia caperata* in *Quercus* dominated forests in south west Norway was studied by Gauslaa (1985).

Coote *et al.,* (2008) studies effects of open space on the vertical distribution of lichens and bryophytes on the trunk and branches of nature Silka Spruce (*Picea sitchensis*) in Island. Thomas *et al.,* (2008) suggested that the surface of dry land soil is frequently characterized by an ecological crust comprising of various combination of cyanobacteria, algae, moss and lichen.

Some other aspects of lichen researches includes study of symbiosis and symbiotic patterns Lane *et al,* (1999); Lange, (2000), Lange, (2002), Lange, (2003 a & b); De Vera *et al.,* (2004); Oquist and Huner (2003); Vrablikova *et al.,* (2006); diversity, conservation and ecological perspectives [Rasanen (1950), Rasanen (1952); Knight *et al.,* (1961); Culberson (1964); Eversman *et al.,* (1987);

Longton (1988); Thor, (1993); Wolseley (1995); Kappen (1996); Peck *et al.,* (1995); Johanson, (2003). Lichens have several reasons to enjoy an extra ordinary success as biomonitoring of air pollution. These plants are perennial, slow growing organisms that maintain a fairly uniform morphology in time and they are highly dependent on the atmosphere for nutrients, and do not shed parts as readily as vascular plants. Nyangababo (1987), Puckett, (1988); Garty (1993).

The lack of waxy cuticle and stomata allows many contaminants to be absorbed over the whole lichen surface without exhibiting damage thereby permitting monitoring over wide areas (Hale, 1983; Puckett, 1988). Other characteristics of lichen are their longevity and their rapid uptake and accumulation of cations (James, 1973). Lichen possess remarkable ion exchange properties similar to many exchange resins and are therefore suitable for collection and retention of air borne metals (Roberts, 1972). There is a physiochemical process involved in the mechanism of high accumulation of metals in the mycobiont of lichen thallus, which does not normally disturb the metabolism of the lichen. This would explain why lichens can tolerate elevated metal contents (Tuominen and Jaakola, 1973; Brown, 1991a&b).

Lichen diversity is an excellent indicator of pollution by phytotoxic gaseous substances (Hawksworth and Rose, 1970; Ferry *et al.,* 1973; Nash and Wirth, 1988; Richardson, 1992; Cislaghi and Nimis, 1997; Purvis, 2000; Nimis *et al.,* 2002). Lichens responds relatively fast to the deterioration in air quality and can re-colonized urban and industrial environment as a consequence of improve conditions within a few years (Rose and Hawksworth, 1981; Kandler and Poelt, 1984). According to Garty (1993), until now many foliose and fruticose lichen species in particular epiphyte and terricolous once have been used as biomonitors of pollution studies. The epiphytic lichens can be used as biomonitors on a national scale as well as around particular pollution to obtain information about the level in lichen are both natural (crustal material, marine aerosols) and anthropogenic (industry, traffic, etc.)

Canters *et al.,* (1991) studied the influence of microclimate on lichen distribution, community development and concluded that the distribution of lichen is governed by microclimatic factors that influences higher plants in different ways or not at all. The microclimate causes a separation to much smaller units in Cryptogams than Phanerogams. John (1955) studied the neighbor relations within a community of epiphytic lichens and bryophytes over whole tree trunks and four sections of trunks to partially eliminate the effects of microhabitat, associations were found to differ from place to place on

the tree trunk. The composition of the epiphyte community differs predictably according to height and aspects on the trunk have also been studied (Hale, 1952; John, 1992 and Rose, 1974).

The medicinal aspects of lichen have turned to new directions. After the untiring research work done by Japanese workers, who studied the anti-tumor and anti- HIV activity of lichens, and now lichens may be a good potential source of photochemical by Jang *et. al.,*(2003) Information on a variety of products isolated from lichens, show a wide range of potentially useful biological activities (Singh *et al*., 2004).

2.2 National scenario

India is a rich centre of lichen diversity contributing about 2080 species of lichens of which 500 taxa are endemic to the country (Singh *et al.,* 2004). Upreti, (2011) reported that 2319 species of lichen and 520 (22.6%) taxa endemic to India. A total of 20,000 species of lichens are so far known from the world (Awasthi, 2000), India is a 5th richest country sharing 10.11% which is about 2.4 of the global land surface (Awasthi, 1988a, 1991; Groombridge, 1992; Upreti, 1998; Negi, 2001). Out of the recorded lichen species 40% are macro-lichens and 60% are crustose forms, 'microlichens' (Negi, 2001), most of which have only been recorded once in the history of more than six decade of lichenology in India. (Awasthi, 1991; Singh and Sinha, 1997). The crustose forms are very difficult to collect and identify and are more likely to be overlooked in the field even by experts (Negi, 2000). Lichen studies were initiated little late in India as compared to the rest of the world. It was Quraishi (1928) published a comprehensive account of lichens of the Himalayas. Awasthi in the late fourties of the last century established a school of Lichenology in India and a number of lichenological investigations related with monographic, revisionary and floristic studies were initiated in the country.

There are eight regions in India that have been ranked based on their area, species and their endemism. The Western Ghats, Western and Eastern Himalaya, seems to be the rich centres of lichen diversity in India. Andaman and Nicobar Island emerge as lichen '*hot spot'* ranking first in terms of endemic species with smallest compared to the rest of the lichenogeographical regions in the country. There seems to be a higher concentration of endemics in the tropics than in the temperate to alpine region of the Western Himalayas. Lower endemism in the Himalayas is probably due to the great affinity of their elements with Europe and regions of central and western Asia. The very poorly

explored Eastern Ghats and Central Indian regions with unique topography may equally prove biological treasure troves of lichens. The Gangetic plains with agricultural predominance and the drier western parts of Rajasthan and Gujarat may be poor habitats for lichens. However, the taxa adapted to this dry climatic condition render endemism as high as 15% of the regional species pool. Balaji and Hariharan (2004) studied the lichen diversity and its distribution pattern in tropical dry evergreen forest of Guindy National Park (G.N.P), Chennai. The quantitative ecological data shows the occurrence of the 31 species of lichen in fewer than 26 genera of 19 family and 9 fungal orders.

Lichen flora of different region of India has been described in several scattered journals [Upreti and Negi (1998); Upreti and Chatterjee (1999); Upreti and Nayaka (2000); Upreti (2001); Nayaka *et al.,*(2001); Upreti *et al.,*(2002); Upreti and Divakar (2003); Upreti *et al*., (2004); Upreti *et al*.,(2005); Upreti *et al*., (2007); Nayaka and Upreti (2002)].Further, Divakar and Upreti (2003, 2005b, 2006) described the Parmeloid lichens of India. Biswas and Awasthi (1948) provided an account on the distribution of Indian lichens; Bhatia (1957) made observation on the lichen communities of the western Himalayas. Upreti (1995) explain loss of diversity in Indian lichen flora; Negi and Gadgil (1996a) studied the pattern of macro lichens distribution in Western Himalayas. Upreti (1996a) provided an account of 35 species falling under 18 genera of the lichens growing on *Shorea robusta* tree of Jharsuguda district, Orissa. While there have been quite considerable studies on taxonomic aspects of 1850 species of lichens and over 2000 species of mosses rich flora of India (Awasthi, 1988b, 1991; Chopra, 1975).

Nayaka *et al.,* (2001) described about the diversity, distribution and ecology of 99 species of lichens belonging to 39 genera and 22 families from Meghamalai Wildlife Sanctuary, Kambam district of Tamil Nadu. The evergreen forest records the maximum number of 50 species, followed by 36 species in moist deciduous, 21 species in dry deciduous and 12 species in scrub forests.

Upreti and Divakar (2003) enumerated 108 species of lichens species representing 35 genera growing on twelve major tree species and other substrates in thirteen forest sites of Cobett Tiger reserve in Utaranchal. There is a dominance of crustose form of lichens in all the thirteen forest sites of the area, represented by 88 species while only 20 foliose lichen species of nine genera (*Bulbothrix*, *Cladonia*, *Coccocarpia*, *Collema*, *Heterodermia*, *Leptogium*, *Parmotrema*, *Phaeophyscia* and *Physcia*) were found on different substrates. Upreti and Nayaka (2006) described *Anisomeridium calcicolum* Upreti and Nayaka (Monoblastiaceae) from India a new species to science. They have

also reported two new records for the Indian Lichen flora i.e., *Lithothelium hyalosporum* (Nyl.)Aptoot and *Polymeridium albocinereum* (Krempelh.) R.C. Haris. Jagadesh Ram *et al.,* (2006) described a new species, *Chrysothrix septemseptata*, which is currently known only from the Sundarbans Biosphere Reserve.

The present known Indian Lichen flora is represented by some 2319 species out of 20,000 species of lichens recognized in the world. The Himalayan region comprised of approximately 1,200 species and about 600 microlichen (squamulose, foliose or fruticose forms) (Upreti, 2001, 2011). The occurrence of a single species of lichens, now under the genus *Rocella* (*R. montagnei*) from India is mention in species Plantarum by Linnaeus (1753). Acharius (1810, 1814) described four species namely *Alectoria arabum* (= *Ramalina arabum*), *Collema rottleri*; *Isidium* (= *Caloplaca*) *bassiae* and *Porina subcutaena* (= *Pertusaria leioplaca*) on material from India. A decade later, E. Fries (1925) added another five lichen species, *Parmelia cirrhata* (=*Everniastrum cirrhatum*), *Parmelia confluen* (= *Dirinaria confluens*), *Usnea dichotoma* (= *Usnea himalayana*), *Trypethelium pruinosum* and *Trypethelium superbum* (= Campylothelium superbum) from 'India Orientalis' a collection from Pondichery and Corromandal Coast described by Belanger (1838). Lichens collected from different parts of the Indian subcontinent (Assam, Darjeeling, Kolkata, Kumaon, Nilgiri Hills and Sri Lanka) by G. watt, a. watt, King and Thomson were ultimately described by the Scottish Lichenologist J. Stirton (1876, 1879, 1881) adding 98 new taxa to the lichen flora of the area.

Contribution of major interest pertained to the genus *Usnea* and Pyrenocarpeae and Graphidaceae. A large number of lichens specimens lodged in many European herbaria were re-examined by J. Muller Argoviensis, and observations were published under the title Lichenogische Beitrage, (Mull. Arg. 1891) in which as many as 60 new species of lichens from Indian subcontinent were described and many taxa nomenclaturally revised. A representative collection of lichens from Manipur by G. Watt during the boundary demarcation period was published Mull. Arg. (1892), which comprised an enumeration of 101 taxa of which 29 species were new to science. A small collection from Sikkim by Stevans, comprising 12 taxa of lichens also enumerated by Mull. Arg. (1895). Majority of the new taxa in the contribution by Mull. Arg. belonged to micro-lichens genera *Arthothelium*, *Graphis*, *Graphina*, *Phaeographina*, *Lecanora*, *Lecidea*, *Pertusaria* and *Trypethelium*.The foremost collection of lichens by Indian nationals was made by Kashyap, Chaudhuri and Chopra from the Himalayas in the twenties of present century. A set of those

collection consisting 76 taxa was enumerated by A.L. Smith (1931), and apparently working on a part of the set, Zahlbruckner (1922-40) described a new genus *Chaudhuria* (*C. indica* = *Heterodermia diademata*). An account of 75 taxa of lichens from the Himalayas was subsequently published by Chopra (1934). Smith (1926) had described two new genera, *Cryptothecia* and *Stirtonia* based primarily on specimens collected from India.

The lichen samples were collected from different parts of the Himalayaa and continental India. The findings of those investigations were published in several journal articles as detailed in Akhtar (1981), Akhtar and Awasthi (1980), Awasthi (1970, 1973, 1975a,b, 1976, 1981, 1982a,b,c, 1983, 1984, 1985, 1986,1987, 1988a,b, 1991), Awasthi and Agarwal (1968, 1970), Awasthi and Akhtar(1977), Awasthi and Joshi (1982), Awasthi and Singh (1970, 1971, 1980), Awasthi and Upreti(1985), Awasthi and Srivastava (1989), Awasthi and Tiwari (1987), Pant and Awasthi (1989). Some of the lichen genera in India are well worked out for their revisionary and monographic studies. The perithecia bearing pyrenocarpous lichen genera are revised. Singh, 1969, 1970 a, b, c, 1971; Singh and Roy chowdhury, 1982; Singh and Upreti, 1986, 1987); and then consolidated the lichenological progress during the period 1966-77 (Singh, 1980a). A. Singh later published detailed accounts on the genus *Anthracothecium* and allied genera (Singh, 1982, 1983, 1984, 1985a, b) and on *Endocarpon* Singh and Upreti, 1984).

Work was carried out on genera *Opegrapha*, *Parmentaria*, *Porina* (Upreti and Singh, 1987a-f; 1988 a & b), on *Pyrenula* Upreti (1987); Upreti (1988); Upreti (1990); Upreti (1991a-c); Upreti, 1992, Upreti, 1993, Upreti, 1994, Upreti, 1998) and *Lecanora* (Upreti, 1997, Upreti,1998; Upreti and Chatterjee, 1997, Upreti, 1998). Other publications were by Upreti and Aptroot (1996), Upreti and Budel (1990) and Upreti and Negi (1998).

2.3 Eastern Himalayas

The eastern Himalaya region comprises of Sikkim, the Darjeeling district of West Bengal and the seven sister states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura) of the North Eastern India. Out of about 20,000 species of lichens so far known from the world, India represents more than 2318 species in India, the eastern Himalayan region including Sikkim, the Darjeeling district of West Bengal and the seven North-Eastern states of India represents

the occurrence of about 728 species of lichen which is about 41% of the total lichen flora of the country.

Awasthi (1988b), father of the Indian Lichenology reported 697 species of macrolichens from India and Nepal while Singh (1999) reported 386 species from Eastern Himalaya including Northeastern States. Botanical Survey of India, the premier organization in the field of taxonomy and floristic studies, has taken up the task to explore the lichen flora of North-Eastern states. As a result of this, lichens of Manipur (Singh, 1981a; Singh, 1981b). Notably enough, 60% of the so far recorded lichens are crustose forms, most of which have only been recorded once in the history of more than six decades of lichenology in India (Awasthi, 1991; Singh and Sinha, 1997). These crustose forms are very difficult to collect and identify, and are more likely to be overlooked in the field even by experts. An exhaustive survey in Nagaland, where they could list only 139 species of microlichens as opposed to 209 species of macrolichens as evident from Singh and Sinha (1994). Similarly, Sinha and Singh (2005) reported 320 species exclusively of macrolichens from Sikkim. An innumerable research papers comprising new species, new records for India, systematic accounts, chemical characterization, biological activity, etc. have been published from the region recently.

There are many factors responsible for rich lichen flora in this region. The region with special horse – shoe shaped arrangement of the fold of mountains coupled with moisture laden monsoon winds, blowing across the Bay of Bengal, ensure plenty of rain in most of the area almost throughout the year. This crest high humid climate is congenial for the growth of lichen both in luxuriance and variation. The topography and varied altitude of the area are other factors which contribute to the rich lichen diversity and endemic elements. The knowledge of lichen in this region, though it is poor at present, is known through the publications of several workers from 19th century onwards. One of the earliest publications on the lichens from this region was by Nylander (1860, 1873) who reported 80 species based on the collections made by Hooker and Thomson from higher ridges of eastern Himalayas and parts of Nepal. Chopra (1934) made an important contribution from this region. Some of the contributing pioneer workers from this region by 19th century were Awasthi (1961), Kurokawa (1966), Awasthi and Agarwal (1968, 1970), Patwardhan (1979, 1980), Singh (1980a, 1981b).

In a series of papers, Sinha and Singh (1986), Sinha and Singh (1987), Sinha and Singh (1989), Sinha and Singh (1991), Singh and Singh (1982), Sinha and Singh (1984), Singh and Upreti (1986) and Singh *et al.,* (1989) have published new taxa, many new records for India and general

account of some genera of lichens from this region. Singh and Sinha (1994) have also published first comprehensive account of state flora of lichen from North-East India dealing with 346 species. Singh and Sinha (1994) investigated the lichen flora of Nagaland and added 331 species more to Nagaland and 136 species to North East India.

Ahti *et al.,* (2002) described *Cladonia singhii* as new report from Eastern Himalayan region. Ahti *et al.,* (2004) reported about two new species of *Cladonia* (Lecanoreles) from the Himalayas. Sinha and Elix (2003) described about a new species of Hypogymnia and a new record in the lichen family Parmeliaceae (Ascomycota) from Sikkim. Upreti *et al*., (2004) studied the lichen flora of Sikkim and resulted in the addition of 181 species representing 56 genera and 33 families as new record for the state, out of which four species *Lecanora austrointumescens* Lumbsch and Elix, *Pertusaria amarescens* Nyl., *P. coronate* (Ach.) and *P. tropica* Zahlbr were new additions to the Indian lichen flora.

Literature reveals number of researches on lichen flora from Eastern part of India have already been recorded viz., Singh (1977), Singh (1978), Singh (1979), Singh (1980 a-c), Singh (1981), Singh (1982), Singh (1983), Singh, 1984, Singh and Awasthi (1979, Singh (1981), Singh and Singh (1982, 1984), Singh and Sinha (1994), Singh and Upreti (1986), Sinha and Singh (1986, 1987, 1989, 1991,1996, 2005). The important contribution from this area was addition of a new Genus *Awasthiella*, and compilation of the 'Lichen flora of Nagaland'.

Rout *et al.,* (2005a) gave an enumeration of about 24 epiphytic lichen species and growing in NIT campus of Southern Assam. Rout *et al.,* (2005) described about the ethnic uses of a common lichen *Cladonia rangifera,* found growing in the alpine regions of West Kameng district of Eastern Himalaya. Rout (2007) described about the various aspects of biomonitoring studies by using lichen as bio-indicators. Singh *et al*., (2002, 2005) enumerated 33 species distributed under 7 genera of Pyrenocarpous lichen from Arunachal Pradesh.

Awasthi (1961), Singh and Upreti (1986), Singh and Nongkynrih (1984), Sinha and Singh (1992) have made some significant contribution in the lichen flora of Arunachal Pradesh. Singh and Bujarbarua (2001) made a preliminary account of the status of the lichen of the state. Singh (1996) recorded 73 species of lichen from Namdapha National Park, Arunachal Pradesh. Singh and Pinokiyo (2004a) reported 2 new records of foliicolous lichens from Mehao Wildlife Sanctuary. Singh *et al.,*

(2002, 2004) recorded 106 species of lichen distributed among 39 genera and 17 families from Mehao Wildlife Sanctuary in Dibang valley district of Arunachal Pradesh. Singh (1999) while enumerating the lichens of the eastern Himalaya region mentioned the occurrence of 112 species, 33 genera and 17 families from the state of Arunachal Pradesh. Few lichen taxa were mentioned in the revisionary studies of Pyrenocarpous lichens from Arunachal Pradesh (Singh *et al.,* 2005).

Dubey *et al*., (2007) reported 94 species belonging to 40 genera and 20 families from Along town of west Siang district of Arunachal Pradesh. Pinokiyo *et al*., (2008) study the diversity and distribution of lichen at 10 sites/locations within the Mehao Wildlife Sanctuary in Arunachal Pradesh. It revealed 177 species belonging to 71 genera and 35 families. Singh and Pinokiyo (2008) recorded two new species *Mazosia luekingii* and *Sporopodium awasthianum* and a new variety. *Aspidothelium scutellicarpum* R.Lucking var. *indicum*. The humid tropical and subtropical forests in Eastern India harbor a rich diversity of foliicolous lichens. Studies of folicolous lichens have resulted in a series of publications (Singh and Pinokiyo, 2003, Singh and Pinokiyo, 2004; Pinokiyo *et al.,* 2005, Singh *et al*., 2006; Pinokiyo and Singh, 2006).

Ethno-medicinal use of lichen *Parmotrema* spp was mentioned by Rozika (2005). Further, Chinlampianga (2009) documented the ethnic use of some lichen species in Mizoram. Chinlampianga *et al.,* (2011) initiated systematic survey of lichen flora of Mizoram and reported 15 additional species of corticolous lichens from Mizoram; Chinlampianga *et al.,* (2013) documented another 10 lichen species and Logesh *et al*., (2015) documented 159 species of lichen from Mizoram. However, investigations on microbial activity of some lichens of Mizoram have been reported by Shukla *et al.,* (2011). Undoubtedly, this is the first time report of lichen species in Mizoram State both from evergreen, subtropical and dry deciduous forests. If all the states such as Mizoram, Tripura and Assam are explored extensively for their lichens, it is expected that the total number of lichen species in the North Himalayas would be more than 1500.

Chapter

3

MATERIALS & METHODS

Chapter : **3**

3. MATERIALS & METHODS

3.1 Grouping of Lichens

By their appearance the lichens can be grouped into three main categories of growth forms and futher categorized based on their morphology and size.

(a) Crustose lichens: The thallus in crustose lichen is closely attached to the substratum without leaving any free margin. The thallus usually lacks lower cortex and rhizines (root like structure) {fig-3.1,(A)}. Such lichens are collected along with their substratum for the detailed study

(b) **Foliose lichens**: They are also called as leafy lichens. The thallus in this case is loosely attached to the substratum at least at the margin {fig- 3.1(B) and 3.17}. Such lichens are collected by scraping them from the substratum.

(c) **Fruticose lichens**: The thallus in fruticose lichen is attached to the stratum at one part and the remaining major portion is either erect or hanging. Lichen usually appears as small shrub on bark. The lichen usually appears as small shrub or bush and easy to collect with hand {fig-3.1(D)}. Besides, there are few intermediate categories of growth forms such as,

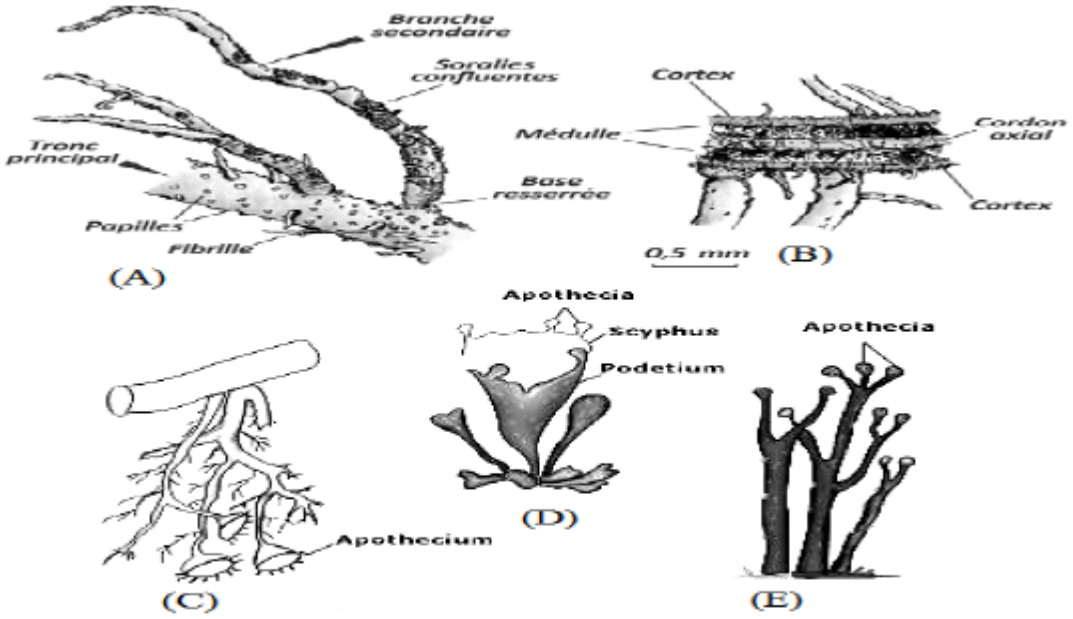
(d) **Leprose lichens:** The leprose lichen is powdery or granular and does not formsmoothlhallus.

(e) **Placodioid lichens:** In this case the lichen thallus is closely attached to thesubstratum atcentre and lobate or free at the margin, but lack rhizines.

(f) **Squamulose lichens:** Here the lichen thallus is in the form of minute lobes, havingdorsiventral differentiation. The rhizines may be present or absent. This is a form intermediate between crustose and foliose.

(g) **Dimorphic lichens:** In case of dimorphic lichens single thallus has the characters of foliose/ squamulose and fruticose lichens. The squamules are the primary thallus, which bears erect body of fruticose lichen, the secondary thallus {fig- 3.1(C&D) and 3.4 (A&B)}

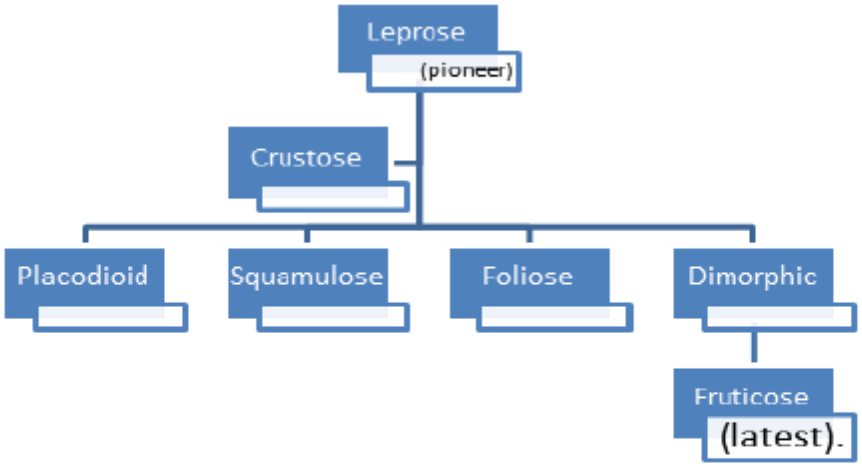
The crustose, few placodioid and squmulose lichens are generally called **microlichens**, because of their smaller size and microscopic studies to identify. The foliose, dimorphic and fruticose on the other hand are called as **macrolichens**. The macrolichens have comparatively larger thallus.
A hand lens, dissection or stereozoom microscope is sufficient to use for identification.



Source: Nayaka (2013)

Fig- 3.1 (A-E): A. Crustose lichen, B. Foliose lichen, C & E. Dimorphic lichen, D. Fruticose lichens

The crustose, foliose, placodicoid squamulose and sometimes dimorphic forms of lichens usually grow in a circular or centripetal manner. The rough and uneven shape of the stratum may change the shapes of lichen colony. The leprose lichen forms irregular patches of thallus on the substratum. The fruticose lichens of smaller side usually grow erect while larger ones hang from the substrate with their growing point located at the tips. The above mentioned growth forms of lichens can be arranged according to their imaginary evolution as shown in (Fig- 3.2)



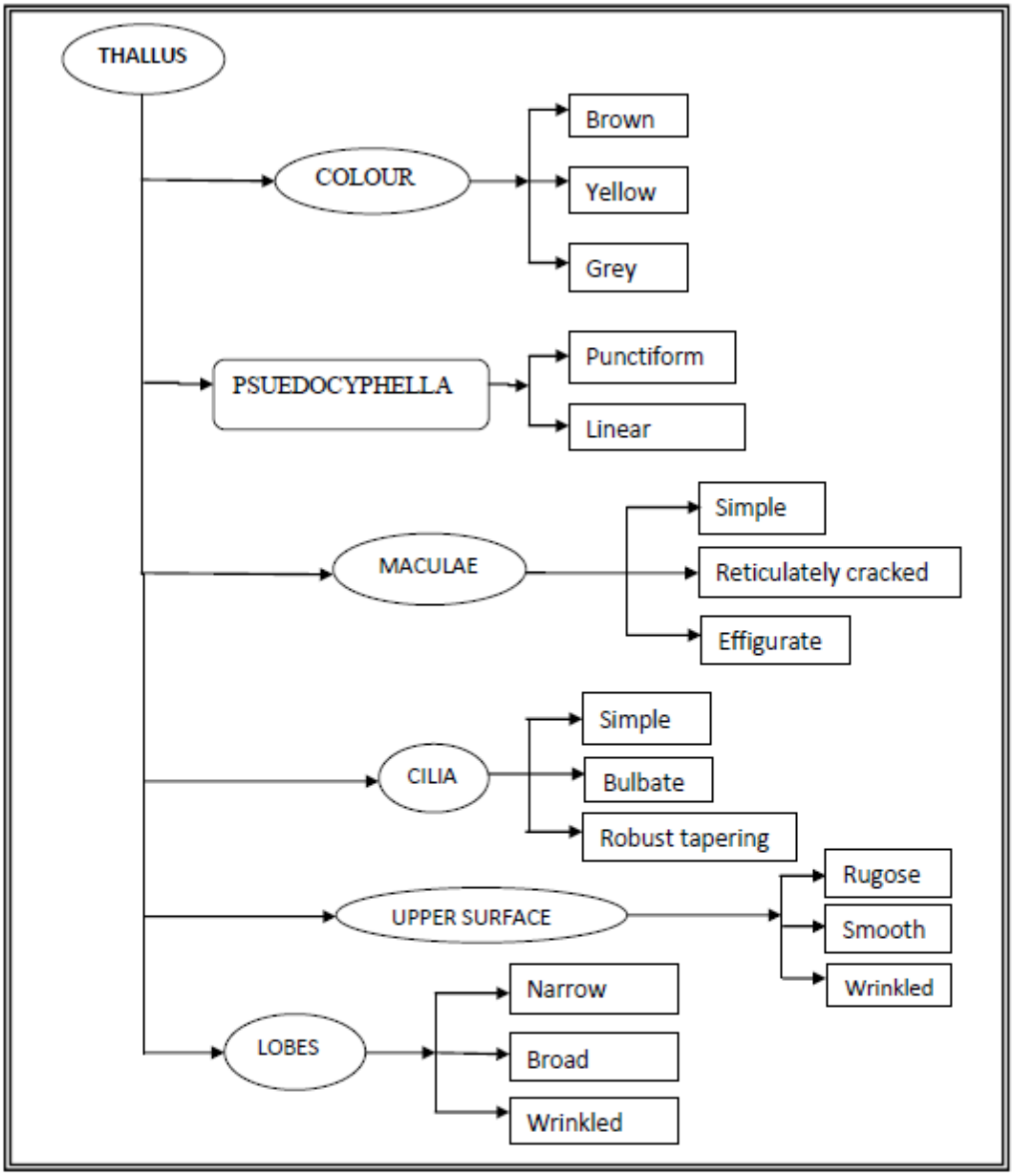
Source: Nayaka, 2013

Fig- 3.2: Growth form of lichen according to their imaginary evolution

3.2 Criteria for the Identification of Lichen Groups

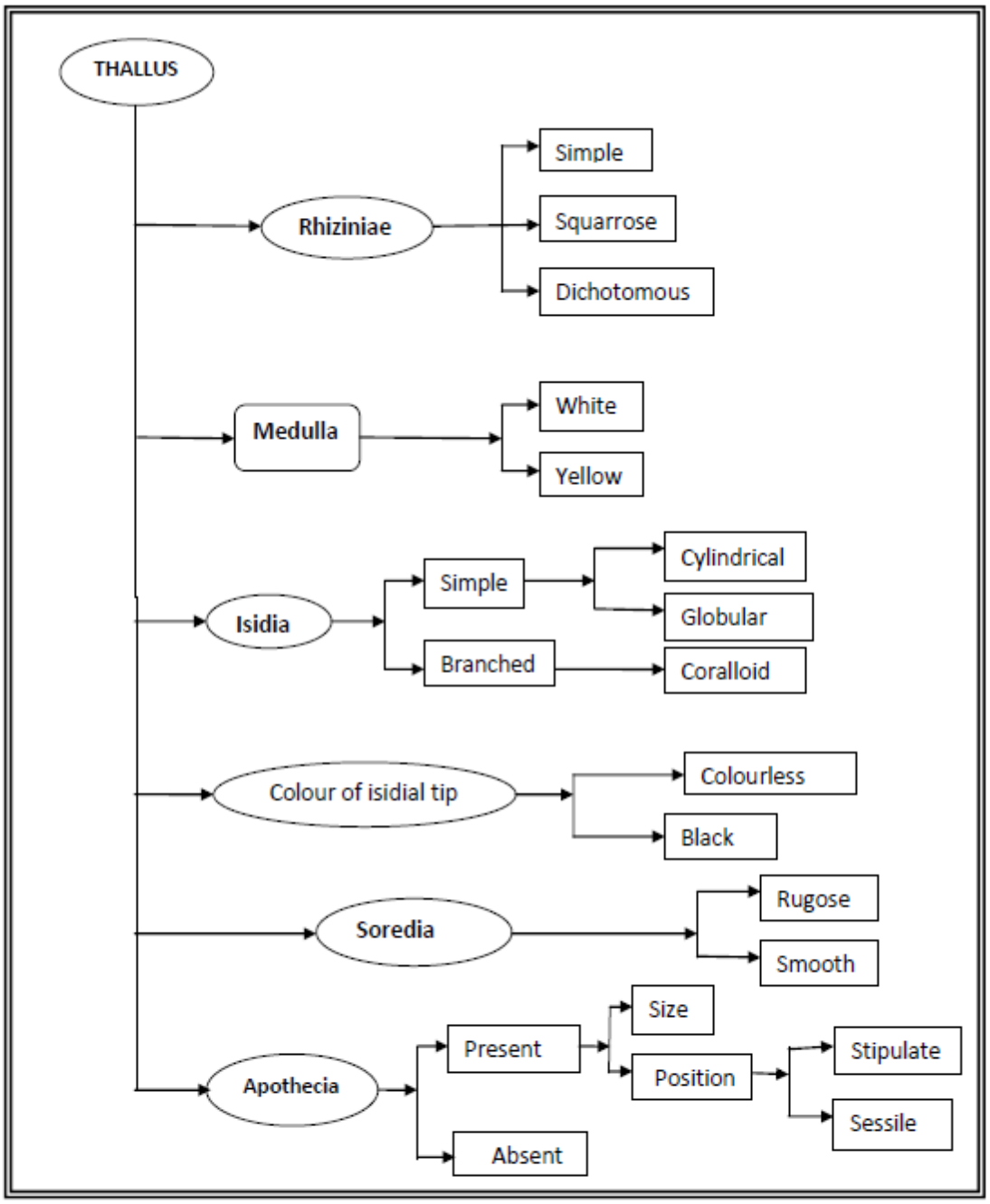
(i) Parmelioid taxa

Majority of Parmelioid taxa are segregated on the basis of their morphological characters as presence and absent, type and shape of pseudocyphellae, maculae, cilia, rhizinae. The presence and absence, shape and structure of vegetative bodies also play important role in segregation of different taxa (fig- 3.3 & 3.20). The anatomical and ascomatal characters are not such a major characters for segregation of parmeloid taxa.



Source: Mishra and Upreti (2015)

Fig- 3.3(a): Basic taxonomic characters used for segregation of *Parmelioid* group of lichens

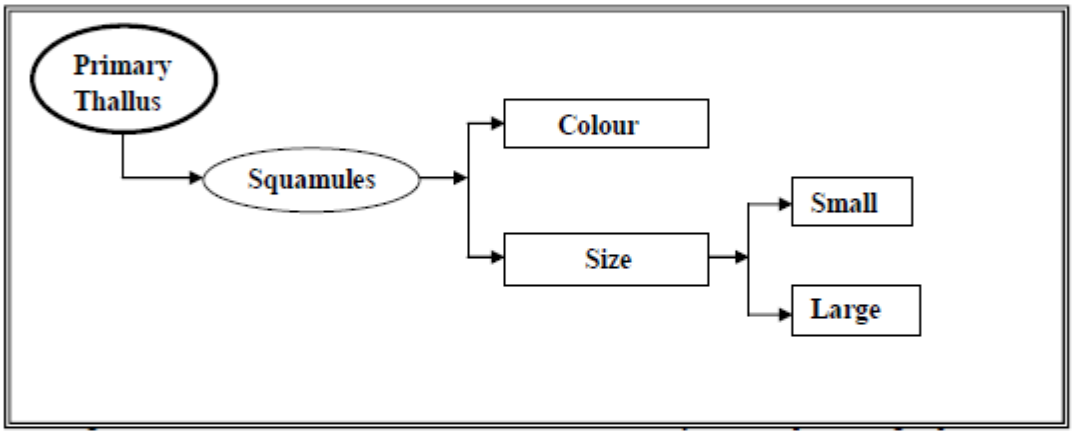


Source: Mishra and Upreti (2015)

Fig- 3.3(b): Basic taxonomic characters used for segregation of *Parmelioid* group of lichens

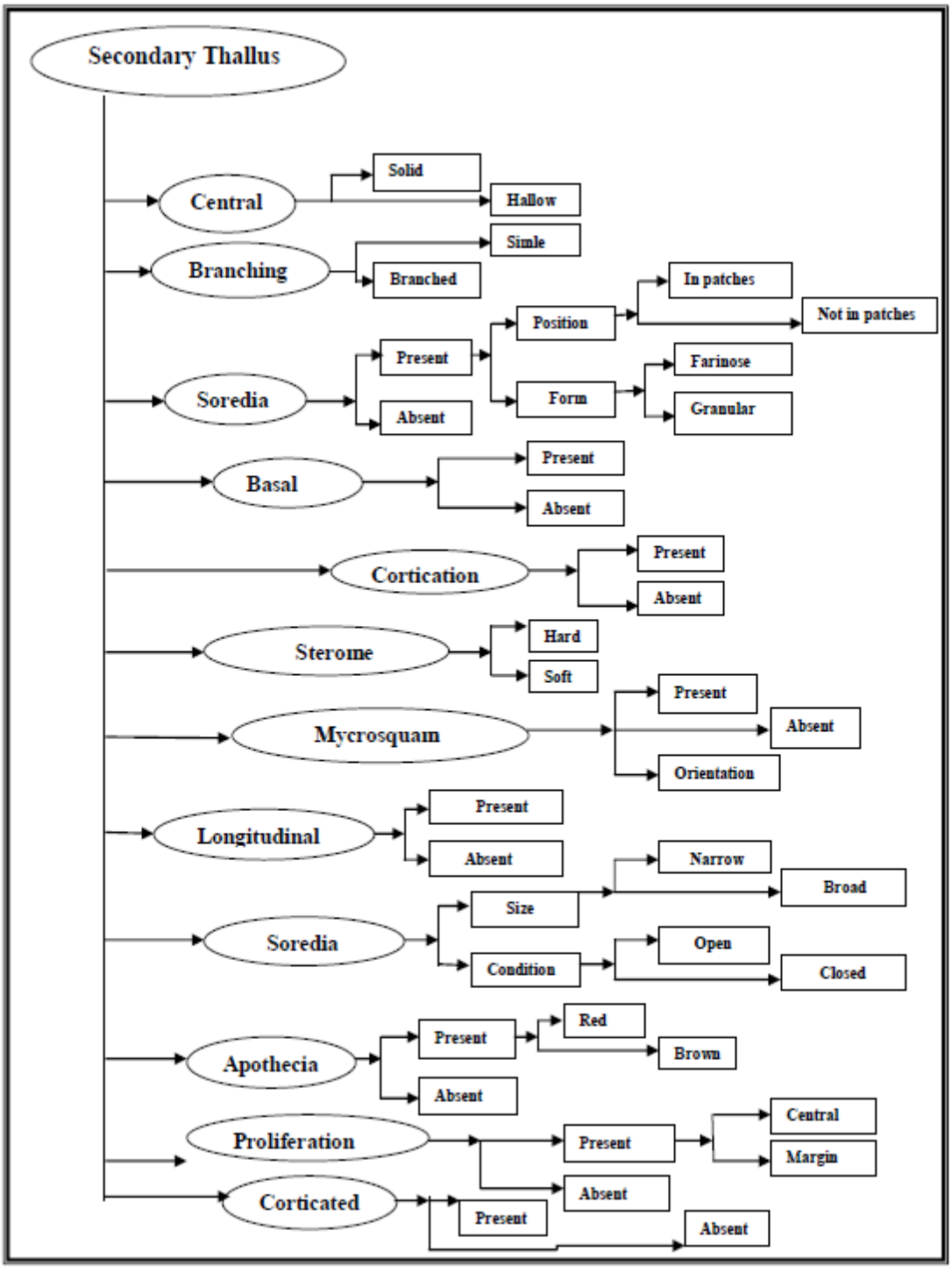
(ii) Dimorphic taxa

The dimorphic lichen consists of two types of thallus. A squamulose primary thallus bears upright secondary thallus called podetia which bears apothecia. The podetia may be hollow or solid (called pseudopodetia). The lichen family Cladoniaceae and Stereocaulaceae belongs to this group. The colour, size and shape of primary thallus squamulose are used in segregation of few taxa while majority of spices are segregated on the basis of the secondary thallus characters. The branching, presence or absence of longitudinal slits, colour of apothecia, presence or nsence of cups, proliferation on cups are some major taxanomical characters used for segregation of dimorphic taxa (Fig- 3.4 a & b).



Source: Mishra and Upreti (2015)

Fig- 3.4 (a): Basic taxonomic characters used for segregation of *Dimorphic* group of lichens

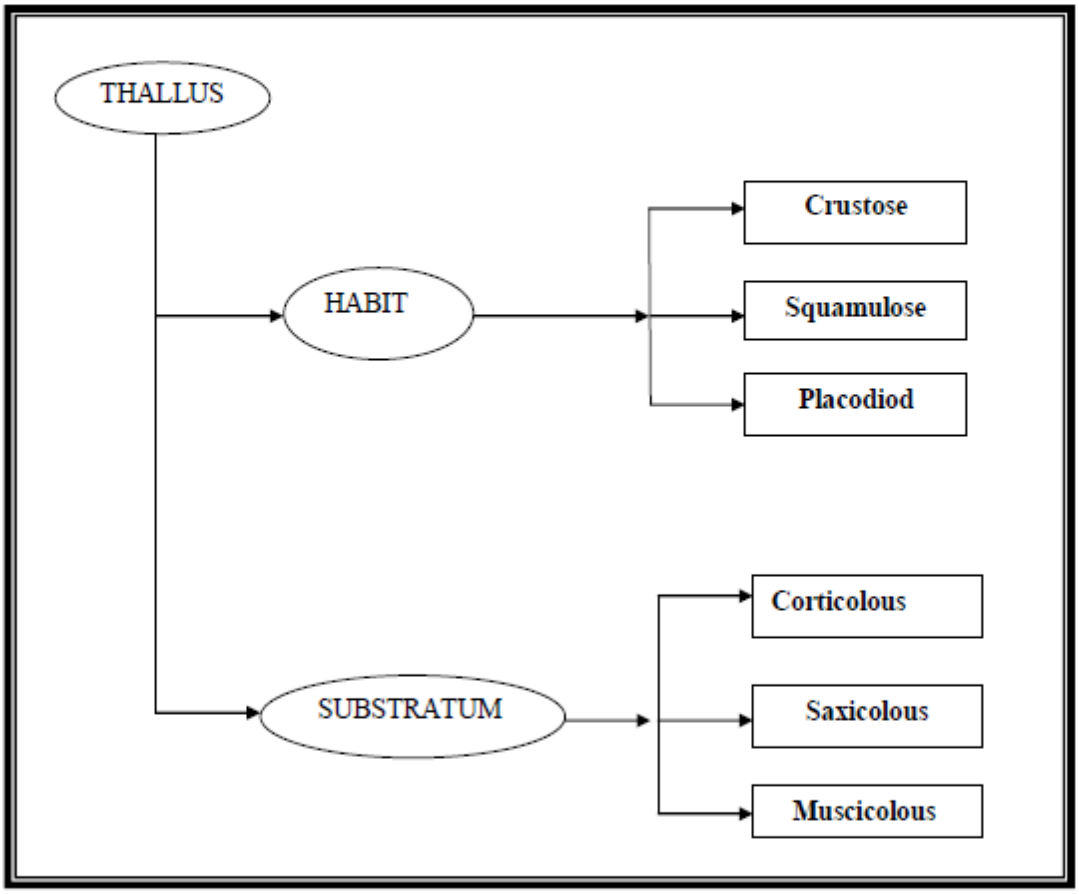


Source: Mishra and Upreti (2015)

Fig- 3.4(b): Basic taxonomic characters used for segregation of Dimorphic group of lichens

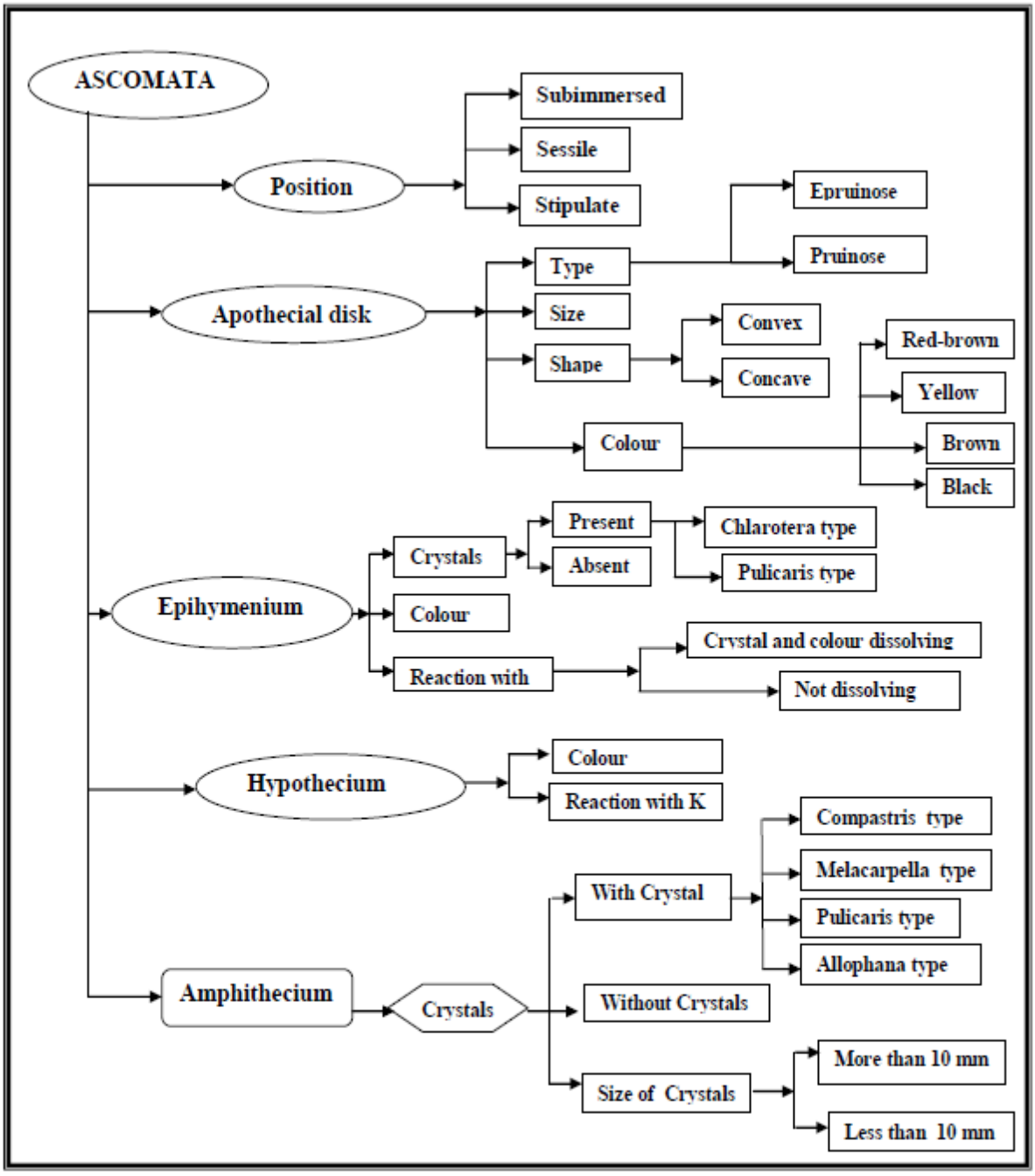
(iii) Lecanoroid taxa

Among lecanoroid taxa, the thallus habit, substratum type and colour of thallus play important role in segregation of different species. The habit of thallus may be crustose, squamulose or placoid. The substratum may be corticolous, saxicolous. Colour of apothecial disc, pruinose or epruinose condition, presence or absence of crytal in epihynium, the colour and K reaction, amphithecium type, hypothecium colour and size of calcium oxalate crystals in amphithecium are the major characters used for segregation of lecanoroid taxa (fig. 3.5 a & b).



Source: Mishra and Upreti (2015)

Fig- 3.5(a): Basic taxonomic characters used for segregation of *Lecanoroid* group of lichens

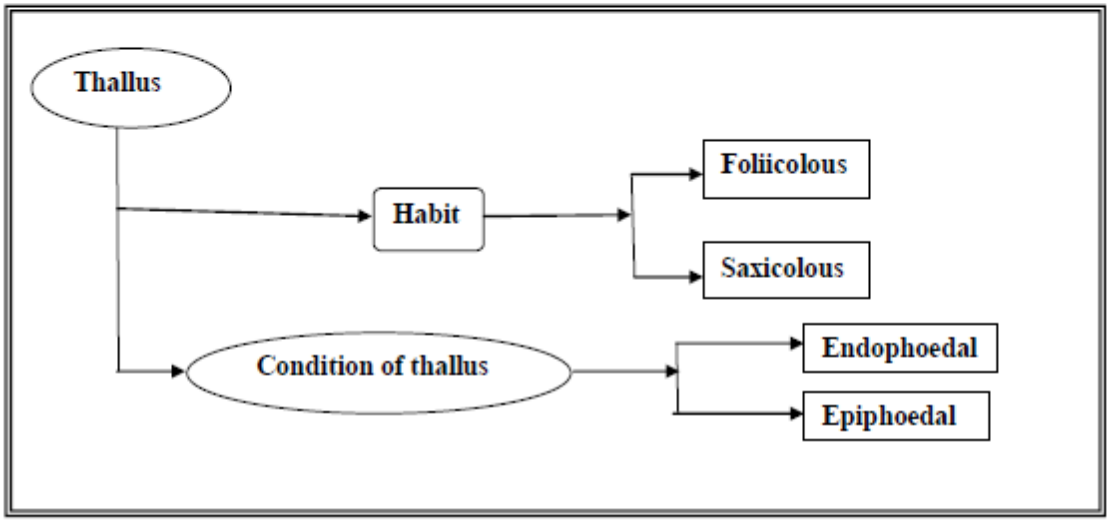


Source: Mishra and Upreti (2015)

Fig- 3.5(b): Basic taxonomic characters used for segregation of *Lecanoroid* group of lichens

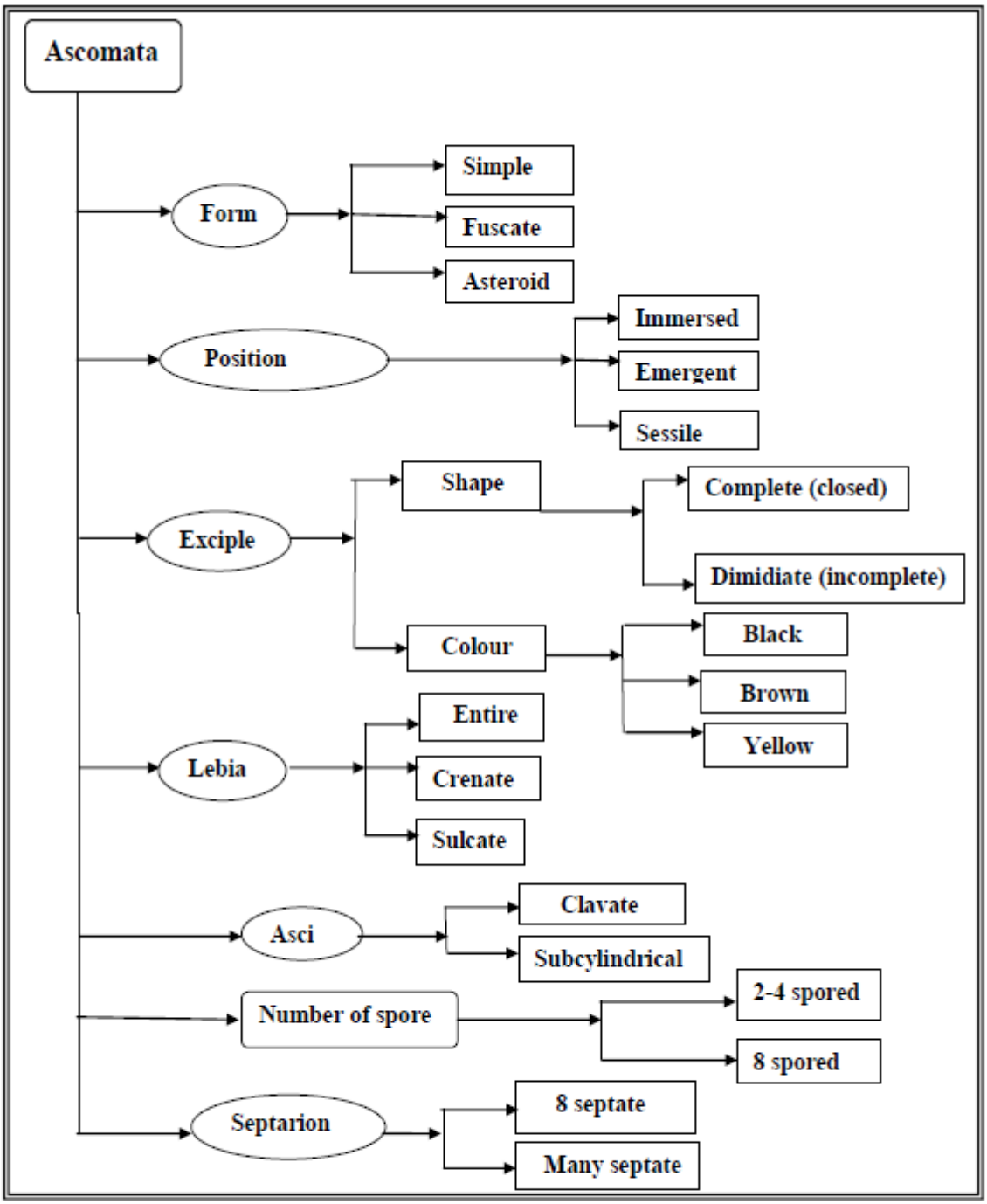
(iv) Graphidioid taxa

The modified elongated structure of the ascocarp, called lirellae, is the only basic character for the identification of the taxa {fig- 3.6 (a & b)}. The branching and position of lirellae, colour of exciple, ornamental and shape of labia, number of spores in asci, size and septation of spore play an important role in the separation of graphidaceous taxa {fig- 3.22 (A) & fig-3.23}. The chemical constituents of this group of lichen charaterized through TLC were shown in (fig- 3.24).



Source: Mishra and Upreti (2015)

Fig- 3.6(a): Basic taxonomic characters used for segregation of *Graphidioid* group of lichens

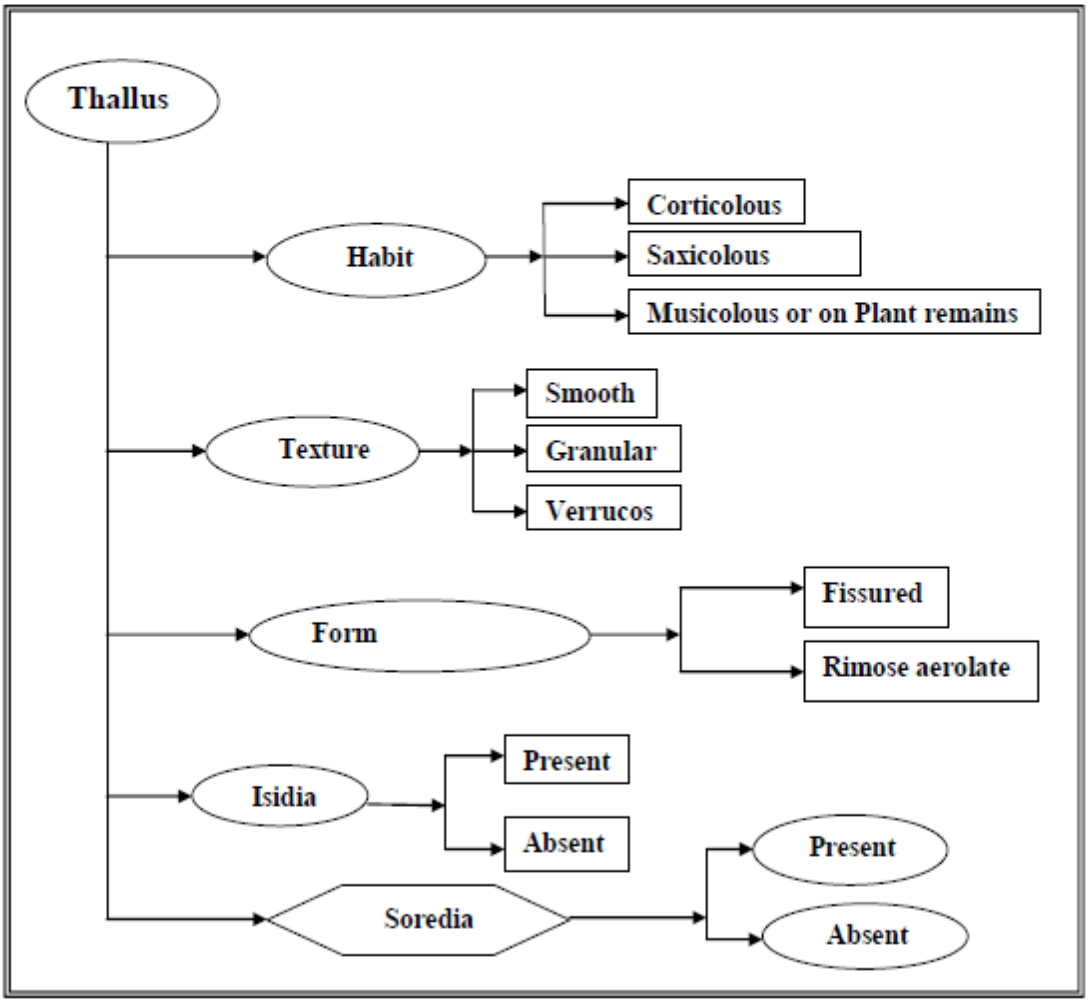


Source: Mishra and Upreti (2015)

Fig- 3.6(b): Basic taxonomic characters used for segregation of *Graphidioid* group of lichens

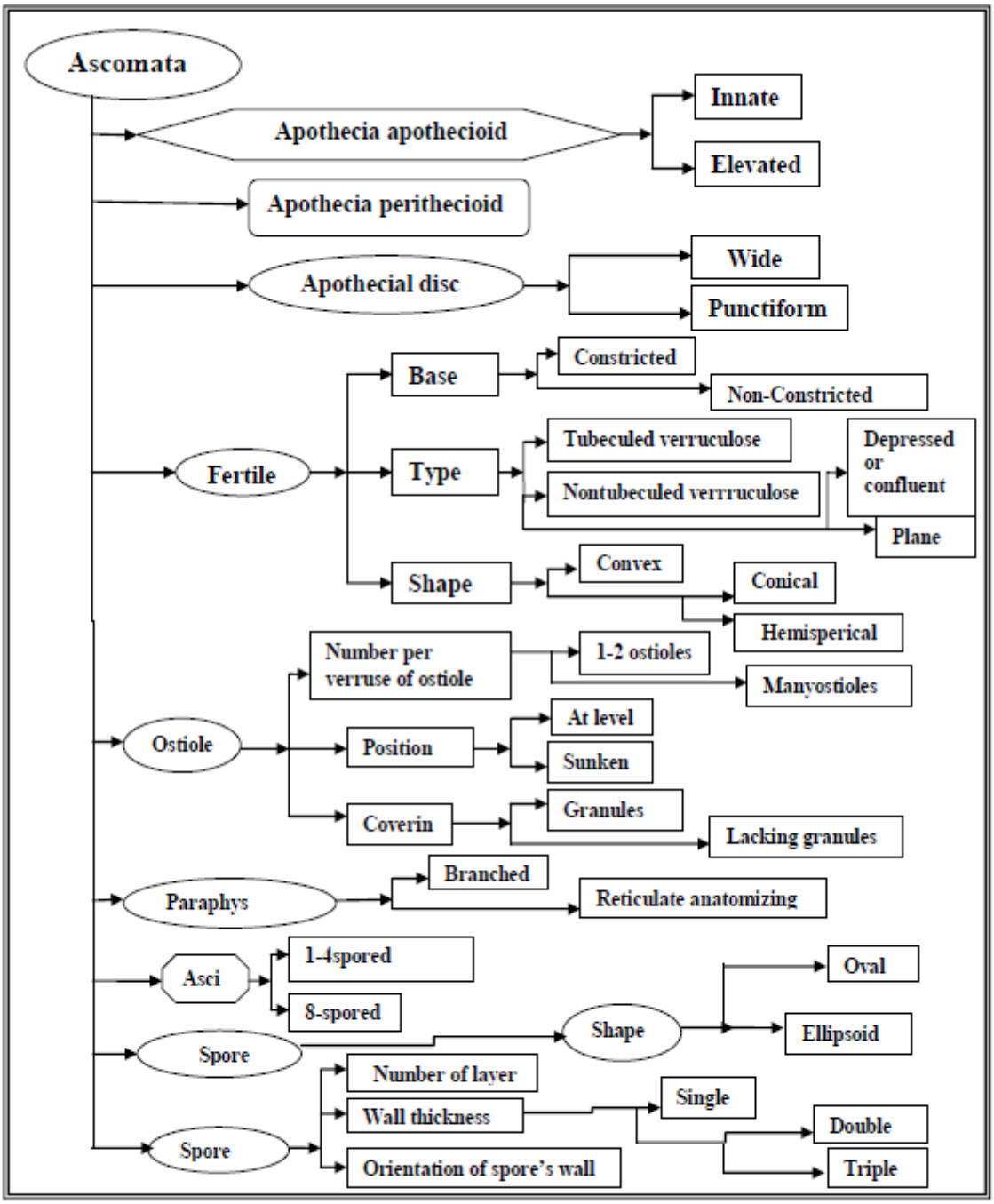
(v) **Pertusarioid taxa**:

The pertusarioid taxa are characterized by presence of thalline verrucae. The thalus colour, texture and habit together with the absence and presence of pseudocyphellae, isidia or soredia are used to segregate different species. The apothecioid or pertusaroid nature of ascomata, width of apothecia disc, colour, shape and size of fertile thalline verrucae, number, colour, position of ostiole, paraphyses branching, number of spores per ascus, shape and size of spore wall play a vital role in segregation of pertusarioid taxa (fig. 3.7 a & b).



Source: Mishra and Upreti (2015)

Fig- 3.7(a): Basic taxonomic characters used for segregation of *Pertusarioid* group of lichens

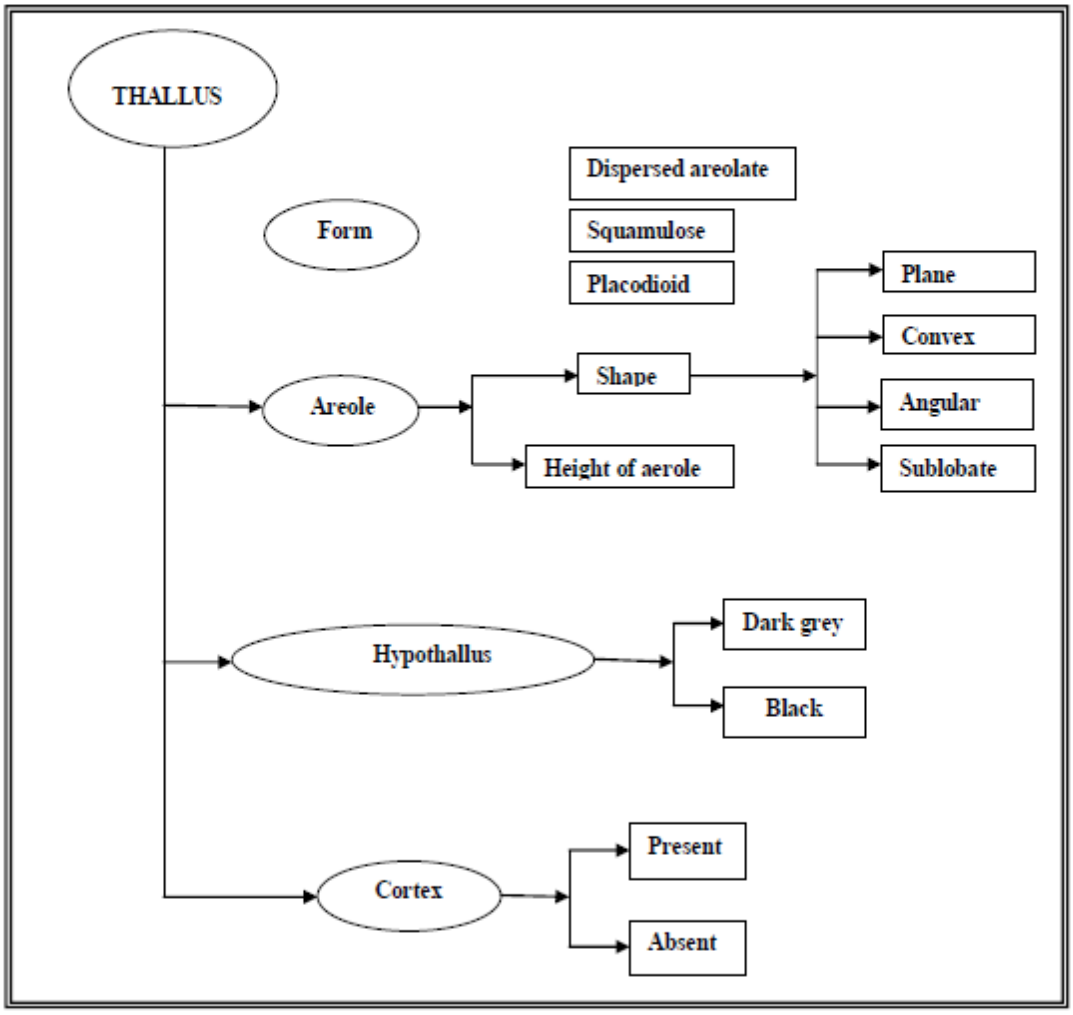


Source: Mishra and Upreti (2015)

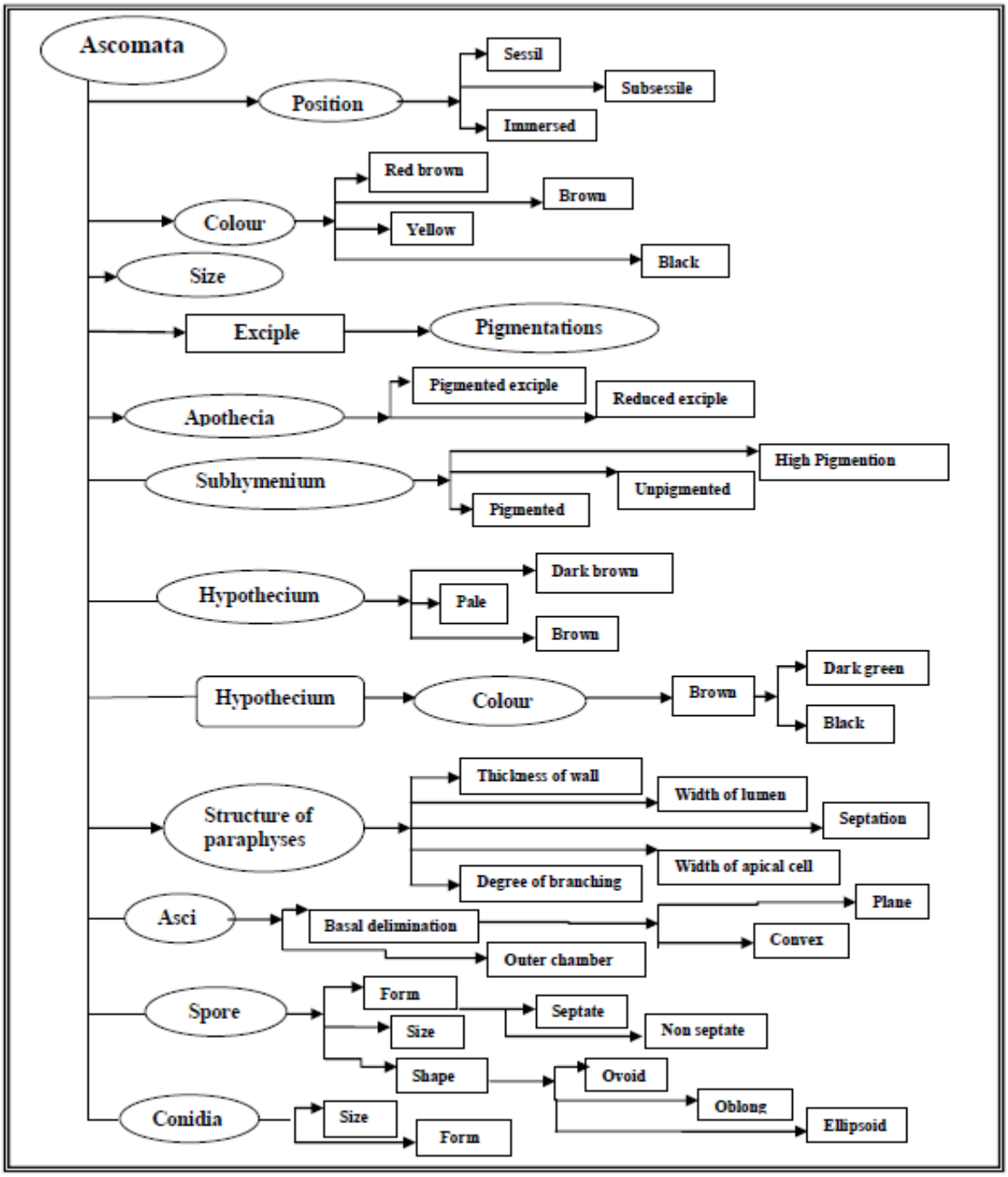
Fig- 3.7(b): Basic taxonomic characters used for segregation of *Pertusarioid* group of lichens

(vi) Lecideoid taxa:

The segregation of the taxa is based on the type of thallus, nature and shape of areoles, colour of hypothallus alongwith position, colour and size of ascomata, pigmentation of exciple, hymenium and hypothecium, structure of paraphyses, shape, size of asci, paraphyses and spore. In lecideoid taxa the ascocarp contains only fungal tissue with a proper exciple or rim similar in colour to the disc (fig-3.8 a & b)



Source: Mishra and Upreti (2015)
Fig- 3.8(a): Basic taxonomic characters used for segregation of *Lecideoid* group of lichens

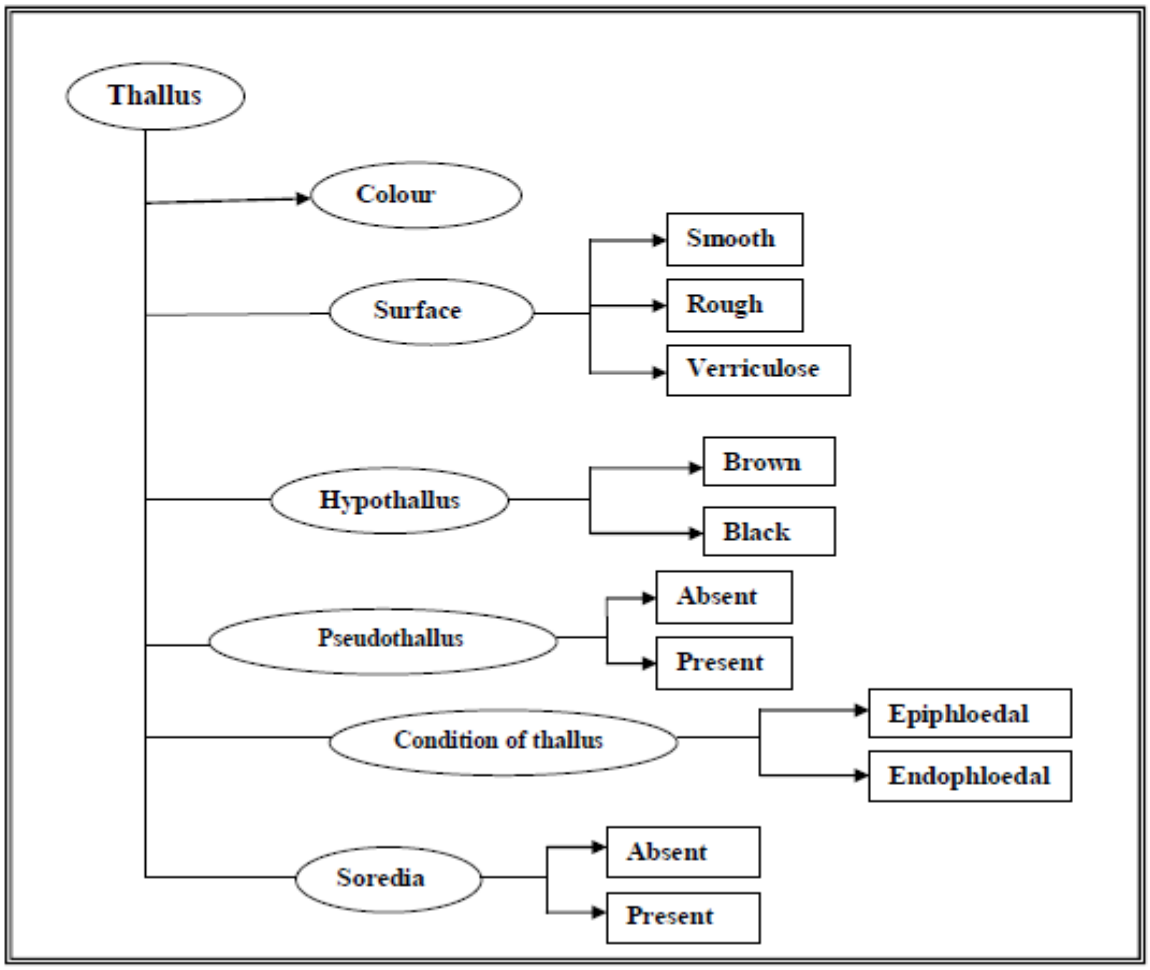


Source: Mishra and Upreti (2015)

Fig- 3.8(b): Basic taxonomic characters used for segregation of *Lecideoid* group of lichens

(vii) Pyrenuloid taxa

The less morphological variation in thallus structure limits the superficial identification of the taxa up to colour and nature of thallus, together with presence or absence of hypothallus and pseudocyphellae. The position, nature, shape, size of ascomata, ostiole and peridium, asi shaped, number of spore per ascus, ascus tip together with spore shape, thickness of spore wall, number of primary septa, size and orientation of cell chamber are the major charaters used for segregation of pyrenuloid group (Fig- 3.9). Structure of ascocarp cover and ostiole types in this group is given {fig. 3.21(A)}.



Source: Mishra and Upreti (2015)
Fig- 3.9: Basic taxonomic characters used for segregation of *Pyrenuloid* group of lichens

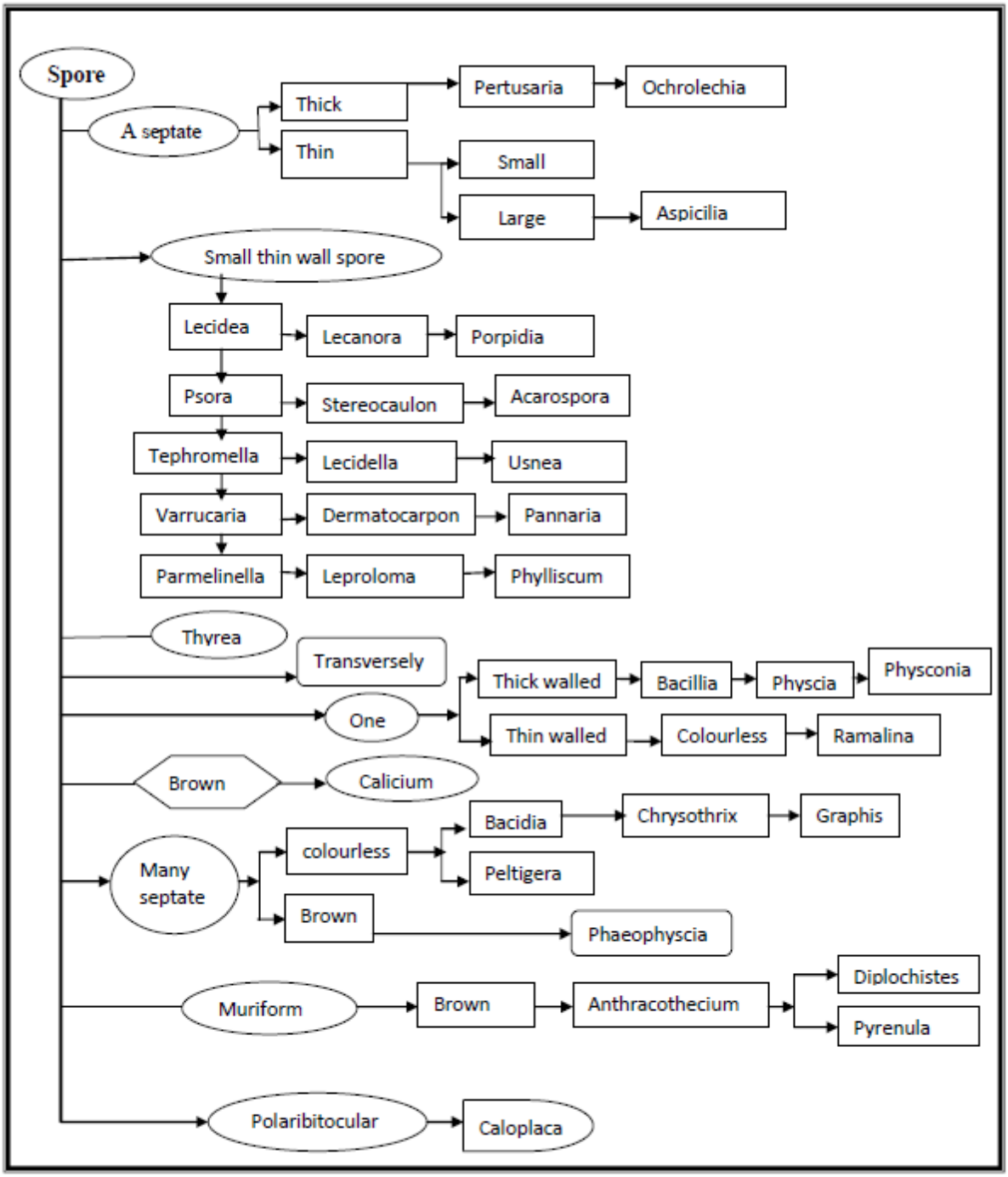
(viii) Spores

Based on the type of septation, the spore may be aseptate, transversely septate, transversely and longitudinally septate, muriform or polariform or polaribilocular. Aseptate spores are usually simple, colourless and small in size are found in the lichen families Acarosporaceae, Hymeneliaceae, Lecanoaceae, Lecideaceae, parmeliaceae, Pertusariaceae and Verrucaceae. Tranversely septate spores may be 1 to many septate (Fig-3.10). The members of lichen family Phyciaceae have one septate thick walled spore while Ramalinaceae and Arthopyreniaceae have colourless bright-brown, tranvesly septate spores. Multiseptate spores are of thick or thin walled, colourless to brown. They belong to the individuals of families Bacidiaceae, Chrysothricaceae, Peltigeaceae, Graphidaceae and Arthoniaceae. Muriform spores are the characteristic features of the families Arthopyniaceae, Diploschistaceae, Pyrenulaceae and Rhizocarpaceae. Structures of different types of spores observed in lichen group were shown in fig- 3.23.

3.3 Differentiating lichens from other groups of plants

The non-lichenized fungi, algae, mosses liverworts are the plants which grow on rocks, bark and on soil and can be confused for lichens at least to the beginners. However, lichen can easily be differentiated from these plants in the field. The lichens are never as green as algae, liverworts or mosses. Foliose lichens in the moist places or in wet condition may look greener, and have thick. Leathery thallus while liverworts have non leathery and shiny thallus. The dimorphic form of lichens such as *Cladonia* may easily confuse with the leafy liverworts and mosses (Fig. 3.18 & 3.19). However, leafy liverworts and mosses have dense small leaf like structures throughout the central axis of the plant while in case of dimorphic lichens the squamules of semicircular shape usually present at the base of the central axis or sparse throughout. Algal mat are usually found in water flooded habitat and shiny. The beginners may confuse the dried mat on rocks and bark for lichens. By spraying some water on these mats one can make out whether it is algal mat or lichen.

The non-lichenized fungi are the most confusing one with crustose lichens in the field. Such fungus usually form patches with loosely woven hyphae, which will be evident under hand lens. The lichens on the other hand form smooth and circular patches.



Source: Mishra and Upreti (2015)

Fig- 3.10: Basic taxonomic characters of *spore* used for segregation of different lichen taxa group

The fungi are usually whitish in colour and lichens are grayish, off white, yellowish, yellowish green or sometimes bright yellow or yellow orange in colour. The lichen thallus usually bears button or cup like structures called **apothecia**, or bulged, globular or immersed pitches like structure called **perithecia** as sexual reproductive organs. The finger like projections called **isidia** or granular (Fig-3.20B), powder like structure called **soredia** is common vegetative organs. Some crustose lichens belonging to family Graphidaceae bear worm like structures, the modified apothecia, called lirellte apothecia (Fig-3.20A). While collecting lichens it is necessary to look for such structures with the help of hand lens. When a lichen thallus does not have any such structures makes it difficult to differentiate from fungus. In any case it is observed that one can collects fungus and other plants in place of lichens. Usually fungus of various colour (mostly appearing like mushroom) are confused for lichens andthe unexpert / beginners could collected them wrongly.

Lichens are extremely sensitive to environmental stress, especially concerning atmospheric pollution, eutrophication and climate change. The absence of cuticular membrane and root system together with spongy nature of thallus, slow growth rate, dependence on atmospheric depositions for mineral nutrient, perennial nature and non-shedding organ parts are characteristic features of the lichens for their extreme sensitivity to environmental stress.

The climate i.e. condition of a particular area plays vital role for habitat diversity of lichens. The availability of water, sunlight, moderate cold climate, unpolluted atmosphere, wind currents and absence of biotic interference together with nature and type of stratum area additional factors responsible for diversity in habitat of lichens. Areas having frequent rains has luxuriant of lichens in comparison to scanty rainfall as the metabolic activities are dependent mainly on moisture content the thallus. In the absence of rain, dew and humid atmosphere can partially fulfill the moisture requirements.Different types of taxa grow or suitably adapted to the availability of water. Moist tropical region having frequent rain is suitable for member of Pyrenocarpous and Graphidaceous lichens. Semi-moist tropical areahas seasonal rains and provides favorable condition for member of Lichinaceae which retains moisture for longer while temperate regions, where the rains are intermittent; the folious and fruticose lichens grow luxuriantly.

3.4 Factors influencing growth of lichens

The cold deserts and hot deserts have scares or no rains, exhibits poor growth of few crostose and squamulose lichens on rocks and soil. The different climatic factors which influence the lichen growth are:

Sunlight : Bright sunlight and high temperature has an inhibiting effect on lichen growth. Such lichens develop cortical pigments. The thallus of such lichens contains anthraquinones to protect the algal layer e.g. *Acarospora* and *Rhizocarpon* growing on exposed places in alpine cold deserts. Majority of lichens occur in intermediate situation of moderate exposure between two extremes.

Temperature : The most suitable temperature for lichen growth is 20-25°C, therefore the lichen growth and their variety, particularly of macrolichen is more in temperate regions of the world. Many lichens are able to withstand high temperatures of the tropics with high rainfall. These lichens are mostly corticolous (growing on tree). Many lichens can tolerate very low temperature in high altitudes in the Artic and Antartic regions as their thallus structure is well adapted for such climate.

Wind : In areas of high wind current the crustose lichens exhibit their dominance. The *Usnea* and *Ramalina* lichens have cushion like or brush like growth which help them to withstand the strong wind currents.

Substratum : The lichens need a certain period of time for the establishment of the thallus on a substratum. It is essential that the substratum remains undisturbed for that period. Freshly cut soil profiles, recently broken surface of rocks, trees with periodic exfoliation and coppicing of bark are usually devoid of lichens. The texture, water relation and chemistry of the substratum also play an important role in the type of lichen vegetation. On the basis of the substrata on which lichens grows they are often referred to as terricolous – on soil; saxicolous – on rock, stone, boulder; lignicolous – on dead wood; corticolous – on bark of tree; foliicolous – on leaves; muscicolous – on mosses; humicolous – on humus; calcicolous – on lime or cemented plaster; omnicolous – on different kind of substrates.

3.5 Profile of Mizoram

Mizoram lies between lies between 21°58' & 24°35'N latitude and 92°15' and 93°29'E longitude and extending over a geographical area of 21,087sq.km (i.e.,0.64% of the total area of India). The average rainfall is 250cm p.a. The altitude ranges from 40m at Bairabi to 2157m at Phawngpui. The tropic of cancer i.e., 23°30'N Latitude cuts across the region in Aizawl district, traversing places like Champhai, Chhawrtui, Darlung and Phuldungsei etc.

Mizoram has predominantly mountainous terrain of tertiary origin. The mountain range runs in North to South direction intercepted by narrow deep valleys and crisscrossed by innumerable small hillocks. The shape is oblong with a length of 320 km N-S and breath 160km E-W. Small patches of flat lands (about 9,000 Ha) are available in few areas like Champhai, North & South Vanlaiphai and border of Cachar District, Tripura and Bangladesh.

The average altitude above msl is 1000 metres with lowest portion at Tlabung 20m above msl to the highest peak Phawngpui (Blue-mountain) 2157m above msl. The major rivers flowing towards the north are Tuivai, Tuivawl, Tuichang and Mat and towards the west is Tuichawng river and Tiau river as international boundary for India and Myanmar along the south eastern part of Mizoram. The slope gradients are very steep thereby causing constraints for cultivation of different agriculture, horticulture and fodder crops.

3.5.1 Soils and climate

The soils of Mizoram in general are young, immature and moderate to highly acidic. The soils are generally fertile and responsive to the vigorous growth of vegetation as well as arable crops. Soils of Mizoram are categorized into three orders (1) Entisols (2) Inceptisols and (3) Ultisols. The soils of Mizoram are broadly classified into Alluvial and Residual soils.

The soils of Mizoram are essentially derived from sedimentary rocks belonging to Barail, Surma and Tipam. Groups of miocene to pleistocene periods or the product of slow dia-genetic changes of the parent materials is comprising mica, schist, ferrugenous sandstone and shales giving the inherent acidic character.

Mizoram enjoys a pleasant and moderate climate. The climatic condition accorded to Mizoram may be called humid tropical, sub tropical and sub temperate climate, characterized by short

winter and long summer with heavy rainfall. Winter last from December – February with temperature varies from 10°C - 22 °C. Springs last from March to May with temperature varying 19°C-29 °C characterized by bright sunshine and clear sky unless disrupted by the pre monsoon rains. Summer last from June to August with temperature varying 20°C - 32°C, monsoon rains and violent storms causing landslide and other minor natural calamities. The autumn last from Sept-November with temperature varying 18° C - 25°C having pleasant climate during day and night. Due to increase in population, urbanization and environmental degradation, temperature increase gradually in today's world.

Mizoram is under the direct influence of maritime tropical air mass brought in by South West Monsoon. Usually, the rainy season occurs during May to October, and the annual average rainfall is 2500 mm. Highest rainfalls occur during July- August whereas, almost no rainfall occurs during December – January. The relative humidity is above 90% during the month of July to August, however, during January – April, it is around 60-75%.

3.5.2 Forest Cover

Out of the total geographical area (21, 087 Sqkm) of the state,the recorded forest area in 2006 was Reserved forest 7909 Sq km, protected forest 3568 Sqkm, unclassified forest 5240 Sq.km and the total forest cover was 16717 sq km or 79% of the total area.

The remote sensing image of North East India with respect to forest richness as well as forest disturbance regime was shown in Fig-3.10 and 3.11). The forests of Mizoram have been broadly divided into 3 categories:-

a) Tropical Wet Evergreen Forests (up to 900 m)

b) Tropical Semi Evergreen Forests (900- 1500 m)

c) Sub Tropical Hill Forest (1500- 2158 m)

3.5.3 Inhabitants

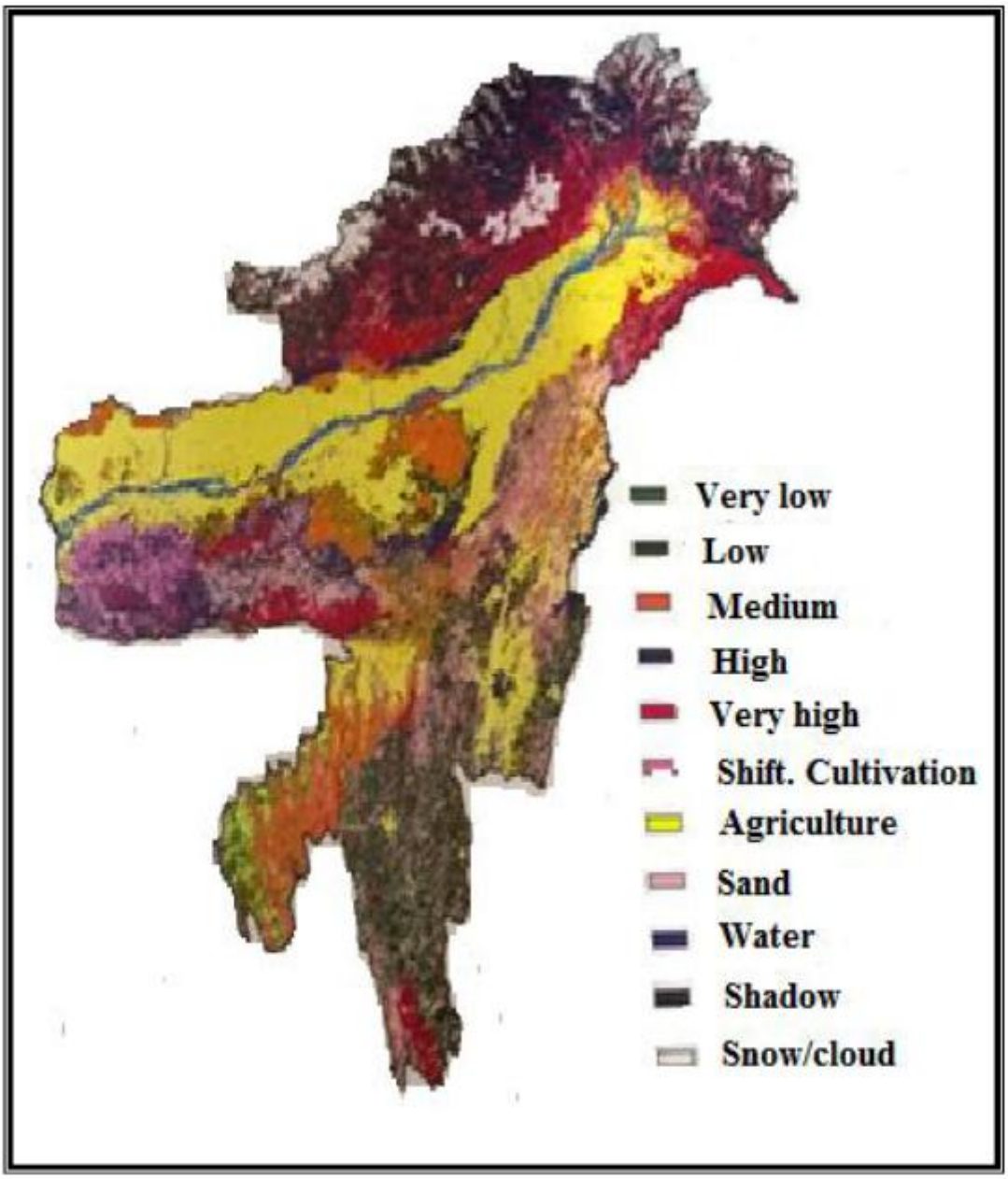
In Mizoram 16 Scheduled Castes, 14 Schedules tribes and 37 sub- tribes have been recognized. The Lushai (Mizo) consists, number of sub tribes or clans and sub clans. The fifteen ethnic groups or population in Mizoram such as Lusei, Paihte, Hualngo, Tlau, Thadou, Ralte, Hmar, Mara (Lakher), Pawi (Lai), Bawm, Pang, Chakma, Buang, Biate and Mog. The Mizo speak Lushai (Mizo) language which belongs to the Tibeto Burman branch of the Dino Tibetan. Agriculture is the main occupation

in Mizoram. More than 70% of the entire population of Mizoram live in rural areas and practice shifting cultivation. Out of the different ethnic groups or population in Mizoram, the Chakmas, the Brus, the Bawms, the Bogs are ethnobioculturely rich in their folklore knowledge whereas other ethnic groups gradually loose their valuable indigenous knowledge of traditional medicines particularly among young generations.

3.6 About the Study Area

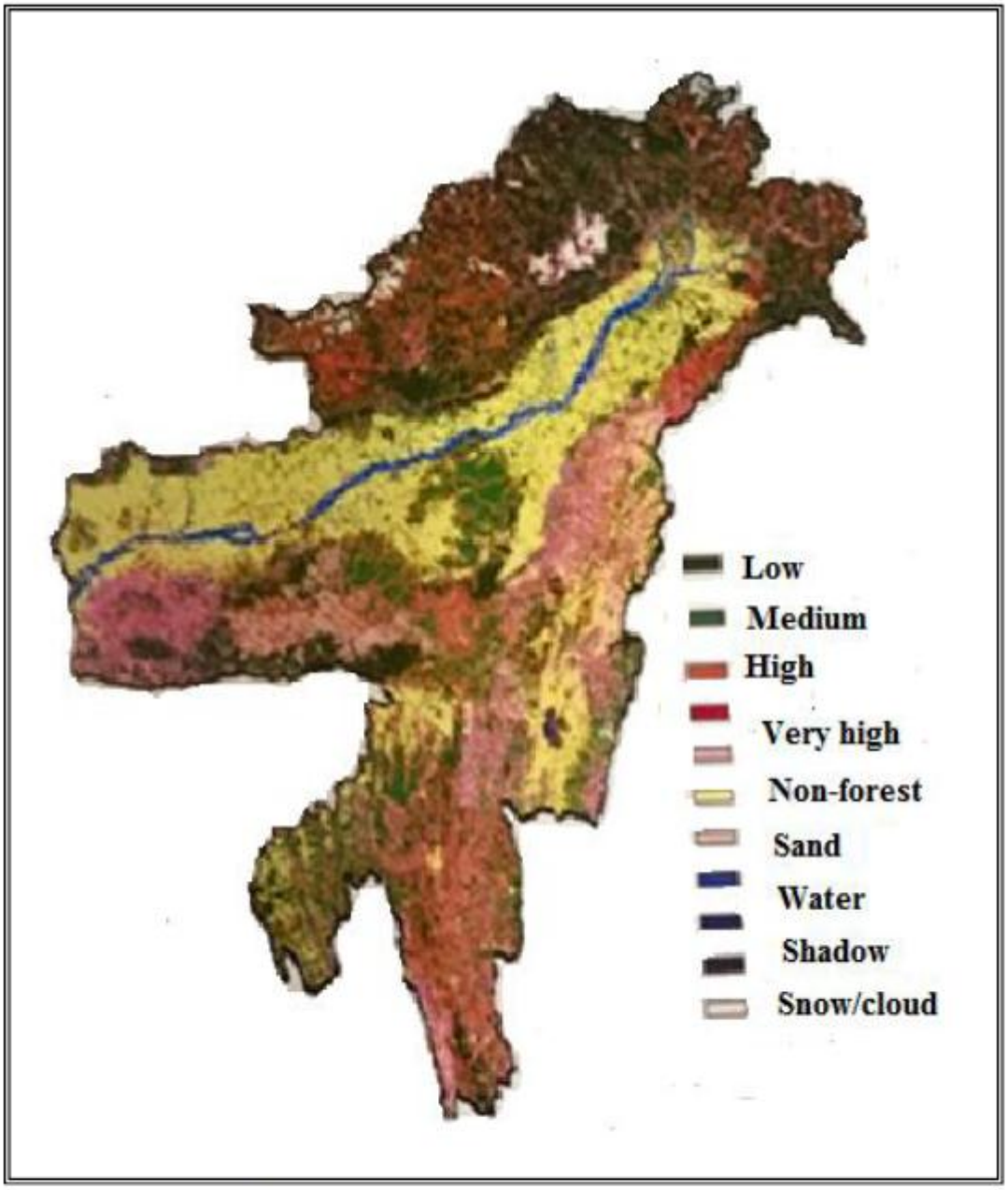
The study area comprises Champhai district of Mizoram located in the North Eastern region of India, lies between 92.15"to 93.29" E longitude and 21.55" to 23.35"N latitude (Fig.3.13a). The Champhai district, 200km distance from Aizawl and located in eastern part of Mizoram and bordering to Myanmar by Tiau river (Fig-3.13 a & b). The average rainfall is 250cm p.a. The altitude ranges from 40m at Bairabi to 2157m at Phawngpui. The tropic of cancer i.e., 23°30'N Latitude cuts across the region in Aizawl district, travering places like Champhai, Chhawrtui, Darlung and Phuldungsei, etc. The state has a total geographical area of 21,087 Sq.km (i.e., 0.64 % of the total area of India.

Murlen National Park is spread in the Murlen village, which is known to be the village of the chief of Hnahlan, Saithuama Sailo. The village is in turn a part of Hnahlan Village. It was declared as a National Park in the year 1991. The Park is fall in the Champhai district of the Indian state Mizoram and initially notified as a Murlen Wildlife Sanctuary in 1989 (Fig.-3.12a); spanning over an area of 100sq.km vide Government of Mizoram No. B.11011/23/89-FST dated 7.9.1989. Later in the year 1991, it was upgraded as Murlen National Park, vide Government of Mizoram No. B.11011/13/84-FST dated 8.7.1991. The Park is situated about 245 km east of Aizawl, the state capital of Mizoram. The Park is one of the protected area, lies close to the Indo-Myanmar border (near the Chin Hills) and ranges in altitude from 400-1897 m above mean sea level (Fig.-3.12b); [GPS- Garmin model) used during the field survey read up to 2092m]. The MNP is well connected by road from Aizawl to Murlen via Champhai and Rabung or Champhai and Vapar.



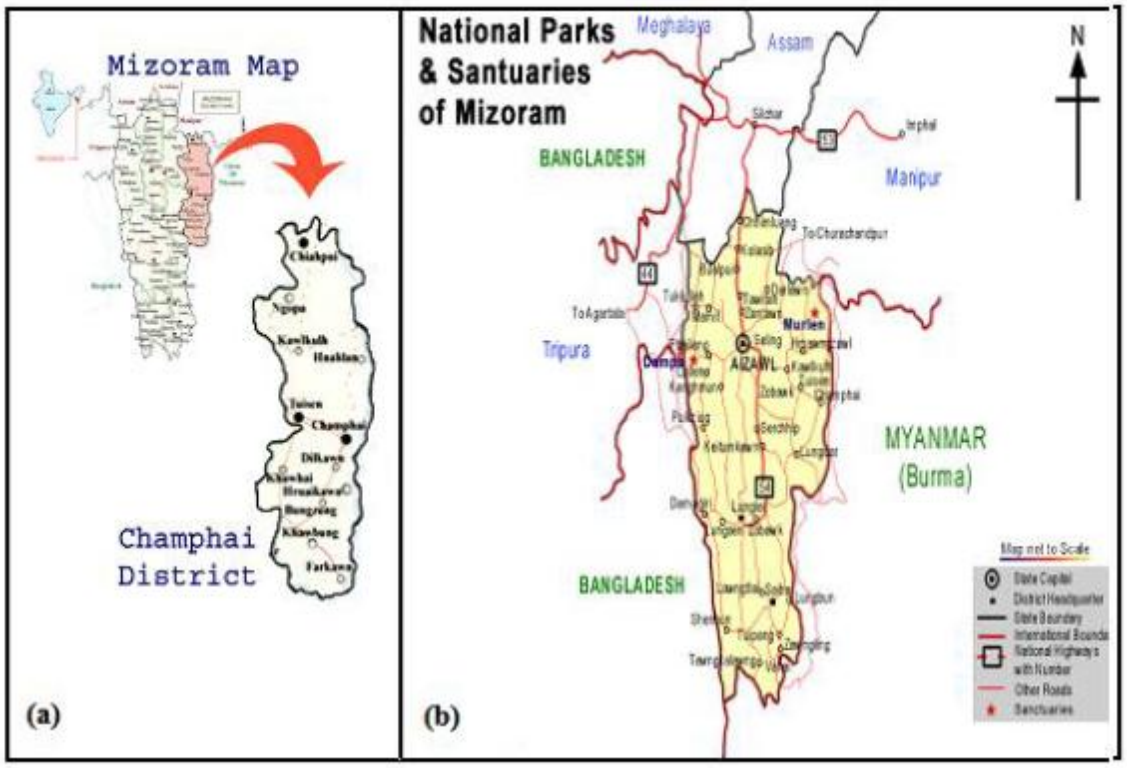
Source: Dubey (2009)

Fig- 3.11: Plant richness map in North East India



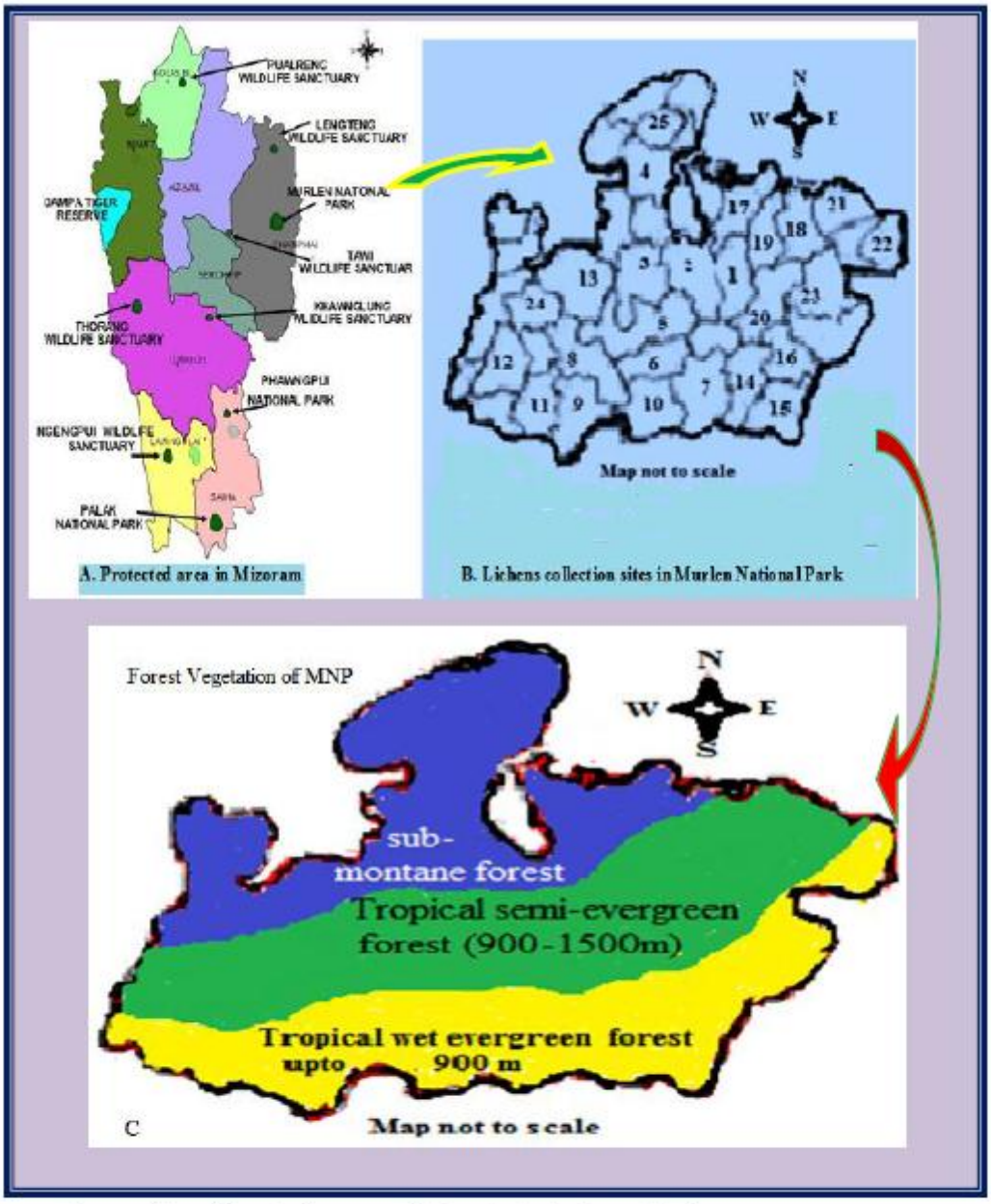
Source: Dubey (2009)

Fig- 3.12: Disturbance regimes of natural resources in North-East India.



Source: http://www.mapsofindia.com/maps/wildlife/wildlife-mizoram.htm

Fig 3.13(a&b): (a) Champhai district, Mizoram, India,
(b) Murlen National Park, study area for lichens collection



Source: https://forest.mizoram.gov.in/page/protected-areas.html

Fig. 3.14 (a-c): Map of protected area of Mizoram, (b) Lichen collection sites in the study area and (c) forest vegetation type of Murlen National Park.

The park has representatives of tropical semi-evergreen and sub-montane forests, which perform a very important role in the watershed catchment areas management (Fig- 3.13c & Table: 3.1). Several rivers, rivulets and brooks traverse the area bestowing pure drinking water abundantly to the thousands of innocent wildlife being purified by nature. One of the scientists that pay visits to the park from foreign countries affirmed that the extremely thick forest in the park is as thick as that of the forest found in the Amazon region. Murlen National Park, in Mizoram, is known to be one of the densest forests of India which allows only 1 percent of the sun's ray to penetrate, even on a bright sunny day bringing about misty and murky inside the forest. This park has some unique trees which are almost 350 years old. Thus the thickness of the national park is often compared with the Amazon forests of South America. This region is famed as 'land of no return' or 'losing area of seven fellow-men'. The forest in the core area had never been so far cleared that most of the trees are mature and huge in terms of size that according the mathematical calculation of Lalthanzuala, the forester of the Park some of them are as old as 325 years.

The MNP falls within the geographical sub-tropic and enjoys sub-tropical climate. The summers are generally warm and wet, but winters are cool and dry. Pre-monsoon rains occur during March- April, whereas regular monsoon commences from June and continues till October. The annual rainfall ranges between 1700 mm to 3900 mm spread over 8 to 10 months. The average temperature varies from 8-20°C during winter and 19-30 °C during summer.

Table 3.1: Agroclimatic and ecological zone of the study area of MNP

Collection Site	Climatic zone	Forest type and Vegetation	Altitude range	Surounding villages around the Park
MNP (E)	Mild-Temperate	Semi-evergreen	1200-1890m above msl	Vapar, Hnahlan
MNP (W)	Sub-tropical	Scattered forestand evergreen and deciduous forest	1200-1650m above msl	Murlen, Kawlkulh
MNP(N)	Mild-Temperate	Evergreen forest	1500-1800m above msl	Khawbung North and Tualcheng
MNP (S)	Tropical to sub-tropical	Semi - evergreen and deciduous forest and bamboo forests	400- 900m above msl	Khawzawl and Rabung

3.7 Flora and Fauna

This park hosts a great diversity of flora and fauna. Common species of flora found here comprise Canes, *Arundinaria callosa*, Rhododendron, *Prunus myrica*, *Pinus khasiana*, *Michelia champaca*, *Betula species*, *Schima wallichii*, *Quercus spp*., *Ficus* sp. etc. The place is also famed for hosting more than 35 species of medicinal plants, 4 species of orchids and many species of ferns and climber plants, etc. Murlen National Park is the home to a vast variety of fauna including Himalayan Black Bear, Malayan Giant Squirrel, Barking Deer, Sambar, Leopard, Tiger, Hoolock Gibbon, Ghoral, Serow (state animal), Malayan Giant, Rhesus Macaque, Wild boar, etc.

Murlen Park is one of the most important bird areas (IBM) supporting several threatened species. The commonly found bird species are Peacock, Sunbirds, Hornbills, Kallej Pheasant, Hume's pheasant, Dark Rumped Swift, Hill Myana, Common Patridges and many more. Murlen National Park however has also reported cases of poaching and hunting. Murlen National Park shelters 150 species of birds, 15 species of mammals. A few people are also involved in the extensive conservation work of Murlen National Park.

3.8 Survey and Collection of lichens

The whole study area Murlen National Park (MNP) is divided into four major locations s, i.e., MNP (East), MNP (West), MNP (North) and MNP (South) respectively and each location was sub-divided into 25 different collection sites (Fig. 3.14b and 3.15). Field survey collection was usually conducted separately for each site and lichen samples were collected randomly from collection sites. A total of more than 1500 specimens of lichens were collected during various field trips in the study area from lower to higher or vice-versa from north to south and east to west within Murlen National Park, Champhi district, Mizoram, India. The specimens were collected usually in three seasons' viz., winter, summer and autumn period.

3.9 Preservation

Both the micro and macrolichens are visible to naked eye in the field. However, a **hand lens,** preferably of10x magnification, is used to examine the fine structure of the thallus for confirmation while collecting. A sharp, flat edged **chisel** (1 to 2 inch wide edge), **a hammer** (1-2kg weight) and sometimes sharp, hard knife can also be used. A pointed or stout flat edged chisel was used to collect lichens growing on rocks. **Polythene packet**s (smaller (6 x 12 inch) and bigger sized), **rubber**

bands, **labeling stickers**, a field book, notebook, pen, pencil, plant press, knife, secateurs (twig cutter),plant press,hand lens, old news papers or blotters, (nylon) ropes, collection bags, herbarium packets are the other items carried during a lichen collection trip. An altimeter, Global Positioning System (**GPS**), or altimetercamera and prepared semi-structural questionnaires were carried for data collection during the study. In case of corticolous lichens the superficial bark is collected to avoid damage to the substratum or the trees. The collected lichen samples are transferred to the polythene packets, labeled and closed with the help of rubber bands. Several such packets are then transferred to larger polythene or collection bags. Sometimes the collected materials are kept in newspaper or blotter packets. The specimens are not kept for longer duration in polyhene as it may get spoiled due to fungal attack due to moisture and changing the thallus colour. Poisoning is not done for preservation of the collected specimen.

The lichens samples are usually collected from the field along with their substratum irrespectively of their growth form. Only the lichens that are very loosely attached to substratum are scraped out and collected. The corticolous lichens growing on tree trunk at reachable height (up to 2 – 3 m from ground) are usually collected and canopy lichens can be found fallen on ground. The ramicolous lichens are collected by cutting twig with secateur. In case of saxicolous lichens smaller pieces of the rocks were collected in order to avoid over weight. The lichens on the edges or crevices of rock are collected by breaking the rock. Sufficient amount of specimens (at least 2 thallus or patch of 5-10 cm) was collected, as the material would be consumed for chemical analysis (TLC), microscopic study and extraction for bio-efficacy investigation. Further, it will also be convenient to distribute it to other herbaria as exsiccates or voucher specimens. The collected lichen samples were transferred to the polythene packets, labeled and closed with the help of rubber bands. Some packets were further transferred to larger polythene or collection bags. The collected materials were also kept in newspaper or blotter packets when packets were lacking / insufficient stock. The different specimens were kept in different packets to avoid mixture. The collections from a single tree or even collections from several same species of tree in a study area were put together in bigger polythene bag. Care was taken for lichen specimens to ensure the specimen not to spoil due to fungal attack when wet or changes in colour as it dries. While collecting the lichens the required data were noted in the field book and its respective number was cut and put in the packet along with the specimen.

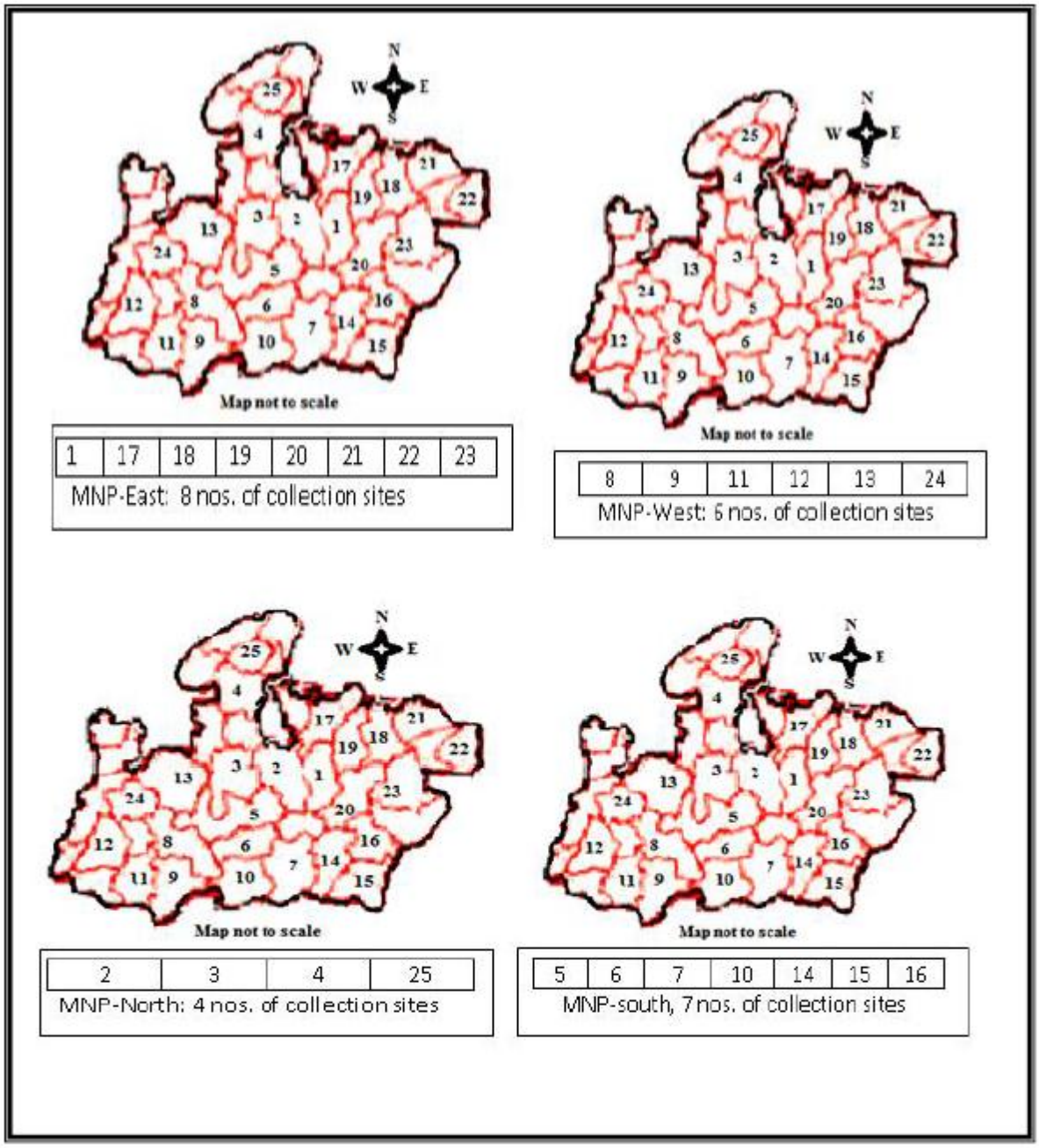


Fig. 3.15: Unscaled map showing different sites sampling for lichen collection in MNP

After returning from field all the specimens were transferred to newspaper or blotter packets along with their labels for drying. The lichen specimens on wet barks were kept in plant press and tied tightly to avoid curled up and shabby look. Much dried and curled specimens can be stretched using water and by spreading on blotters. The specimens were exposed or dried under sun as and when required. In case of insects seen in a collection they should be killed either by drying the specimens openly in hot sun or by placing sealed specimen polythene in deep freezer (- 20°C) for three days. Thick, white or brown colour hand- made paper is used as herbarium packets. The paper sheet of dimension 13.5 x11.5 inches is folded lengthwise twice and the side ways to produce the packet of dimension 7 x 5 inches with upper flap of 3.5 inches to stick the label. The herbarium label contain information on name, local name, if any, family of the lichen species (which is written after identification), details of locality, altitude, longitude, latitude, date of collection, reference number (i.e, Lucknow Botanic Garden (LWG) collectors name and notes on its substratum and other comment based on observation in field as well as in laboratory. After identification name of the expert person who identified (determined) all the specimens is metion along with the date. The dried lichen specimen were pasted on to a thick, hard paperboard of dimension 6.5 x 4.5 inches (little less than the total packet size) and then placed inside the herbarium packet. The board also given the same reference (LWG) number as on the label. A herbarium packet contain single specimen of single species and mixtures is avoided. The properly labeled herbarium packet were stacked in rectangular boxes (like shoe box) and such boxes were kept inside the steel almerahs or wooden cupboards in the department of Horticulture, aromatic and Medicinal Plants, Mizoram University, Aizawl and NBRI lichenology laboratory, Lucknow for further reference.

3.10 Identification of lichens

The collected lichen specimens were initially segregated according to their growth form. Within the growth forms the specimens were further grouped according to the type of their fruiting bodies (apothecia, perithecia, or sterile). Before starting the examination of specimen for identification, the simple but necessary items like razor or snapper blades, plastic-handled needles, pointed and flat-tipped forceps, injection syringes (2 ml capacity) or capillary tubes or glass rods, pencil, sharpener, eraser, small transparent scale, round brush of 0 – 1 size, Quick Fix, permanent ink pen, etc. were collected. Syringes were used for keeping and applying chemical reagents during identification. One syringe contains distilled water in it. The syringes were kept capped while not in

use. All the collected lichens were identified by studying their morphology, anatomy and chemistry. The identifying morphological and anatomical characters to be observed is differ from group to group as shown in Fig 3.3 - 10. However, some of the common characters observed for segregation of lichen were shown as flow chart as given in fig- 3.16.

3.10.1 Morphology

The morphological characters of lichens specimens were studied under dissection or stereo microcope. Type of thallus or growth form (leprose, crustose, foliose, squamulose, dimorphic, fruticose) its shape (irregular, circular) and size were recorded (Fig- 3.1 and 3.20).

(a) Upper surface

The colour of the thallus, textures (smooth, rough, warty), presence of finger like projections (isidia) (fig- 3.22, B), granular structures (soredia), fine powder (pruina), black dots (pycnidia) and whistish decorticated areas (pseudocyphellae) was noted. The branching pattern, length and breadth of marginal lobes, presence of hair-like structures (cilia) in case of foliose lichens were noted. In case of fruticose lichens length of the thallus, branching pattern, flatness or cylindricalness of the thallus also noted down (fig. 3.16).

The morphology of fruting bodintes has studied separately. In case of apothecia, shape (rounded or stretch, size, attachment (stalk or sessile), colour and texture of the margin and disc, presence or absence of powder (pruina) on the disc, shape of the disc (convex or concave) were noted as necessary characters for identification. In case of perithecia, its colour, shape, size and the position of its opening (ostiole, apical or lateral), single or grouped were noted (fig- 3.21 B).

Some lichens thallus emits florescence (whitish, creamish, yellowish, and bluish) when observed under UV light due to the presence of chemical substance called lichexanthone.

Such lichens were examined by keeping them in a closed UV lamp chamber under UV light of wavelengths 254 and 365nm.

(b) Lower surface

The lower surface of only foliose lichens were seen. This was absent in crustose lichens while dimorphic and foliose lichens did not show dorsiventral differentiation. The colour of lower surface,

presence of any pores (cyphaellae, pseudocyphellae), presence or absence of rhizines (root like structures), their colour, distribution, branching pattern, abundance were noted down.

The identification was done morpho-anatomically using a Labomed TM stereo-microscope and Leica TM DM 500 optical microscope and chemically with the help of thin-layer chromatography. Identification was done using relevant key and monographs (Divakar & Upreti 2005; Awasthi 2007) as they were the important literatures referred for identification of lichens especially for India, Nepal and Sri Lanka.

3. 10.2 Anatomy

The anatomy of lichen thallus and fruting bodies was examined under compound microscope with minimum magnification of 40x. The anatomy of the thallus was occasionally studied to see the thickness of various layers (Upper cortex, algal layer, medulla, lower cortex) type of algae and their distribution (stratified – heteromerous or uniform- homeomerous) and arrangement of fungal hyphae (vertical or horizontal) within the thallus. The section of thallus was cut with snapper or razor blade by keeping the fragment of thallus in potato or papaya pith. Lichen with blackish, bluish, slate grey thallus usually has blue green alga, while grayish, yellowish, brownish, greenish thallus has green alga. The algal layer of the lichen thallus was exposed by scrapping the upper cortex with blade and algal part (which appears dark green, blue green, black) was picked up with blade or needle, transferred to the slide and examined under microscope.

The anatomical character of fruting bodies (ascocarp) is very important identification aids especially in case of crustose lichens. The type of spore (simple, septate) (Fig-3.21), colour hyaline, brown) their shape, size, numbers of spores in a spore-sac (ascus), colour of ascocarp wall (exciple), presence or absence of crystal and algal cells in the wall, colour and height of different layers (hymenium, epi and subhymenium, hypothecium) within in the ascocarps were noted. The branching pattern (dichotomous, simple, forked) and arrangement of paraphyses, shape and colour of apical cell are important character noted for identification. The thin, hand cut section of ascocarp was taken with the help of blade while it was still attached to the thallus or substratum and by viewing through dissection or stereomicroscope (Fig- 3.21 B).

The anatomical structures, sexual reproductive organs and spores were studied after cutting the section of dry material by microtome and with the help of safety razor blade. The thin dry sections

of the thallus and ascocarp were immersed in 90% ethyl alcohol to drive off the intercellular or inter-hyphal air bubbles and the sections were mounted in water or in cotton blue in lactophenol. The colour of medulla, epithecium, hypothecium and ascus were recorded. The shape and size of the asci, ascospores and conidia were measured in the sections mounted in water. The measurements of the thallus, medulla, epithecium and hymenium were generally taken in the sections mounted in cotton blue. The thallus size was measured in centimeter, lobe size and ascocraps in millimeter and thallus, epithecium, hymenium thickness, asci and ascospores size in millimicron (µm).

3.10.3 Chemistry

Lichens produce around 800 secondary metabolites which are commonly known as **lichen substances**. Out of the 800 lichens substances around 650 are unique to the lichens and not available in any other groups of plants. The first chemical test conducted on lichen thalli for taxonomic purpose was by ylander in 1860. In recent times spots test is much standardized and one of the important step in identification of lichens. Today species discrimination on the basis of chemistry has become inseparable procedure in the lichen taxonmy.

Most of these lichen substances useful for identification of lichens (chemotaxonomy). The lichen substances were identified by performing colour test, microcrystalography, thin layer chromatography (TLC) or by high performance liquid chromatography (HPLC). The probable metabolic pathway for synthesis of lichen substances occurs in lichen was shown in fig- 3.24.

3.10.4 Colour tests

For spot test the upper cortex of thallus of each specimen was initially scraped off with a razor blade to expose the medulla. A drop of solution, K, C, Pd, KC and was placed on the cortex or medulla and colour reaction was noted down I (See box no. 2). Colour tests were performed by chemical reagents by applying it on thallus and medulla resulting change in colour. A positive change is denoted by a positive symbol (+ ve), followed by the colour produced and no change in colour is denoted by a negative symbol (-ve).

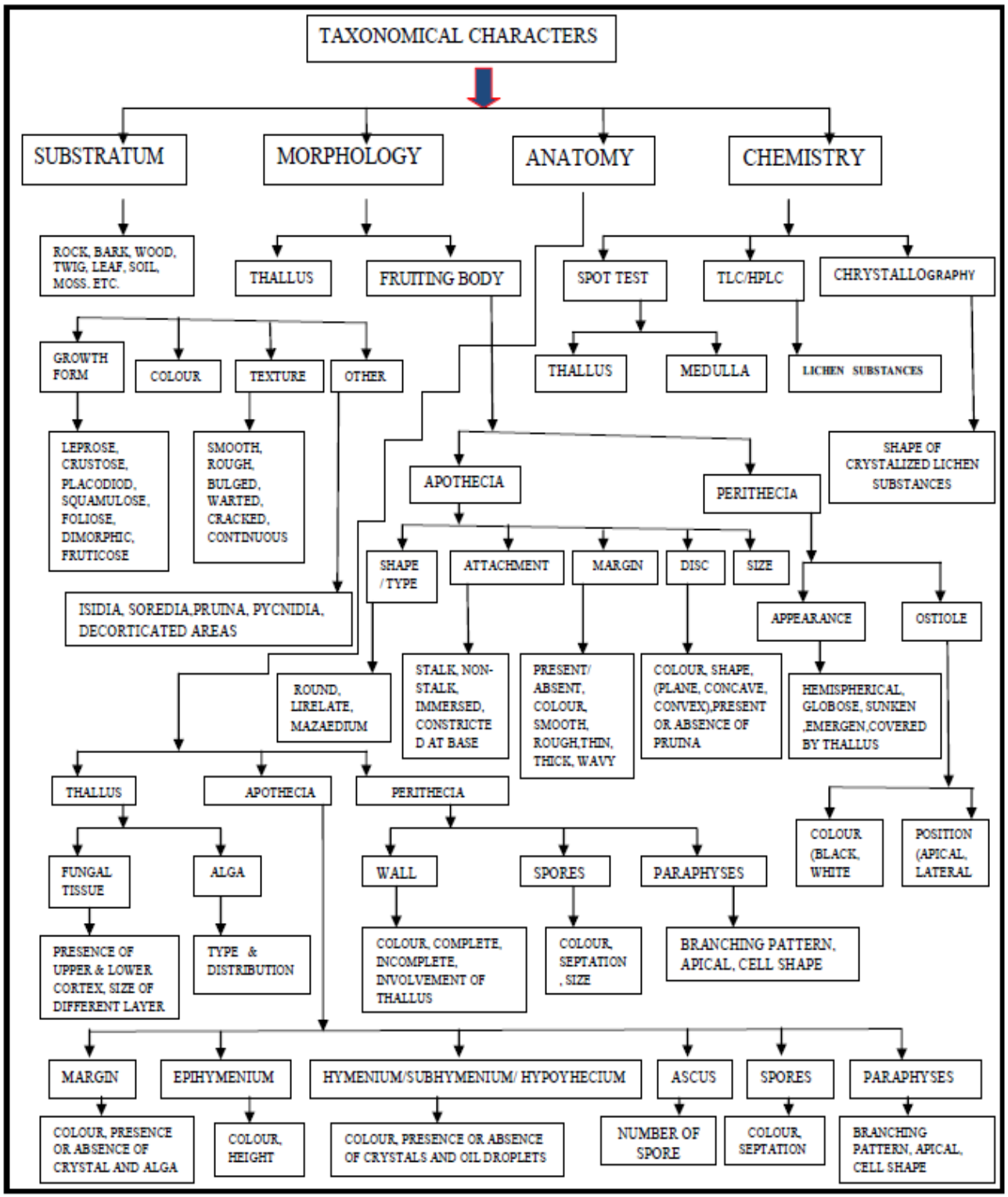
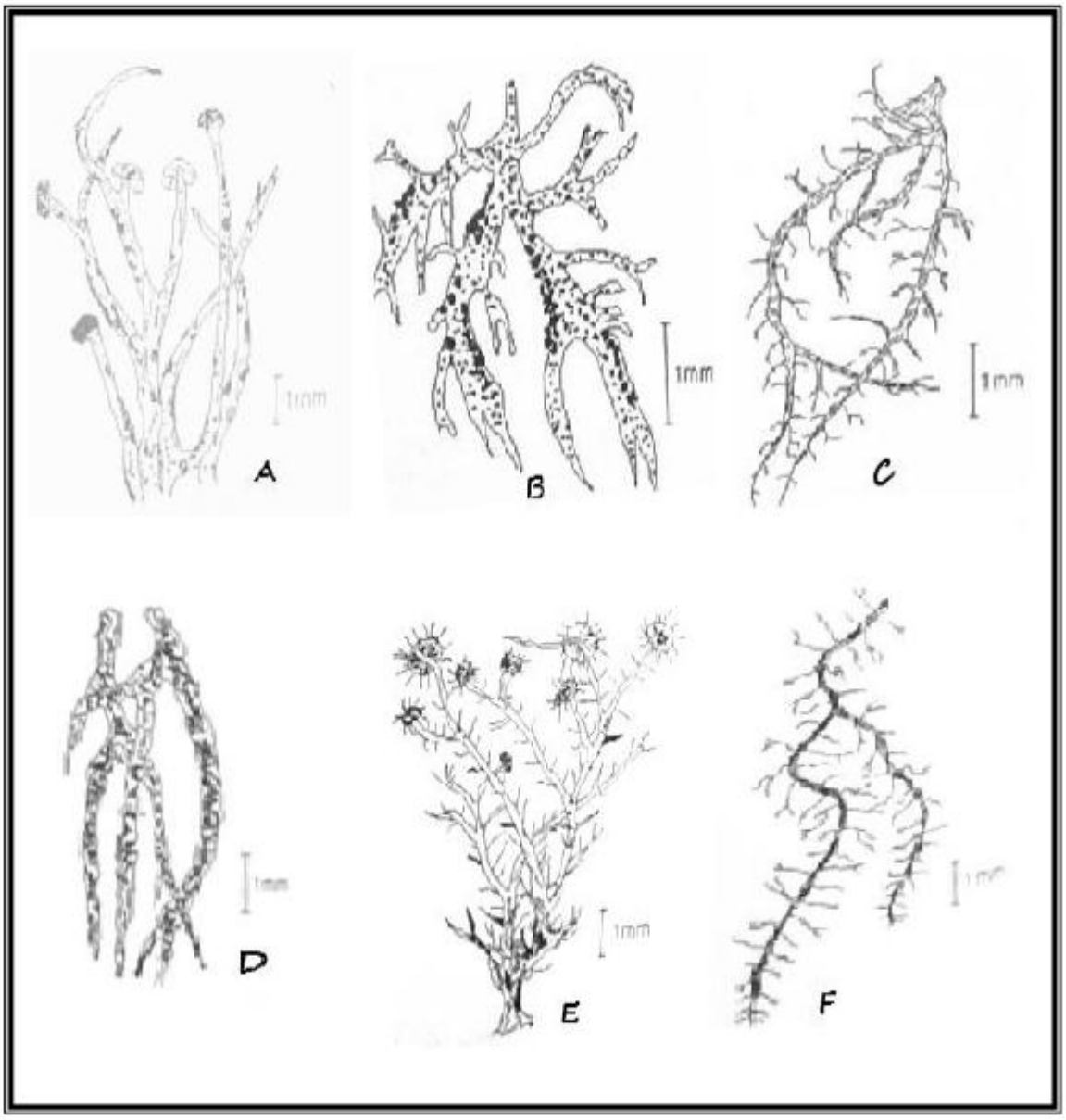
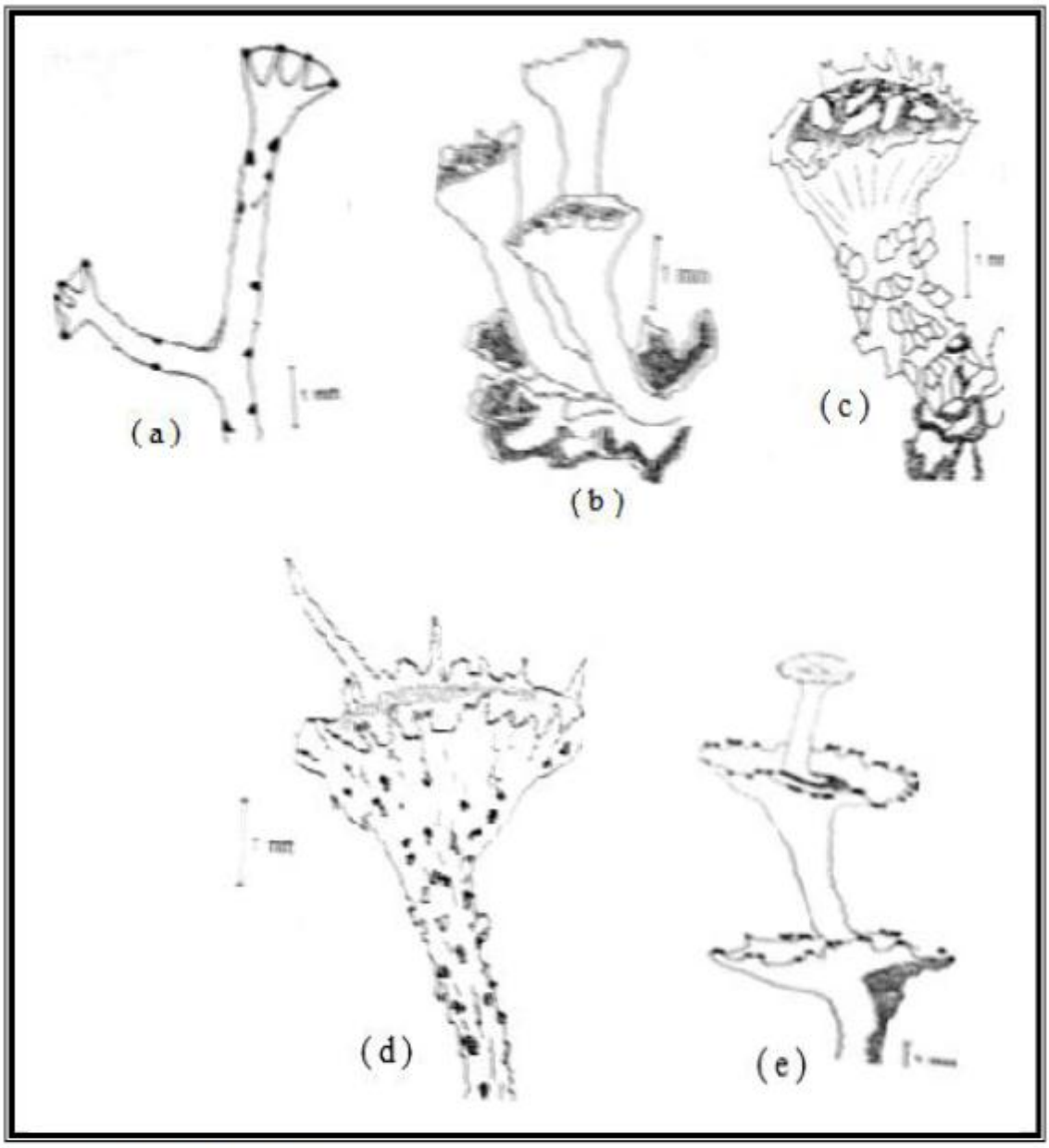


Fig- 3.16: Flow chart of common characters used for segregation of lichens **Source: Nayaka (2013)**



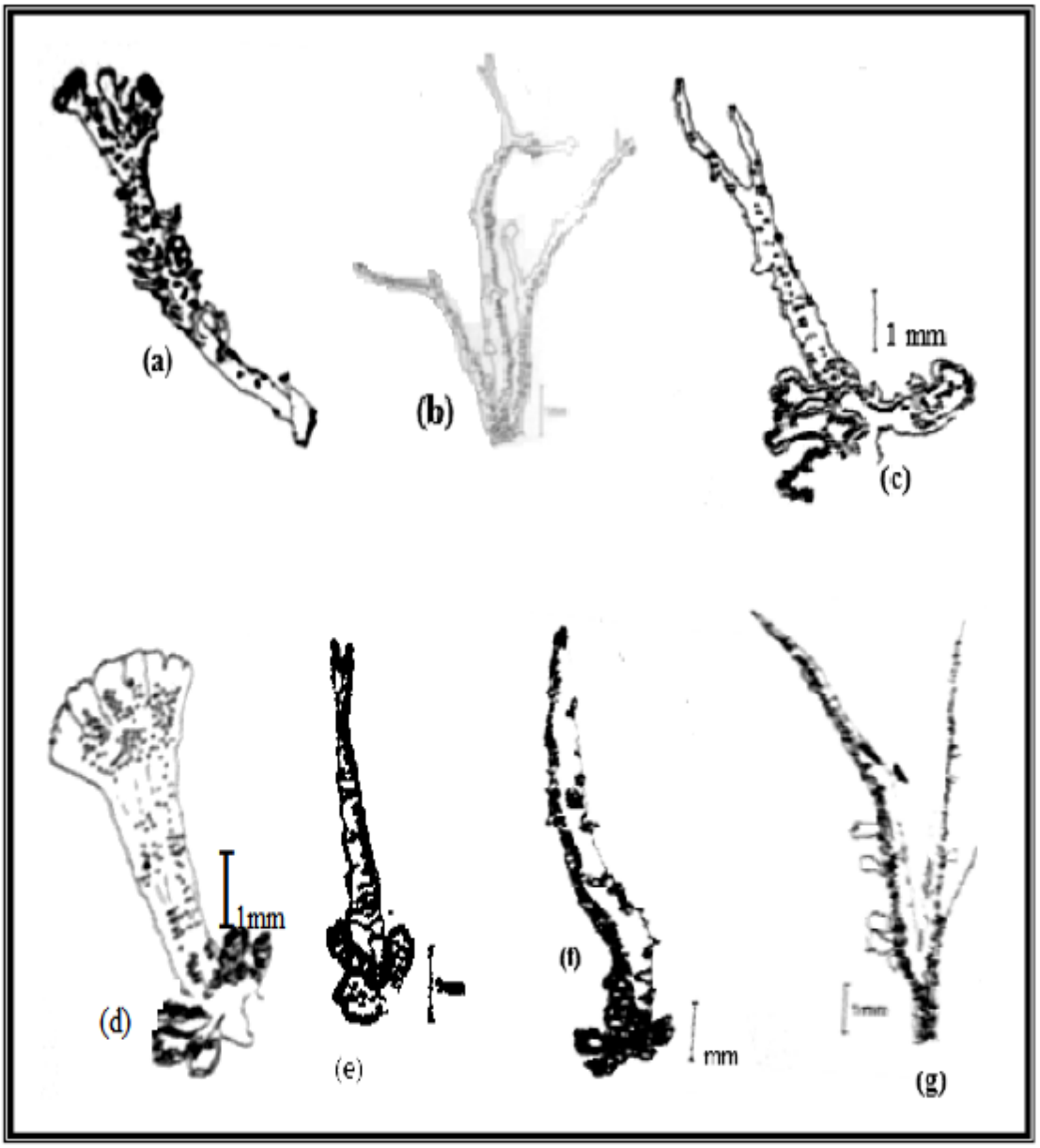
Source: Mishra and Upreti (2015)

Fig. 3.17(A-F): Different types of fruticose thalli: (A) *Rocella montagnei* with marginal soralia, (B) *Bryoria himalayana,* (C) *Evevnia mesomorpha,* (D) *Ramalina sp.* (E) *Usnea* sp. (F) *Usnea longissima*



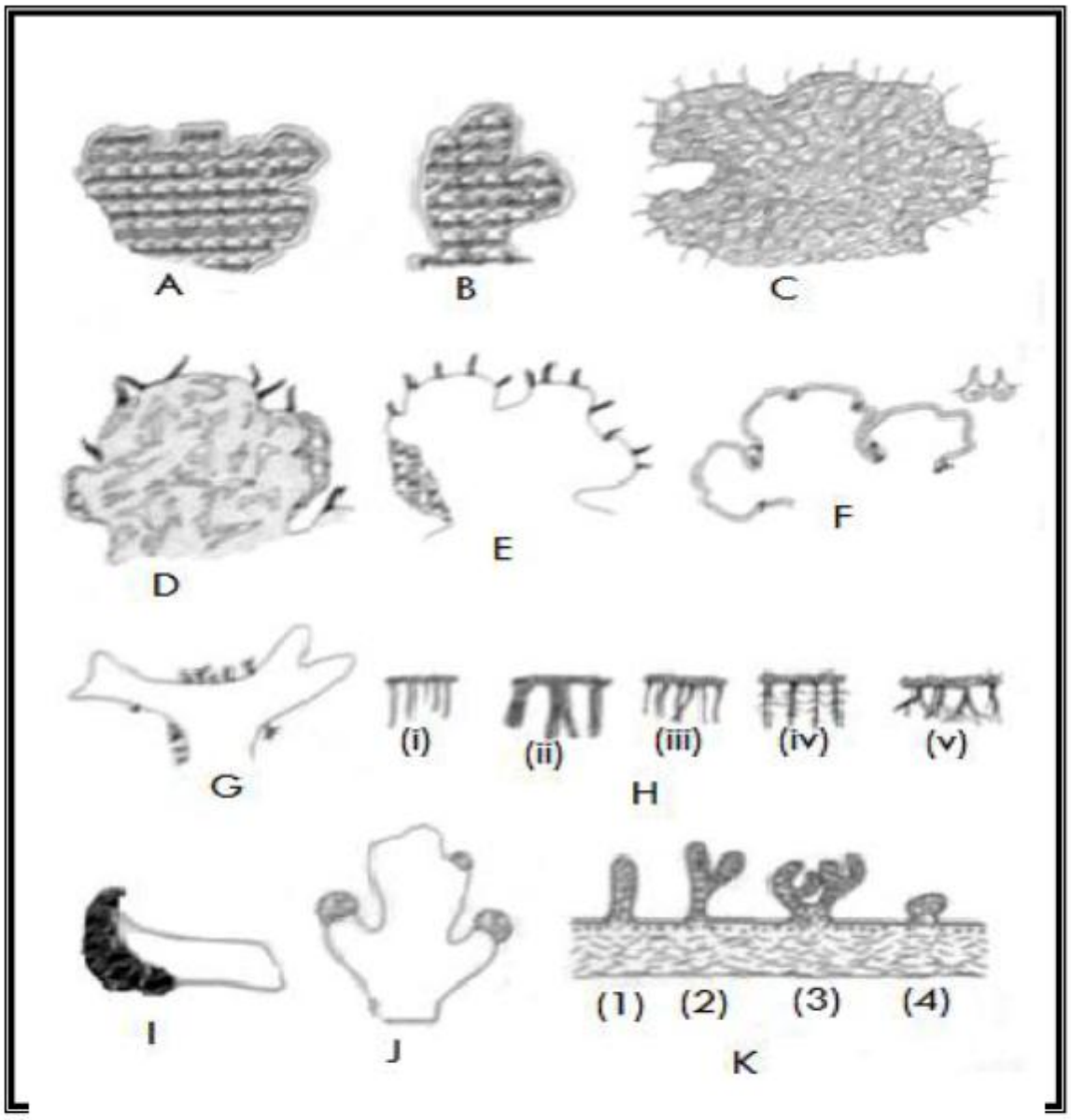
Source: Mishra and Upreti (2015)

Fig. 3.18(a-e): Different morphological character of podecia in *Cladonia* (a). Podecial cup opens and asciopen, (b) Podecial cup without corticated plane with cavity white squamulose, (c) Podecial cups with apothecia and corticated plane, (d) Marginally prolirelate podecial cups (e) Podecia with centre proleratum



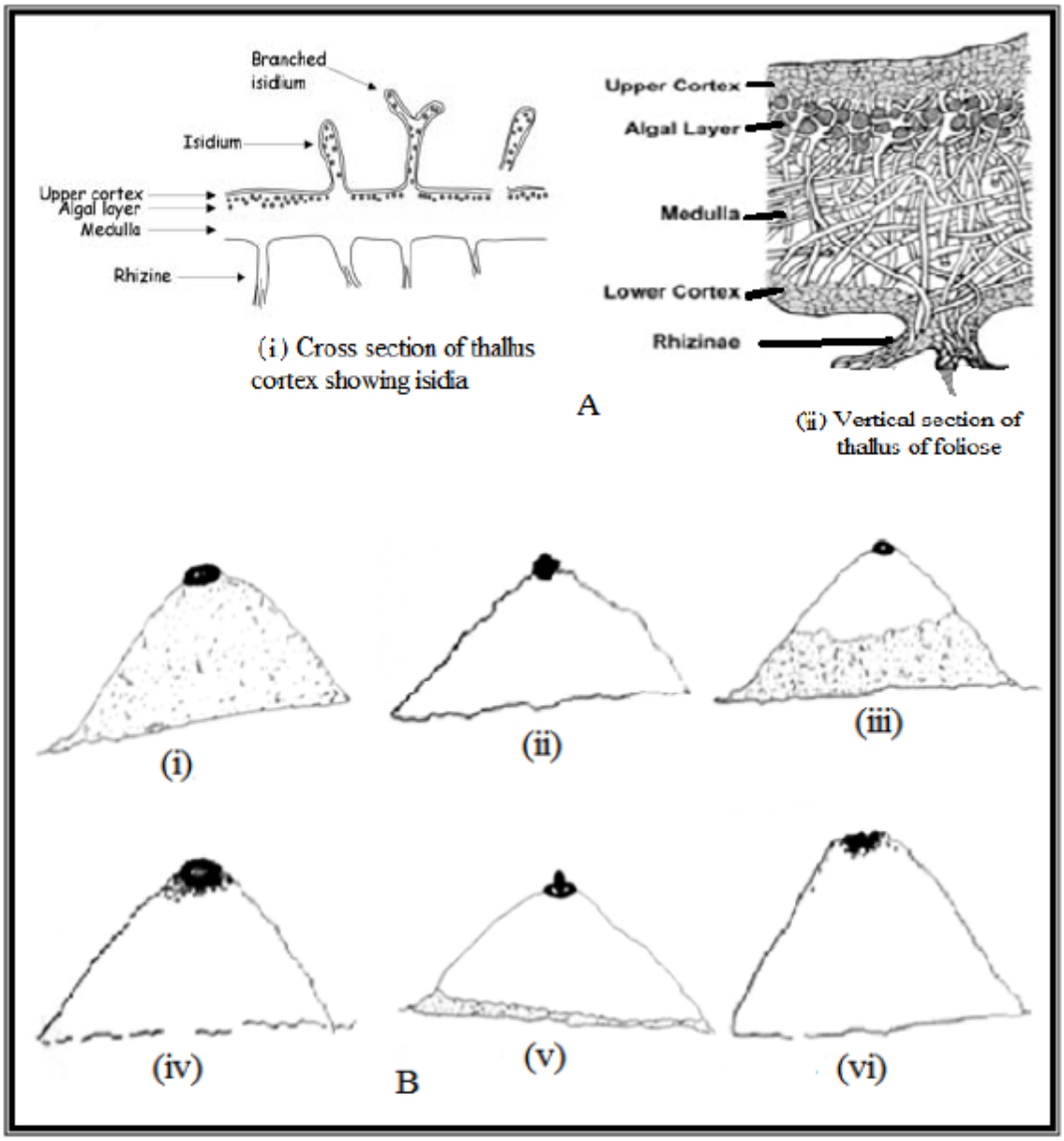
Source: Mishra and Upreti (2015)

Fig-3.19 (a-g) : Different morphological character of podecia in *Cladonia*
(a) Decorticated podecia with basal squamules, (b) Sparingly branched podecia,
(c) Sorediate podecia with macrosquamules, (d) Farinose sorediate,
(e) Podecia corticated base, (f) soredia with microsquamules,
(g) Longitudinal fissures and open end of podecia



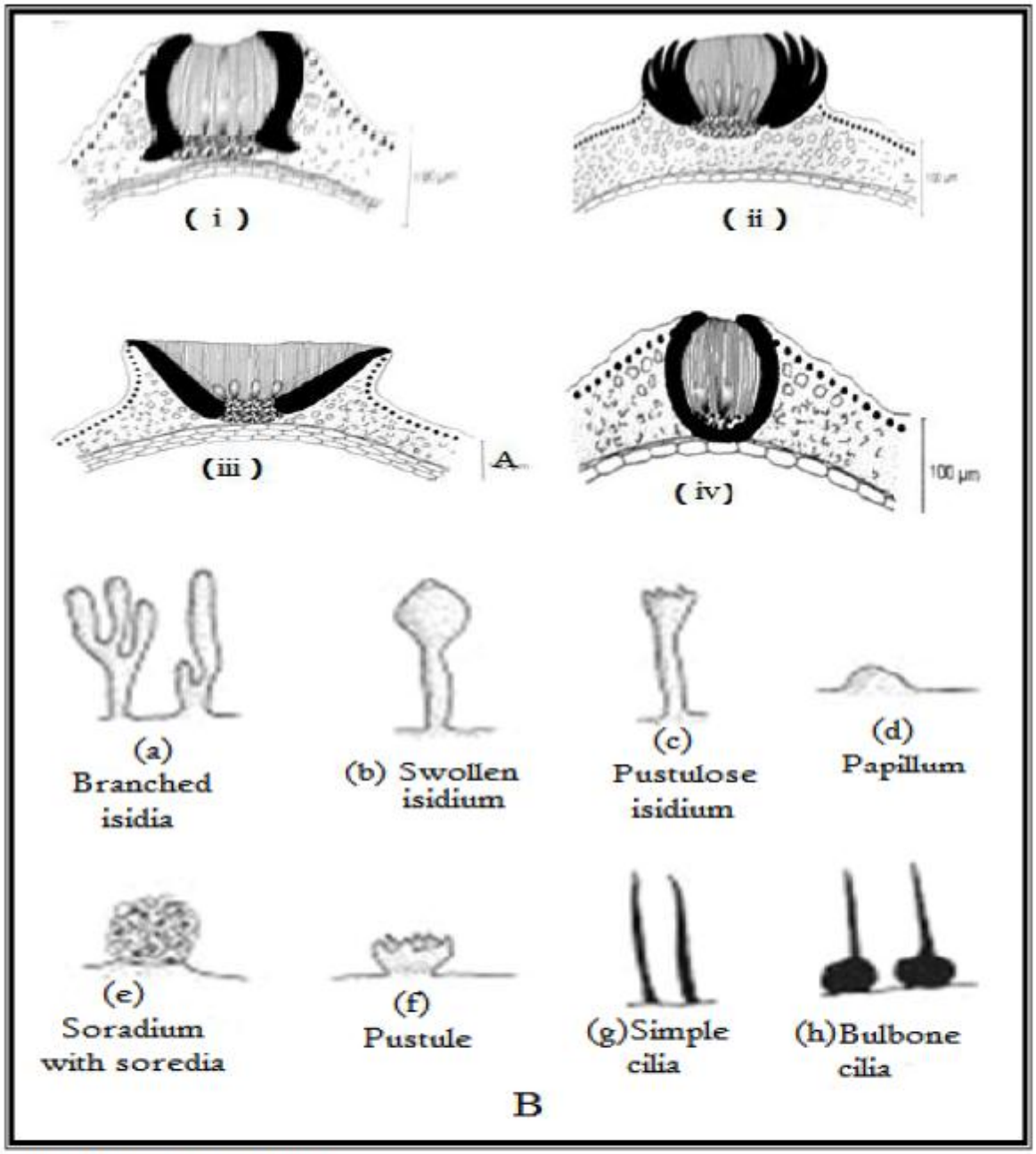
Source: Mishra and Upreti (2015)

Fig. 3.20 (A-K): Morphological characters for the segregation of Parmeloid taxa
(A) Punctate pseudocyphellae, (B) Effigurate pseudocyphellae, (C) Reticulate maculate, (D) Effigurate maculate and robust cilia, (E) Simple cilia evenly distributed, (F) Bulbate cilia, (G) Tuttled cilia , (H) Rhizines, (i) Simple hyphal, (ii) Hyphal rhizines in bundles, iii) Simple, (iv) Squamously branched, (v) Dichotomously branched, (I) Labiom sorelia, (J) Terminal Sorelia, (K) Isidia, (i)Simple, (ii) branched, (iii) Coralloid, (iv) Globose.



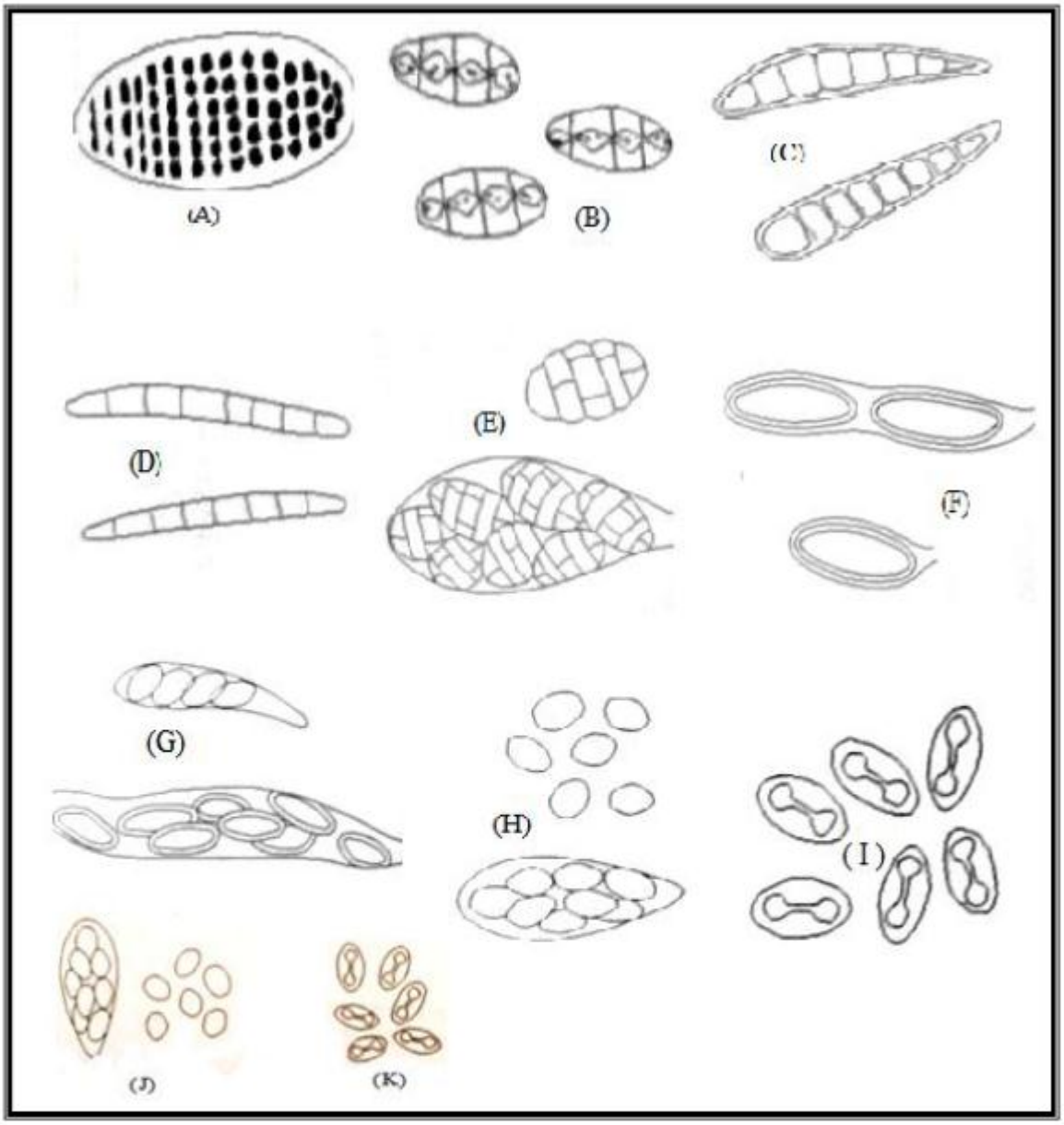
Source: Nayaka (2013) and Mishra and Upreti (2015)

Fig- 3.21 (A&B) : A. (i) C.S. of thallus showing cortex isidia, (ii) V.S of thallus of foliose
B. Ascocarp cover and ostiole types in pyrenocarpous lichen (i) Ascocarp completely covered, (ii) Ascocarp hat covered, (iii) Ascocarp naked, (iv) Ostiole papilate, (v) Ascocarp ulbicate, (vi) Ostiole depressed.



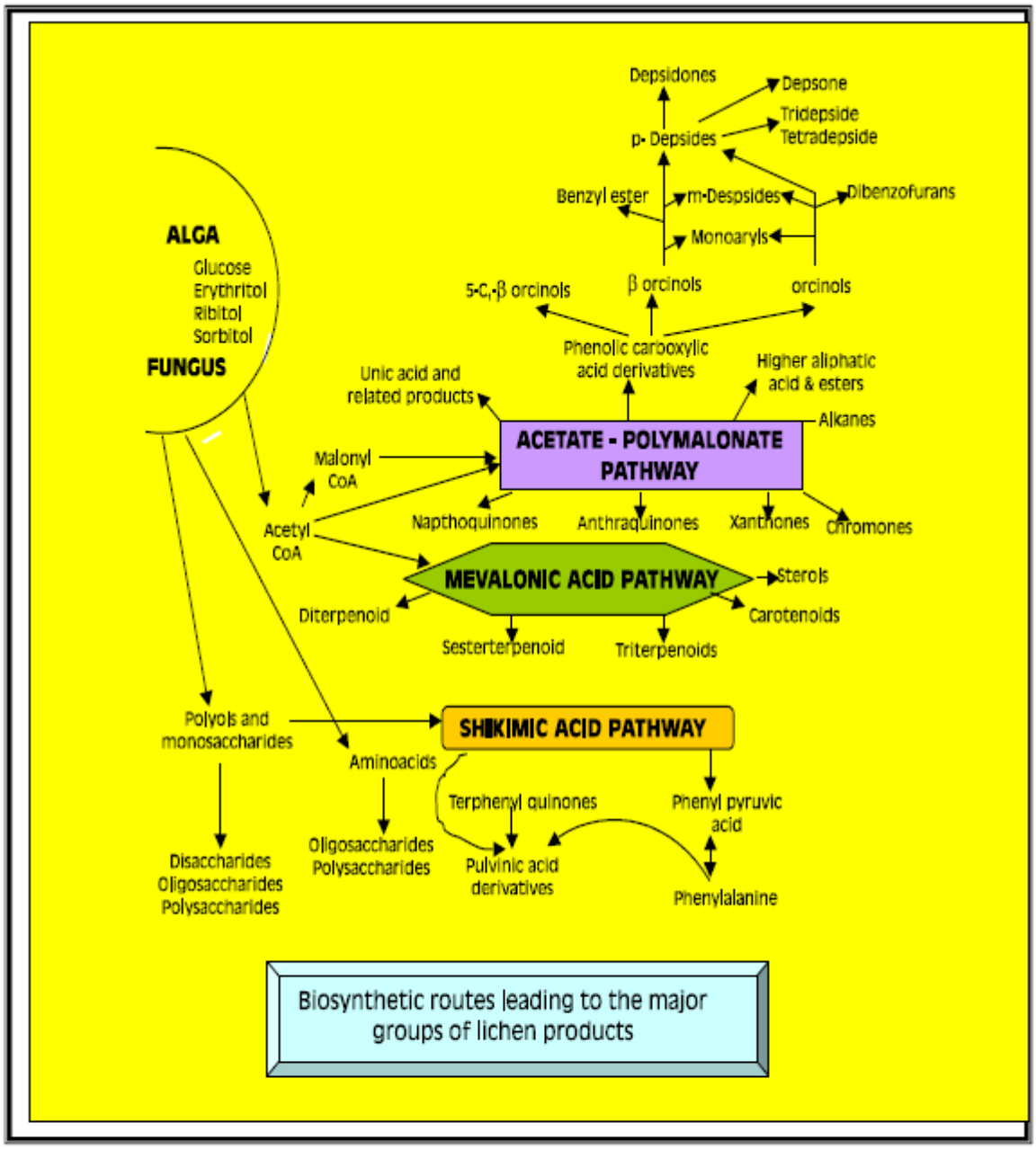
Source: Mishra and Upreti (2015)

Fig- 3.22 (A&B): A. Different anatomical charaters of lirellae of graphidaceous taxa
(i) Exciple open, labia convergent, entire, (ii) Exciple open, labia convergent, sulcate,
(iii) Exciple open, labia divergent, entire, (iv) Exciple closed, labia convergent entire.
B (a-h): Different types of anatomical character of isidium in lichens.



Source: Mishra and Upreti (2015)

Fig- 3.23(A-K) : Different types of spore of lichens (A) Rinodina, (B) Anthracothecium, (C) Archopyrenia, (D) Pyrenula, (E) Graphis. (F) Bacidia, (G) Diplochistes, (H) Pertusaria (1-2 spored), (I) Pertusaria (4-8 spored), (J) Lecanora, (K) Caloplaca



Source: Thomas (2008)

Fig- 3.24: Schematic diagram of biosynthetic pathway for major groups of lichens natural products.

Box. 1: The colour spot test reagents and their possible reactions are given in below box

K = **% aqueous KOH solution**

(a) Turns yellow then red with most *o-hydroxy* aromatic aldehydes.
(b) Turns bright red to deep purple with anthraquinone pigments.

C = **saturated aqueous $Ca(OCl)_2$ or common bleach (NaOCl) solution.**

(a) Turns red with m-dihydroxy phenols, except for those substituted between the hydroxyl groups with a –CHO or $–CO_2H$.
(b) Turns green with dihydroxy dibenzofurans

KC = **10% aqueous KOH solution followed by saturated aqueous Ca $(OCl)_2$ or common bleach (NaOCl) solution.**

(a) Turns yellow with usnic acid.
(b) Turns blue with dihydroxy dibenzofurans.
(c) Turns red with C-depsides and depsidones which undergo rapid hydrolysis to yield a *m-dihydroxy* phenolic moiety.

PD = **5% alcoholic p-phenylenediamine solution.**

(a) Turns yellow, orange or red with aromatic aldehydes.

Sources: Nayaka (2013)

The chemical reagents used for colour spot test were aqueous potassium hydroxide solution (K), Bleaching powder or aqueous solution of calcium hypochlorite (C) and aqueous solution of paraphenyldiamine (Pd). The composition of the reagents is given below and the possible mode of action is given in the box 1.

K test: 25 % aqueous solution of potassium hydroxide (10 g KOH pellets + 100 ml distilled water) was applied to upper surface of thallus (cortex), or on the medulla and part of apothecia by exposing it with blade, or on both. A drop of K solution was placed on the cortex or medulla and colour reaction was noted. It is also used as a clearing agent for sections of fruiting bodies and thalli, as it often dissolves the crystalline lichen subs-tances and removes some mucilage that may obscure detail in sections. Confirmation test also performed on the medulla of *Parmelinella wallichiana* which gives K+ red colour.

Pd test: Solution of paraphenylenediamine is prepared in ethanol or alcohol in a small quantity for the use of a day, because it is unstable and cannot be used for the next day. A more stable solution called Steiner's Pd is prepared by dissolving 1.0 gm of paraphenylenediamine and 10 gm of sodium sulphite in 100ml of distilled water with 1.0ml of a liquid detergent. This reagent keeps well for about a month. The confirmation test also performed on the medulla of *Parmelinella wallichiana* which gives Pd+ orange colour.

C test: A freshly prepared aqueous solution of calcium hypochlorite or bleaching powder or modern commercial bleaching fluid containing active chlorine is used. This solution is prepared by dissolving calcium hypochlorite in the distilled water in 2% ratio. Usually, C and Pd test were performed on the medulla and colour changes were recorded. Confirmation test was performed on the medulla of *Puctelia borreri* which gives C+ pink colour.

KC test: At a particular spot of thallus, K is applied first and immediately followed by Csolution over earlier K solution. The immediate change in colour of the thallus indicated a positive reaction (Hale, 1979).

I test : 2-5 gm of iodine will be dissolved in water with 0.5 gm of potassium iodide. It does not react with lichen secondary metabolites but rather with starch like polysaccharides in thethallus or fruiting body. The reagent keeps well for several days and is to be renewed when colour fades.

UV test : A number of secondary metabolites in lichens exhibit a characteristic fluorescence under UV light. The response of (+ve or - ve) these metabolites plays a vital role in the lichen identification. Identification was done following comparison of the morphometric and biochemical test results with those in published literature and identification keys, e.g., Here (1963), Hale (1979), Nash III (1996), and Sipman (2005).

3.10.5 Micro-crystallography

Micro-crystallography was introduced by Asahina (1936 & 1955). The method does not need elaborate equipment. A small fragment of lichen to be investigated will be placed on the middle part of a microscopic glass slide and one-two drops of acetone or any other organic solvent aredripped on to the fragment by means of dropper pipette. Lichen substances if present will be dissolved in the solvent (Box 2) and extracted on the slide as residue in a ring form around the fragment as soon as the solvent evaporates. The thallus fragment will blow off. A microcover glass is placed over the residue

and a drop of one of the crystallizing fluids (detailed below) is placed at the edge of the cover glass. The fluid gradually seeps in. The slide is then heated gently over a sprit lamp. The residue dissolves in the fluid and lichen substances gradually crystallize into their characteristic of shapes on cooling. These crystals are observed under low power of microscope and identified by comparison with the photographs or line diagram published by Asahina (1950, 1952), Hale (1967), Thomson (1967), Krog (1951) and others. Identification of depsides, depsidones and dibenzofurans can usually be confirmed by this method.

Box. 2: Reagent/solvent adopted to study Micro-crystallography of lichen systematic

- G.E. Glycerol: acetic acid, 1:3
- G.A.W- Glycerol: ethanol: water, 1:1:1
- G.A.Ot- Glycerol: ethanol: ortho-toluidine, 2:2:1
- G.A.An- Glycerol: ethanol: aniline, 2:2:1
- G.A.O- Glycerol: ethanol: quinoline, 2:2:1

Sources: Nayaka (2013)

3.10. 6 Chromatography

Thin Layer Chromatography (TLC) was performed in solvent system A (Toluence 180ml: 1-4 Dioxane 60 ml: Acetic acid 8ml) following Walker & James (1980) for identification of secondary metabolites. Incase of lichen genus *Dirinaria* microcrystalography was performed for identification of divaricatic and sekikaic acids through their shape and structures of crystal.

(1) Extraction of lichen substances for identification by TLC: A standardized protocol developed by Culberson (1972), Culberson and Kristinson (1970) and Culberson *et al.,* (1981) was adopted for identification of lichen acids. Firstly, the extracted lichen crude extracted was dissolved in acetone to prepare a final concentration of 2mg/ml.

(2) Preparation of TLC Plate: Silica gel pre-coated thin Aluminium plates (silica 60 F254 aluminium plates, Merck) were used for TLC. A line was drawn at 2 cm from base of the plate (loading line) and anther at 15 cm (finishing line). On the 2 cm line several spots were marked at equal distances.

(3) Loading : The acetone extract in the test tube were the then spotted on the TLC plate with the help of capillary tube. The capillary tube should be thin and separate tubes were used for each extracts to avoid contamination. The spot on the TLC plate was concentrated enough by repeated loading of the extract on the same spot. In the same TLC plates, *Parmelinella wallichiana* species is used as control to distinct the Rf classes 2 and 7, as it gives 2 spots, salazinic acid and atranorin as given in (Table 3.2).

(4) Prepration of solvent system and TLC tank : Freshly prepared solvent (box 3) was used for the experiment. Rectangle specimen jar was used as TLC tank and it was covered with the glass lid. The tank was made air tight by applying grease os Vaseline at the rim of the jar where the glass lid touches. Inside the TLC tank towards back side filter paper sheet was placed. The wet filter paper provide uniform vaporous atmosphere inside the tank and help lichen compounds to separate better. The quantity of the solvent was sufficient enough and it was just below 2 cm loading line of TLC plate. In the bottom of the TLC tank a flat broader glass slide was placed at the base to provide flat 'flat form' for placing TLC plate. Plate is developed in a standard solvent (3 of the most common).

Box No. 3: Solvent systems usually used for the chromatography (TLC)

Solvent A: Toluene: 1,4-dioxane : Acetic acid (180 : 60 : 8 ml)
Solvent B: Hexane: Methyl ter-butyl ether: Formic acid (140 : 72 : 18 ml)
Solvent C: Toluene: Acetic acid (70 : 30 ml)

Sources: Nayaka (2013)

(5) Running : The spotted TLC plate was placed inside the TLC tank. The solvent rises up on the TLC plate passing through the loaded spots. The heavier lichen substances are carried away as the solvent rises upwards; hence the lichens substances get separated. The solvent was allowed to touch the finishing line drawn at 15 cm and then removed out of the TLC tank. The process takes about 40 – 50 minutes.

(6) Colouring the spots and charring : The lichen substances which separated on the TLC plate are usually invisible or paler in colour. They were made more visible by spraying colouring reagent and heating. 10% sulphuric acid solution was finally sprayed over the coated surface of the

plate which was preheated by placing in an oven at a temperature of 110 ° C for about 5-15 minutes to visualize the lichen acid or until the coloured pots at different levels become clear (Santos and Mondragon, 1969). The plate was then taken out, allowed to cool. The process takes about 45-50 minutes. Sulphuric acid charring detects the broadest range of characteristic visible colours, some even have a characteristic fluorescence (White and James, 1985). The colour of the spots, their position for each extract were noted, and observed again under ultra violet light at 350 nm wavelength before and after charring and finally Rf value were calculated.

(7) **Identification of the spots :** Lichen substance present in the sample was identified on the basis of the position, colour of the spots appeared on the TLC plate and the distance they travelled from the loading point. The distance travelled by a lichen substance (spot) is either referred as Rf value or Rf class and was calculated by using the formula:-

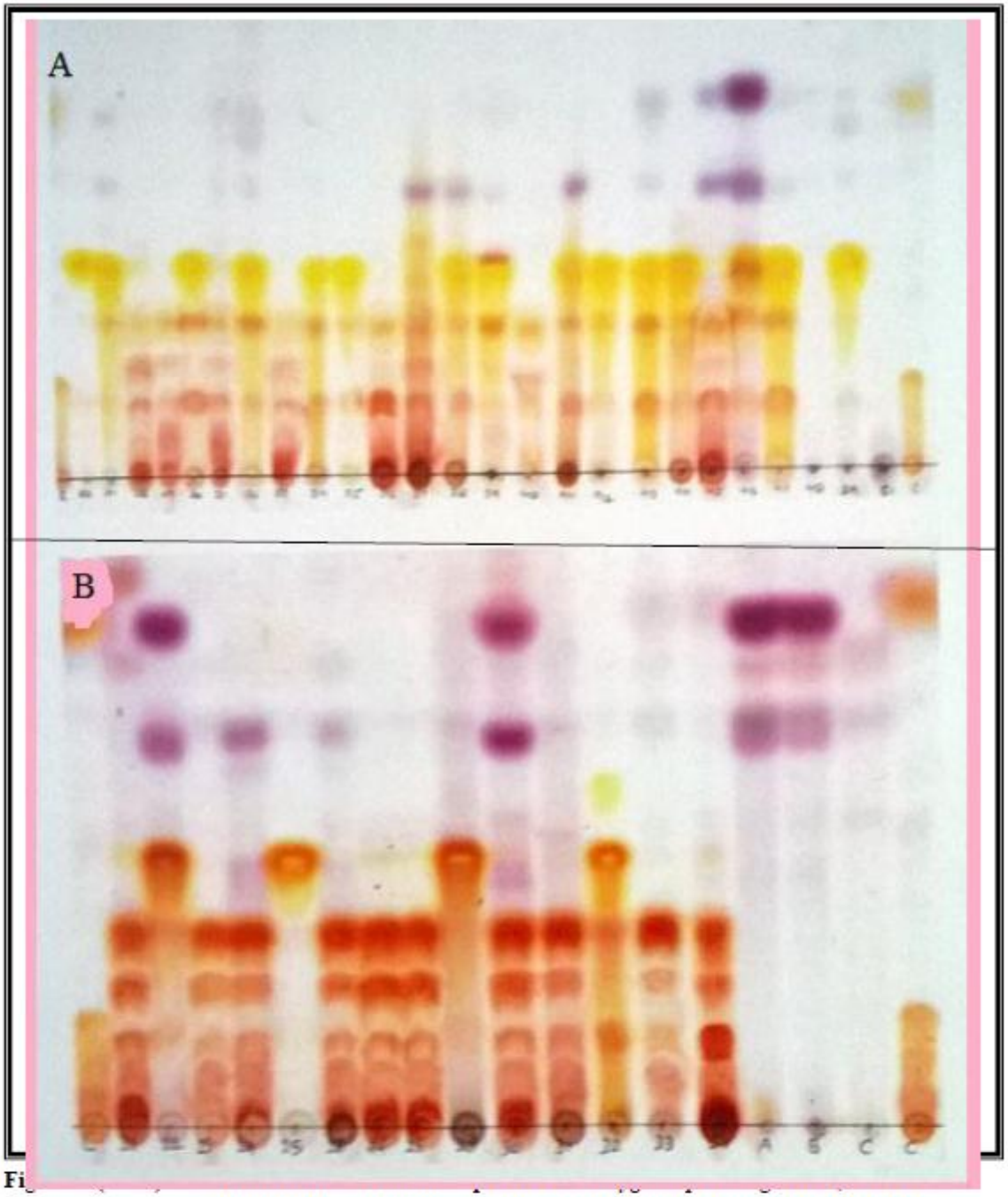
$$Rf\ value = \frac{\text{Distance travelled by lichen substance (indicated by spot)}}{\text{Distance travelled by solvent (Solvent front)}} \times 100$$

Rf class: Divide TLC plates into approx. 7 equal parts from the loading line to the last spot (usually atranorin); each division is Rf class. We have taken *Parmelinella wallichiana* as control, it give 2 spots, salazinic acid and atranorin. Hence, Rf classes of salazinic acid and atranorin were used for referring other spots (Table- 3.2). The identification of lichen products by TLC was adopted from Culberson (1972), Culberson and Kristinson (1970), and Culberson *et al*. (1981). The appearance of substances in TLC plate for some lichen species was shown in fig- 3.25 & 3.26.

3.10. 7 Identification of fatty acids

After removing the TLC plate from the tank it was spray with distilled water. The fatty acids appeared as oily, grey spots as the water dries up. They were circled with pencil as dotted lines. The sulphuric acid solution was sprayed after this step and then the plate was heated.

The fatty acid spot had not given any colour after heating. The fatty acids were also identified based on their Rf class or Rf value (Table - 3.2).



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B. substances present in *Sarcographa* species of lichen detected through TLC

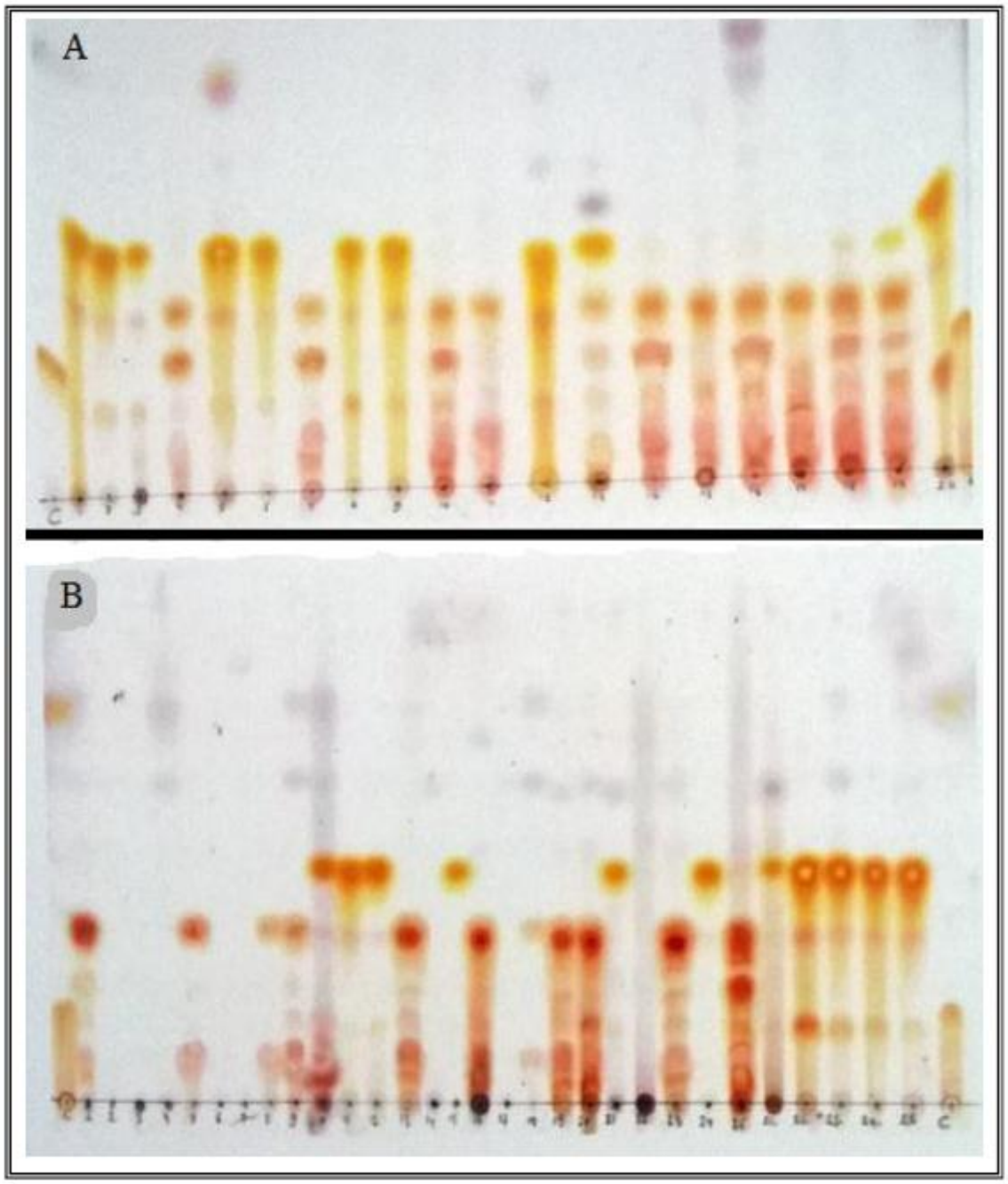


Fig- 3.26 (A & B): Constituents of secondary metabolites in Graphidaceous members of two lichens detected in TLC

Table 3.2: Identification technique of Rf classes lichen by TLC, colour spot, colour test and substances

Rf Classes	Colour of Spot	Identification of lichen Substances	Colour test
1 – 2	Dark grey	Fumarprotocetraric acid	PD+ yellow – red
1 – 2	Dark grey	Protocetraric acid	PD+ yellow – red
1 – 2	Grey – orange	Thamnolic acid	K+ yellow – orange,PD+ orange
2	Yellow – orange	Salazinic acid	K+ yellow – orange,PD+ red
2	Pale violet grey	Pannaric acid	C+ green
3	Orange	Stictic acid	K+ Yellow, PD+ Orange
3	Pale	Physodic acid	KC+ orange – red
3	Yellow or grey	Gyrophoric acid	C+ red
3	Yellow – grey	Lecanoric acid	C+ red
3	Pale green – grey	Lobaric acid	KC+ red
3	Dull yellow – brown	Psoromic acid	PD- yellow-red
3 – 4	Pale straw	Olivetoric acid	C+ red
4	Bright yellow	Norstictic acid	K+ red, PD+ orange
4	Orange	Sekikaic acid	--
4	Yellow	Barbatic acid	--
4 – 5	Yellow – orange	Perlatalic acid	--
5	Violet	Zeorin	--
6 – 7	Pale	Lichexanthone	UV+ yellow – orange
7	Greenish grey	Usnic acid	UV+ quench
7	Dark green	Pannarin	PD+ orange
7	Yellow – orange	Atranorin	K+ yellow

A dilute aqueous solution of nitric acid and an aqueous solution of ferric chloride were used, sometime, for identification of some crustose species like *Melanelia* and *Buellia* species. The spot tests were carried out on the thallus as well as younger parts, so that the better results can obtain. Colour test conducted with a small fragment of the desired lichen thallus part or thallus or ascocarp. A definite colour shows the presence of lichenic acid. The identified taxa were confirmed by matching them with the original protologue, type material and well identified specimens available at LWG herbarium. Following the recent classification proposed by Lumbsch & Huhndorf (2007) the nomenclature of the taxa were updated.

3.11 Bioprospection

3.11.1 Lichens sample used for antimicrobial assay

The selection of lichen species used for antimicrobial investigation was based on the availability/ frequency and their ethnomedicinal uses. Three lichen species [viz., *Everniastrum cirrhatum* (Fr.) 14-031427(LWG), *Parmotrema reticulatum* (Taylor) M.Choisy,14-021050(LWG) and *Usnea longissima* Ach. 13-019399 (LWG)] were selected for antimicrobial *in vitro* investigations against some common plant pathogens (viz., *Colletotricum capsici* Butler & Bisby (MTCC 8473), *Fusarium* oxysporum Schltdl. (MTCC 2087) and *Aspergillus flavus* Link (MTCC 8790).

3.11.2 Extraction of constituents from the samples and test fungal strains

The lichens samples (whole thallus), used for *in vitro* antimicrobial investigations, were cleaned/ washed and then air dried at room temperature. Before extraction, the dried samples were pulverized to powder form. Each powdered form of lichen sample was stored in a sterile glass bottle in the refrigerator. A stock solution was prepared by macerating 10g of lichen material in 20 ml each of sterile distilled water, acetone and methanol respectively, and kept it for 48 hours at room temperature. Further, the solution was filtered through muslin cloth, followed by millipore filter (pore size 0.22µm). The extracts were then evaporated to dryness using rotavatory evaporator. Thus, solvent extract converted into concentrated form/ powder. The concentrated powder form of the lichen samples were used for antimicrobial investigations against the test pathogens *C. capsici* (MTCC 8473), *F.* oxysporum (MTCC 2087) and *A. flavus* (MTCC 8790) at different graded concentration ranges from 10 - 50 µl/ml.

The microbial type culture were maintained at 4°C, revived and sub-cultured in PDA (Potato Dextrose Agar) media at a regular interval of 3-6 months. Protocol for solvent extraction is shown in Fig. 3.27.

3.11.3 Potato Dextrose Agar (PDA)

Commercially available readymade PDA powder form was suspended in 100ml of distilled water in a conical flask. This mixture was sterilized by autoclaving at 15lbs pressure (121°C) for 15 minutes. The freshly prepared media and agar plate was employed for the study.

3.12 Bioassay for antimicrobial activities of lichens extract

The antimicrobial activity of the aqueous, methanol and acetone extracts of lichen samples were determined following the modified spore germination inhibition technique (MSGIT) of Shahi *et al.* (1997) with a slight modification of Shukla (2010 and 2011). Potato dextrose broth was prepared and amended with Penicillin G (5mg/l) and Streptomycin sulphate (5mg/l) in the medium at 40°C in order to prevent bacterial growth, as suggested by Gupta and Banerjee (1997). Culture discs containing spores (5mm diameter) cut out from the 7 day old cultures, grown in petri dishes were transferred aseptically in flasks (100ml) containing the broth, and shaken thoroughly for homogenous distribution of spores. The numbers of spores were counted per microscopic field using 'Modified Cytometer Technique' (MCT) Shahi *et al.* (1997). The diameter of Microscopic field was measured by using micrometer and then the area and volume of microscopic field was calculated by the formula:

$$\mathbf{AMF} = \pi r^2 \qquad \mathbf{VMF} = \mathbf{(AMF)\ h}$$

Where, AMF = area of microscopic field; VMF = volume of microscopic field;

h = thickness of medium (in between slide and cover glass) 0.1mm.

The number of spore (average count value of 5 microscopic fields) was counted just by eliminating the overlapped spores. The number of spores in the volume of microscopic fields (NSV) was calculated by the formula:

$$\mathbf{NSV = ANS / VMF}$$

Where, ANS = average number of spores in microscopic field.

The volume of liquid medium (VLM) per microscopic field was calculated by the formula:

$$VLM = 2rh$$

The total inoculums density (TID) was calculated in the initial volume of medium as per formula:

$$TID = (NSV/VLM)\ IVM$$

where, IVM = initial volume of medium.

The effective concentration of water, methanol and acetone extract were determined by dissolving requisite quantity of extracts in water, methanol and acetone respectively (2% of the required quantity of the seed medium) and mixed it to the standardized inoculums suspension in the culture tubes. In controls, synthetic fungicides Thiram and mancozeb was used so as to compare their activity with the solvent extracts. Culture tubes thus prepared were incubated at 27° ± 1°C and the observations were recorded at the interval of 24 hr up to 96 hrs by counting the number of germinated spores. Percentage of zone of inhibition/ spore germination (SGI) by the extracts against test fungal culture was calculated as per formula:

$$SGI\ (\%) = (Gc - Gt) / Gc \times 100$$

Where, Gc = number of spore germination in control; Gt = number of germinated spore in treatment.

3.12 Range of spectrum

The range of spectrum of the aqueous, methanol and acetone extracts of these tested lichen species viz., *Everniastrum cirrhatum* (Fr.) Hale, *Parmotrema reticulatum* (Taylor) M.Choisy, and *Usnea longissima* Ach.) at 50.0 µl/ml were subjected against seven pathogens viz., *Alternaria alternata* (Fr.)Keissl., (MTCC 1362) *Trichophyton mentagrophytes* (Robin) Blanchard (MTCC 8476), *Salmonella typhimurium* Karl. (MTCC 98), and *Pythium aphanidermatum* (Edson) Fitzp. (MTCC 10247), using modified spore germination inhibition technique (Shahi *et al.* 1997) with a slight modification of Shukla (2010 and 2011). All the experiments were repeated twice and each of the test was made in three replicates; the data were presented in the tables are the mean value (table 4.9 – 4.17).

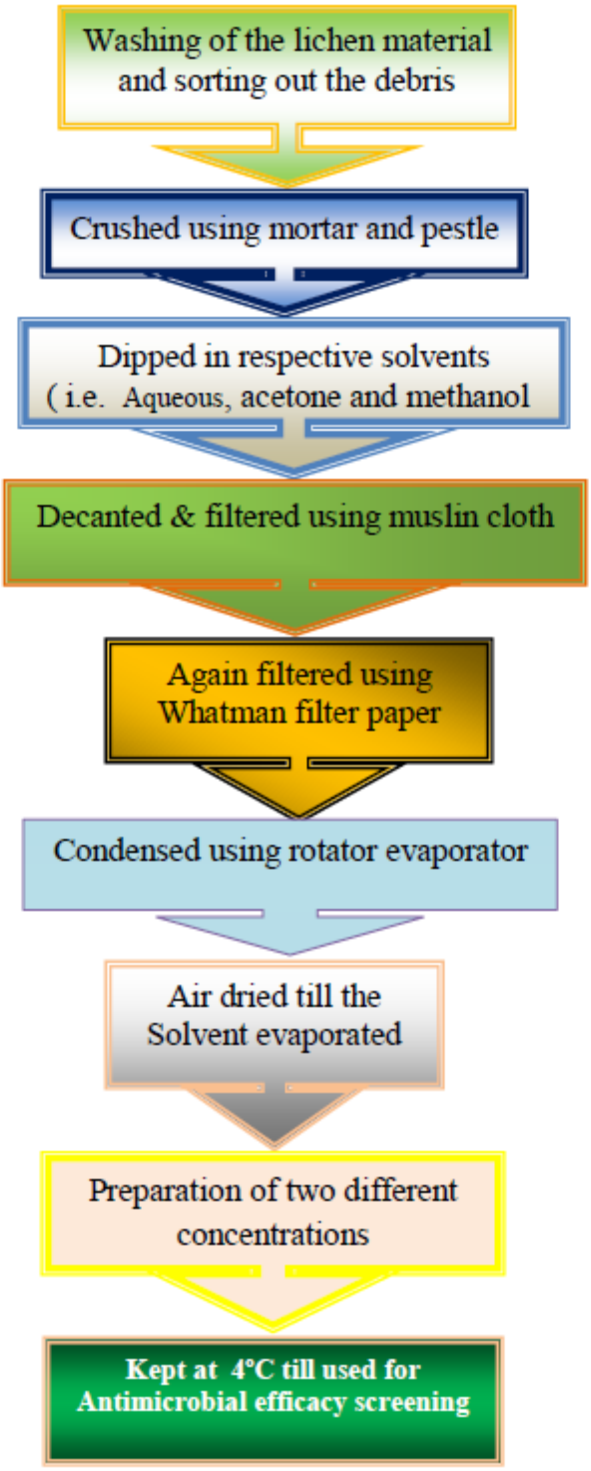


Fig- 3.27: Protocol for extraction of secondary metabolites from lichen thallus

Chapter

4

RESULTS

Chapter : 4

4. RESULTS

4.1 Systematic investigation

The present chapter described the detailed systematic investigations of 143 lichens species collected from four major localities of Murlen National Park (viz., MNP-East, MNP-West, MNP-North and MNP- South), comprising of 25 collection sites within the study area (fig- 3.15). Information on diversity of genus in the world, India and occurrence of available lichen genera from the study area are clearly mentioned. All the lichen species names are arranged in alphabetical order under different families. The botanical names are givens in bold print and synonyms in italics. For each species its family name, description, chemistry and localities and site of collection in the study are given chronologically. Colour photographs have also been recorded for easy identification and references. **Further, 14 lichen species were reported as new record to Indian lichen flora.**

Amandinea M.Choisy ex Scheid. & H. Mayrhofer in Scheid
(Physciaceae)

The genus *Amandinea* is represented by 54 species from the world and and seven species occurs only in Indian and only single species recorded from the study area.

1. ***Amandinea placodiomorpha*** (Vainio) Marbach **[Plate: 1/A]**
Bibli. Licheno. 74: 99, 2000; Anse L Ivrogne, 31, 2007; Bot. J Linn. Soc.137: 311–345.

Description: Thallus crustose, grey to greenish- or whitish grey, slightly to moderately warted, not to strongly fissured, usually smooth, sometimes granular to pustular; Apothecia purely black, rarely disc slightly reddish or very dark brown, apothecia to 0.4 mm diam., sessile to strongly immersed; disc flat, non-pruinose; margin non-pruinose, often seemingly with thalline margin; Ascospores seemingly 4-locular, with additional locules developing in the septum; septa measuring over half of the spore length, persistent. Ascospore septa thickened, ca. 2-15 mu thick, sometimes thick only in rather young spores, or with widened tubus reminding 4-locular spores, 8/ascus, 16-18(-20) x 7-8 µm long hymenium without or with scarce oil droplets mainly near the hypothecium. Pycnospores filiform, 15-23 x 0.7 µm.

Chemistry: K-,C-, KC-, Pd-; TLC: no lichen substance seen.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **1**), alt. 2092 m, on bark, 23.09.2014, M.Chinlampianga & A.R.Logesh,14-031407(LWG).

Anthracothecium Hampe ex Massal
(Pyrenulaceae)

The genus *Anthracothecium* is represented by 90 species in the world and 20 species in India and only one species is reported from the study area.

2. ***Anthracothecium macrosporum*** (Hepp.) Müll. Arg **[Plate: 1/B]**
The Lichenologist 44(1); 5-53, 2012. *Anthracothecium manipurense* Mull. Arg., Journ. Linn. Soc. London. Bot. 29: 231, 1892. Linnaea 63: 44, 1880. *Verrucaria macrospora* Hepp in Zoll., syst.. Verz.: 9, 1854.

Description: Thallus corticolous, endophloeodal, ascoscarps 2-5mm in diam. ; ascospores 60- 170 x 25-35µm.

Chemistry: - Thallus K-, C-, KC-, PD- ; no lichen substance in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. 1), alt.1604 m, on bark, 21.09.2014, M. Chinlampianga & A.R.Logesh, 14-021054, 021060, 021064, 021067 (LWG).

Arthothellium Patwa & Malch
(Arthoniaceae)

The genus ***Arthothellium*** is represented by 120 species in world wide; 42 species in India: Awasthi (1991). Only two corticolous species is recorded from MNP.

3. ***Arthothellium albescens*** Patwa & Malch **[Plate : 1/C]**
Biovigyanam 7:125, 1981

Description: Thallus corticolous, crustose, effuse, ecorticate, whitish-grey. Ascocarp, solitary or aggregated, emergent,black, upto 0.5 mm in diam., ascospores brown, 32-44 x 18-20 µm. Ascocarp innate or adnate, round or irregular in outline, excipuloid tissue absent; 0.5-0.8 mm diam., spores 23-35 x 12-15 µm ; thallus white, K+ yellow; Ascocarp white pruinose, spore more than 30 µm long. Paraphyses branched and anastomosing. Asci bitunicate, thick walled, 8-spored per ascus. Spores colourless, multicelled-muriform.

Chemistry: - Thallus K-, C-, KC-, PD- ; no lichen substance in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. 1), on bark, 15.01.2015, M. Chinlampianga, 15-031612 (LWG).

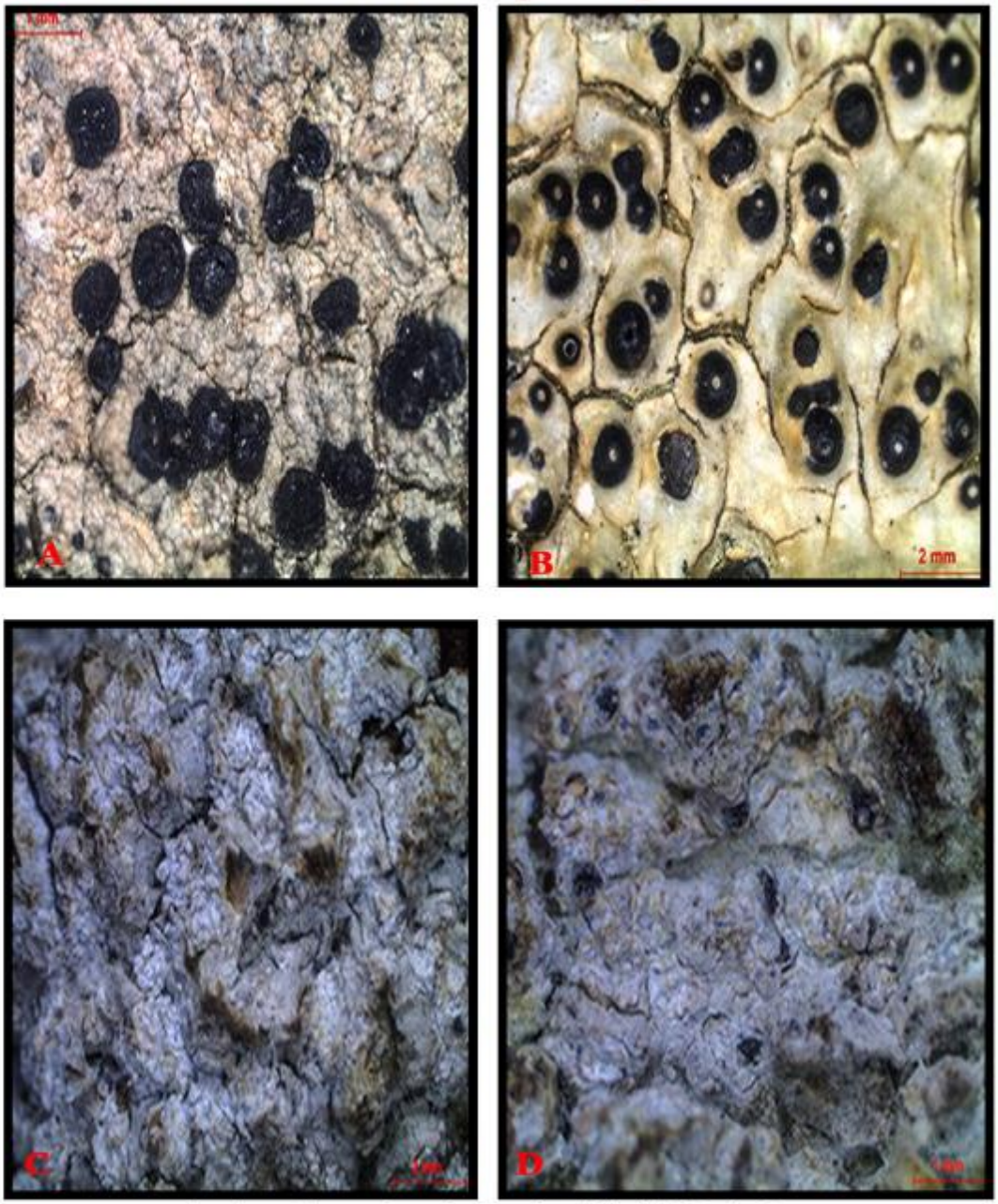
4. ***Arthothelium verruculosum*** Patwa & Malch **[Plate : 1/D]**
Biovigyanam 7:121-129, 1981

Description: Thallus corticolous, crustose, effuse, ecorticate, whitish-grey. Ascocarp, solitary or aggregated, emergent,black, upto 0.5 mm in diam.,ascospores brown to black, 32-44 x 18-20 µm. Ascocarp innate or adnate, round or irregular in outline, excipuloid tissue absent; 0.5-0.8 mm diam., spores 23-35 x 12-15 µm ; thallus white, K+ yellow; Ascocarp white pruinose, spore more than 30 µm long. Asci bitunicate, thick walled, 6-8spores/ascus. Spores colourless, multicelled-muriform.

Chemistry: - Thallus K-, C-, KC-, PD- ; no lichen substance in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. 1), on bark, 800mts, 15.01.2015. M. Chinlampianga, 15-031617, 031617 (LWG).

Plate: 01 (A - D)



A. Amandinea placodiomorpha (Vainio) Marbach
B. Anthracothecium macrosporum (Hepp.) Müll. Arg.,
C. Arthothellium albescens Patwa & Malch
D. Arthothelium verruculosum Patwa & Malch

Bacidia De Not
(Ramalinaceae)

The genus *Bacidia* is comprised of about 230 species in the world. The Indian sub-continent is represented by 29 species (Awastha & Mathur, 1987; Awasthi, 1991) out of total Indian subcontinent species only 4 species contributed from the study area.

5. *Bacidia fusconigrescens* (Nyl.) Zalhbr. **[Plate: 2/A]**
Cat. Lich. Univ. 4: 200, 1926; *Leicidia millegrana* var. *fusconigrescens* (Nyl.) Acta Soc. Sci. Fenn. Vol. 7: 461, 1863.

Description : Thallus corticolous, effuse, granulose, to furfuraceous some what rough, yellowish grey to brownish grey, 42-100 µm thick. Apothecia sparse to dense, constricted at base, 0.2-1.5mm in dia., disc plane to convex, brown, dark brown to black, epruinose; margin distinct, yellow brown, ntire and thick in young apothecia becoming thinner, darker and almost excluded in mature and convex apothecia. Exciple colourless to pale brown, sometimes marginally brown, 74-130 µm thick at margin, K-. Epithecium brown, 8-16 µm, thick, K-; hymenium 70-120 µm, thick, I^+ blue; hypothecium colourless to pale yellow, 36-62 (80 µm thick, K-. Spores ocicular, transversely 10-16 (18) septate, 9460 57-80, 2.4-3.2(4) µm; paraphyses. Simple to branched, thickened at apices.

Chemistry: TLC; pale yellow spot at Rf value of 0.69 and brown spot at Rf: 0.58.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **1**), on bark, 2092m, alt. 24.09.2014, M. Chinlampianga & A.R.Logesh, 14-021091(LWG).

6. *Bacidia inundata* (Fr.) Korb. **[Plate: 2/B]**
Syst. Lich. German: 187, 1855. – *Biatora inundata* Fr. in Kgl. Vetensk. –Akad.Ny Handle., 1822, p. 270.

Description : Thallus corticolous, effuse, rimose, surface granular warted, usually with a conspicuous white bordering prothallus, greyish brown. Apothecia numerous, sparse to dense, constricted at base, 0.2-0.6 (-1) mm in diam., flat to covex, pale to dark reddish brown. Mature apothecia sometimes split up into lobes, there is sometimes a glomerulose aggre-gation of 3-4 apothecia, disc yellow brown, brown to red, plane to convex, epruinose; margin entire, distinct, pale yellow to pale brown and later excluded. Exciple colourless to pale yellow, 36-70 µm thick at margin. Epithecium colourless to pale brown, 10-12 µm thick, K- hymenium 45-56 µm tall, colouless or pale pink- or purplish.

Chemistry: K-, C-, KC-; No chemical in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **5**), on bark, 2092m alt. 15.01.2015, M. Chinlampianga, 15-031619 (LWG).

7. ***Bacidia laurocerasi*** (Delise ex Duby) Zahlbr. **[Plate: 2/C]**

Zahlbr. Cat. Lich. Univ. 4: 213, 1927, 1926, *Patellaria laurocerasi* Del. Ex Duby, Bot.Gall. 2: 653, 1830.

Description : Thallus corticolous, effuse, thin (36-56 µm), ± smooth, to cracked, yellowish grey to brownish grey. Apothecia numerous, sessile, 0.3-1 (1.5)mm in diam., disc initialting yellowish to brown, plane, later reddish brown to ultimately black, convex and the margin excluded, pruinose. Exciple colourless to pale yellow, sometimes reddish brown adjacent to the hymenium, 52-90 µm thick at margin, K-, epithecium brown to blackish green, 8-14 µm thick, K-; hymenium 70-92 µm thick, I^+ deep blue sometimes turning red; hypothecium pale yellow to pale brown, 32-52 µm thick, K-. spores acicular, transversely 8-15 septate, (28) 40-56 (80) x 2.4 -3.2 µm; para-physes simple to branched, thickened at apices. TLC: pale blue spot at Rf value 0.66.

Chemistry: Thallus K-, C-, KC-, Pd- ; Nolichen substance detected in TLC.

Specimen Examined: Champhai district, Murlen National Park (East – Site No. **1**), on bark, 1812 m, alt. 20.09.2014 M.Chinlampianga & A.R.Logesh, 14-021090(LWG).

8. ***Bacidia medialis*** (Tuck. in Nyl.) Zahlbr. **[Plate: 2/D]**

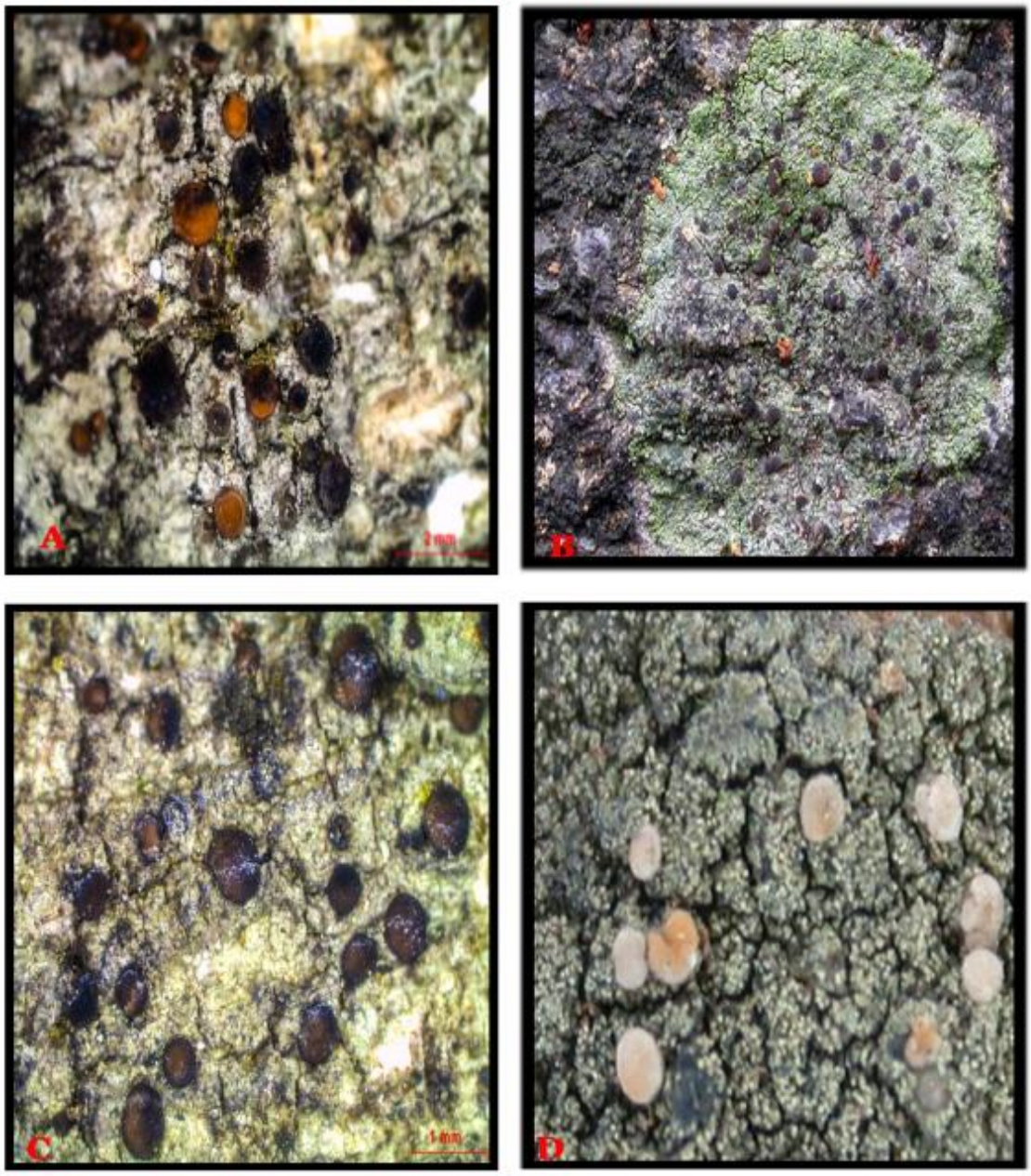
Denkschriften der Akademie der Wissenschaften (Wien) Mathematischaturwissen-schaftliche Klasse 83: 127 (1909); Synm: *Lecidea medialis* Tuck., Annales des Sciences Naturelles Botanique 19: 346 (1863) *Patellaria medialis* (Tuck.) Müll. Arg., Flora (Regensburg) 67 (24): 467.

Description : Thallus rugulose-subverrucose, apothecia 0.3-1.0mm diam., reddish brown to dark brown, margin red-brown to brown, darker than disc in young apothecia, spores 3-5 septate, 20-30 x 2.4-3.2µm, rod shaped or sometimes acicular; from Manipur and Tamil Nadu.

Chemistry: No chemical detected.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **10**), on bark, 1780m; alt. 07.07.2012, M.Chinlampianga, 12-019385(LWG).

Plate: 02 (A - D)



A. *Bacidia fusconigrescens* (Nyl.) Zalhbr.
B. *Bacidia inundata* (Fr.) Korb.
C. *Bacidia laurocerasi* (Delise ex Duby) Zahlbr.
D. *Bacidia medialis* (Tuck. in Nyl.) Zahlbr

Buellia De Not
(Physiaceae)

The genus *Buellia*about 455 species known from world and 41 species of *Buellia* have been reported from Indian sub-continent (Marbarch 2000; Singh & Awasthi, 1981) One new species is reported from the study area of Murlen National Park and the species under the genus is increased by one from the Indian subcontinent.

9. ***Buellia aeruginascens*** (Nyl.) Zalhbr. **[Plate: 3/A]**
Syn. *Lecidea disciformis* var. *earuginascens* Nyl. Cat. Lich. Univrs. 7: 331, 1931.

Description : Thallus crustose, corticolous, grey to whitish, areolate, UV-; apothecia round to sessile, up to 0.6 mm diam.,disc flat, white pruinose; epihymenium dark brown, 10-20 µm width; hymenium 80-85 µm thick, not inspersed withoil; 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.

Chemistry: Thallus K+ yellow, C-, KC-, PD+ yellow; UV+ pink; stictic acid and atranorin present in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **1**), on bark, N 23° 36' 58.2", E 93° 20' 24.2" & 2092 alt. 23.09.2014, M. Chinlampianga and A.R.Logesh , 14-021055 (LWG).

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

Caloplaca Th. Fr
(Teloschistaceae)

The genus *Caloplaca* is represented by 510 species in the world and 71 species under this genus have been reported from India (Joshi, 2008). Out of which only 2 species are reported so far from the state including the study area.

10. ***Caloplaca amarkantakana*** Y.Joshi & Upreti **[Plate: 3/B]**
Lichenologist 38(6): 537-540, 2006.

Description : Thallus crustose, orbicular, 10-20mm in diam., coalescing with other thalli to cover large, lobate to ± subsquamulose, central portion generally sub squamulose, imbricate, occasionally

areolate to verruculose, olive grey to brownish grey. Lobes generally narrow but sometimes wide, (0.5-) 1.5-2.5 9-3.5 x 0.3-0.7mm, branched, flat to subconvex, coherent, and sometimes pruinose. Apothecia numerous, scattered to clustered, restricted to central portion of the thallus but sometimes ± on peripheral lobes 0.1-0.6 9-1.5) mm in diam., disc orange to brown. Ascus 8-spored, spores polaribicolour, (8.5-) 9.0-10.0 x 4.0-5.0 µm, isthmus 3.0-4.0 µm Pycnidia present, conidia bacilli form, (1.0-) -3.0 x 0.5 – 1.0 µm.

Chemistry: Thallus, medulla & thalline margine K-,C-,Pd-; Parietin present in apothecial disc and an olive green spot at Rf class 4.

Specimen examined: Champhai district, Murlen National Park (East-Site No.1), on bark, N 23° 36' 58.2", E 93° 20' 24.2" and 2092m alt. 23.09.2014, M.Chinlampianga and A.R.Logesh, 14-031418 (LWG).

11. *Caloplaca cerinelloides* (Erichs.) Poelt **[Plate: 3/C]**
Bib. Lich. 50: 99, 1993. Basionym: *Caloplaca pyracea* f. *cerinelloides* (Erichsen, verh. Bot. Ver. Prov. Brandenburg. 72: 35, 1930.

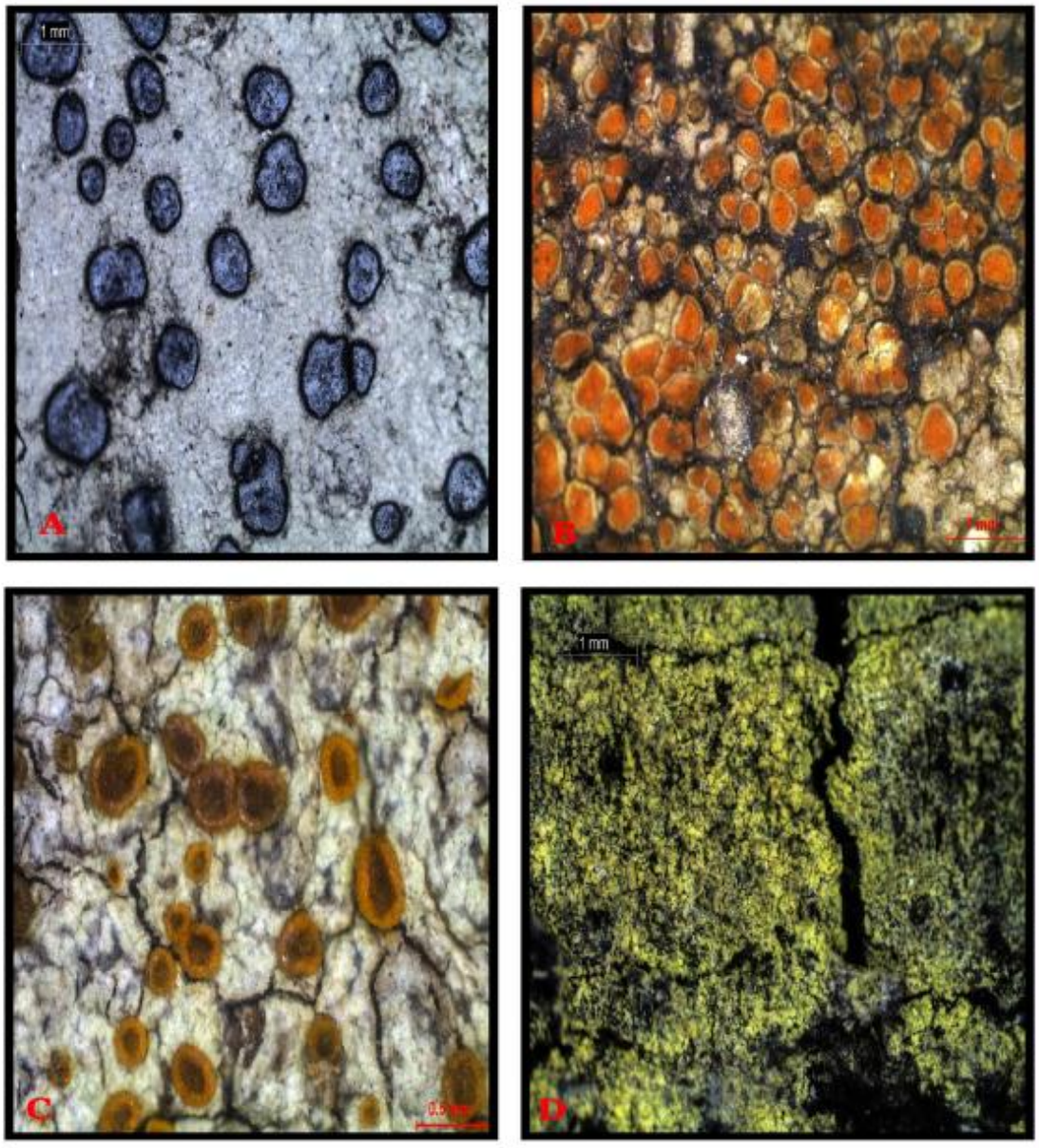
Descripion : Thallus crustose, corticolous, thin slightly distinct, 5-15 mm in diam., often coalescing with other thalli to cover large areas, areolate, areoles dispersed,0.1-0.2 mm in diam., greyish-white, cortex para plextinchymatous, 10-20 µm thick. Apothecia numerous, scattered to clustered, sessile, disc yellow to yellow orange, concave to flat, rarely subconvex, proper margin thin to moderate, smooth, entire, persistent, initially raised above the level of the discthalline margine absent. Epihynium golden brown, with episamma, 10.0-25.0 µm high, hymenium hyaline, 50-70 µm high, hypothecium hyaline, oil globules present, parathecium of elongated cells, amphithecium with algae. Ascus 8-spored, spores polaribilocular, ellipsoid to broadly ellipsoid, 8.0-12.0 x 4.0-5.0 µm, isthmus 3.0 – 5.0 µm. Pycnidia not seen.

Chemistry: Thallus K-,C-,Pd-: TLC: Parietin substance in apothecial disc.

Specimen examined: Champhai district, Murlen National Park (East – Site No. 1), on bark, N 23° 36' 58.2", E 93° 20' 24.2" & 2092 alt. 23.09.2014, M.Chinlampianga & A.R.Logesh,14-031414 (LWG).

12. *Chaenotheca chrysocephala* (Turner ex. Ach.) Th. (Coniocybaceae) **[Plate: 3/D]**
Nova Acta regiae Soc. Sci. Upsaliensis 3: 103-398, 1861.

Plate: 03 (A - D)



A. ***Buellia aeruginascens*** (Nyl.) Zalhbr.
B. ***Caloplaca amarkantakana*** Y.Joshi&Upreti
C. ***Caloplaca cerinelloides*** (Erichs.) Poelt
D. ***Chaenotheca chrysocephala*** (Turner ex. Ach.) Th

Description : Thallus crustose, corticolous, granular to squamulose, shiny, deep yellow; photobiont *Trebouxia*; apotheciastalked, stalk 0.4-2.0 mm long and 0.4 -0.8 mm diameter; capitulum disc yellow, pruinose, obconical, 0.2 - 0.3mm diam.; asci cylindrical, one-celled, 12-18 x 2.0-3.5 µm; ascospores spherical to ellipsoid, 5-7 × 3.5 - 4 µm.

Chemistry: Thallus K-, C-, KC-, PD-. No chemical substances.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **8**), on bark, 1500 alt. 19.02.2014. M. Chinlampianga 14-019194 (LWG).

Comment: The species is earlier reported from North and Central America, Europe, Scotland, British Isles, Australia, Asiaand New Zealand. Awasthi (1991) reported the occurrence of this species from Nepal. It is reported as **new record** for the Indian lichen flora.

Chapsa A Massal.
(Graphidaceae)

Only 7 species of the genus *Chapsa*out of 15 species from the world reported in India (Mangold *et al*. 2009; Joshi *et al*. 2012) and only one species represented by the study area of MNP.

13. ***Chapsa alborosella*** (Nyl.) A. Frisch **[Plate: 4/A]**
Biblioth. Lichenol.92: 90, 2006. *Graphis alborosella* Nyl., Ann. Sci. Nat., Bot., ser. 4,19:372, 1863.

Description : Thallus corticolous, pale olive green, chroodiscoid,oblong to angular or irregular pale brown apothecia level with the thalus, 8-spored per asci and hyaline, transversely septate, fusiform to clavate or oblong, I- ascospores, ascospore 17-22 µm long, 3-6 septate, ecorticate.
Chemistry: Thallus K-, C-, KC-, PD-. No chemical substances.
Specimen examined: Champhai district, Murlen National Park (East – Site No. **1**), on bark, N 23° 36' 58.2", E 93° 20' 24.2" & 2092 alt. 23.09.2014, M. Chinlampianga and A.R.Logesh,14-031438 (LWG).

14. ***Chiodecton leptosporum*** Müll. Arg. (Roccellaceae) **[Plate: 4/B]**
Flora 65: 332, 1882; Thor, Opera Bot. 103: 45, 1990.

Description: Thaullus tightly attached to the stratum, slightly verrucose, yellowish green, 5-7 cm across, 0.07-0.1 mm thick; prothallus distinct, pale brown at margins; medulla whitish with few crystals; ascocarps black, perithecicoid, aggregated and immersed, into elevated stromoid structures appearing as small dots; stromoid structures constricted at base, rounded to irregular or elongated; hypothecium black in upper part, pale brown in basal part; exciple brown-black; hymenium

colourless, 80-95µm high; asci clavate to sub-cylindrical; ascospore colourless, obovate straight, 25-45 x 2-3 µm.

Chemistry : Thallus K-, C-,PD-, TLC: Roccellic acid

Species examined: Champhai district, Murlen National Park (East – Site No. **17**), on bark, 18.09.2014, 1832m alt, M. Chinlampianga and AR. Logesh, 14-021056 (LWG).

Cladonia (Hill.)Web. in Wigg.
(Cladoniaceae)

About 59 species of the genus *Cladonia* are known from India, two terricolous species reported from the study area of Murlen National Park.

15. ***Cladonia coniocraea*** Flörke) Spreng **[Plate: 4/C]**
Sprengel.Syst.Veg.4(1):272,1827. *Cenomyce coniocraea* Florke, Deutschl. Lich.7 Lief.:11, 1821.

Description : Thallus terricolous, dimorphic; squamules of primary thallus small to medium sized, Podetia green, sparingly branched, 5-15 mm tall, 0.5-1 mm thick at base, usually simple, sparingly branched, tapering, subulate, escyphose or sometimes scyphose; scyphi infrequent, 1-2 mm wide, totally sorediate. Podetial surface corticated near base, with or without squamules, major upper part decorticated farinose-sorediate. Hymenial disc brown at tips of podetia.

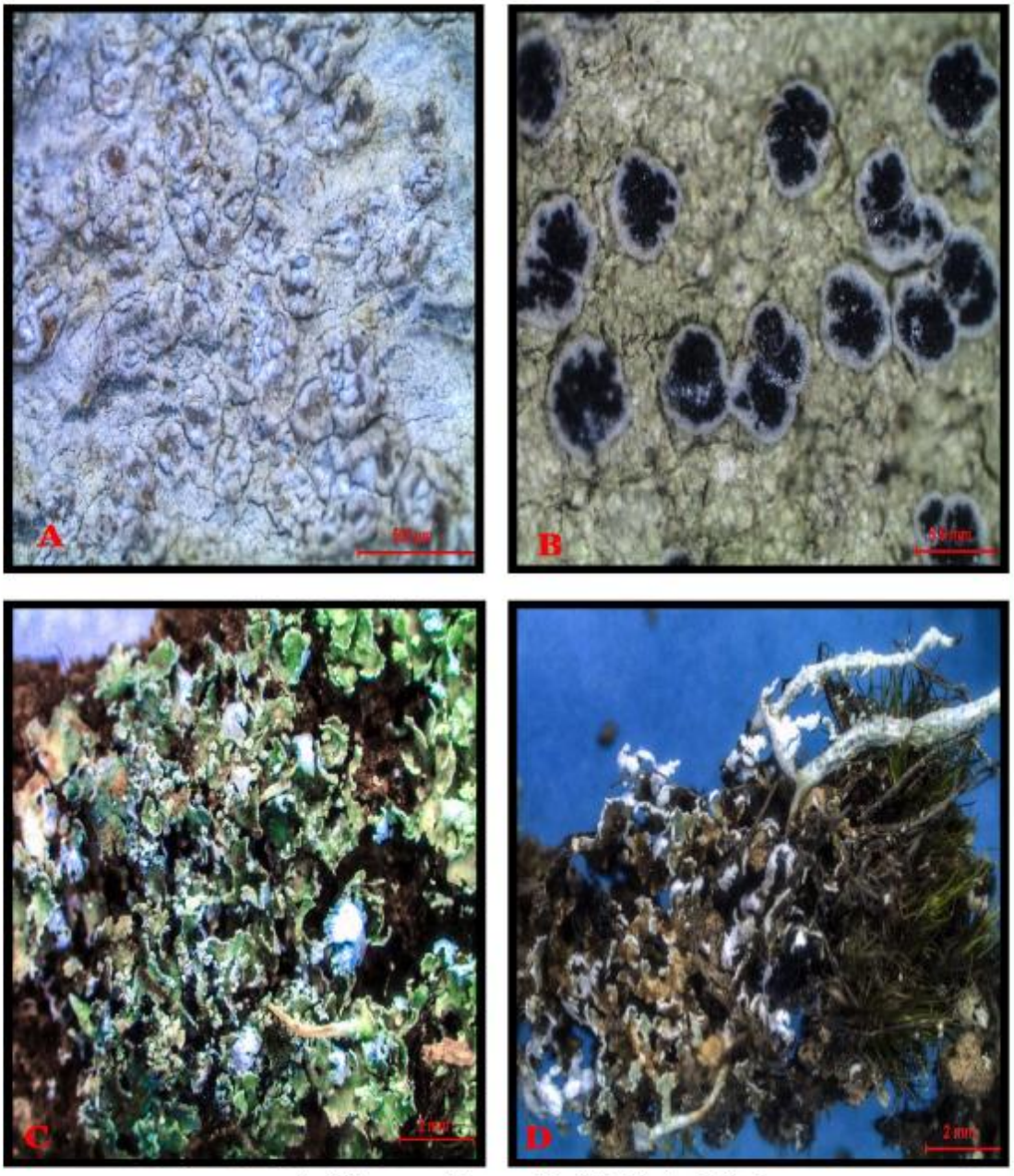
Chemistry: Podetia K^+ fainty brownish, C-, KC^-, PD^+ red.TLC: Fumarprotocetraric acid.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **1**), on soil, N 23° 36' 58.2", E 93° 20' 24.2" & 2092 alt., on soil, 23.09.2014, M. Chinlampianga and A.R.Logesh, 14-019178 (LWG).

16. ***Cladonia fruticulosa*** Kremp. **[Plate: 4/D]**
Verhandl. Zool. – Bot. Ges. Wien 30: 331, 1881 (1882) Synonym: *Cladonia formosana* Asahina, J. Jap. Bot. 17:485, 1941.

Description: Thallus, corticolous, dimorphic, squamules of primary thallus small to medium sized, persistent, cottony and granulose-sorediate on lower side. Podetia pale grey, usually 10-20 (-30) mm tall, 0.5-1 mm thick at base, simple to rarely branched; apices blunt or rarely scyphose; scyphi to 4 mm wide, shallow, close, often deformed. Podetial surface irregularly corticated with squamules or

Plate: 04 (A - D)



A. Chapsa alborosella (Nyl.) A. Frisch
B. Chiodecton leptosporum Müll. Arg.
C. Cladonia coniocraea (Flörke) Spreng.
D. Cladonia fruticulosa Kremp.

totally sorediate; soredia granulose or farinose, exposing medulla. Pale brown hymenial disc at tips of podetia or margin of scyphi.

Chemistry: Podetia K-, C-,KC-,PD+ deep yellow or red; TLC: fumarprotocetraric acids

Specimens examined: Champhai district, Murlen National Park (East – Site No. **5**), on bark, 23° 36' 58.2", E 93° 20' 24.2" &1700m alt. 22.09.2014, M.Chinlampianga and A.R.Logesh, 14-031446; 15-031623; 12-019396 (LWG).

Coccocarpia Pers.
(Coccocarpaceae)

The genus Coccocarpia comprises of 22 species known from the world. Awasthi (2007) provided a detailed account of 8 species in India, of which only single species is reported from the eastern side of the study area in sub-alpine region.

17. ***Coccocarpia palmicola*** (Spreng.) Arvid. & D.J. Gallo. **[Plate: 5/A]**
Arvid.sson & D.J. Galloway, Bot. Notiser 132: 242, 1979, *Lecidea palmicola* Sprengel, Vetensk. Acad. Nya Handl.1: 46, 1820.

Description : Thallus corticolous, foliose, adnate; upper side growing in orbicular patches, sometimes irregular, loosely or closely attached to the substratum, whitish grey to lead-grey, 5-15 cm across; lobes 2-8mm wide, ± imbricate , broad, deflexed; upper surface glossy, matt, smooth to minutely wrinkled, usually with concentric rings, isidiate, rarely lobulate in older parts; isidia laminal, sparse to dense, concolous with the thallus or darker, terete, globular to cylindrical, simple to rare branched, 0.1-1.0 mm long; lower surface pale brown to blackish; medulla colorless to yellowish. Apothecia to 4 mm in diam., hairs projecting from base; ascospores ellipsoid to fusiform, 5-10 x3-5µm.

Chemistry: Thallus K-, KC-, C-,PD-, TLC: no chemical substance

Specimens examined: Champhai district, Murlen National Park (East – Site No. **2**), on bark, N 23° 36' 58.2", E 93° 20' 24.2" & 2092 alt. 23.09.2014 , M. Chinlampianga and A.R.Logesh ,14-019168, 019174, 021071; 12-019398 (LWG).

Collema Web. ex Wiggers
(Collemataceae)

Total 82 species of the genus *Collema* are known from the world, out of which 35 species were reported (Akhtar &Awsthi 1980; Awasthi, 2007), one species is now reported from eastern part of Murlen National Park, Mizoram.

18. ***Collema subconveniens*** Nyl., **[Plate: 5/B]**
Lich. Nova Zeland.: 8. 1888.

Description : Thallus corticolus, rarely saxicolous, foliose; lobes 3-8mm wide; upper side light olive-green to brownish black, Apothecia up to 2mm in diam., thalline exciple with pseudocortex; proper exciple sub-para to euthyplectenchymatous; ascospores fusiform, submuriform to muriform, with 3-5 transverse and 1-2 longitudinal septa, 18-31(40) x 6-10 µm.

Chemistry: Thallus K-,C-,KC-,PD-. TLC: No lichen substance.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **17**), on bark, N 23° 36' 58.2", E 93° 20' 24.2" & 2092 alt. 23.09.2014, M. Chinlampianga and A.R.Logesh, 14-031405(LWG).

Cryptothecia Stirton
(Arthoniaceae)

Total 75 species of the genus *Collema* are known from the world,India represent 31 species under this genus (Awasthi, 1991), out of which 2 species reported from study area of Murlen National Park, Mizoram.

19. ***Cryptothecia lunulata*** (Zahlbr.) Makhija & Patw. **[Plate: 5/C]**
Biovigynam, 11(1): 6, 1985.

Description: Thallus corticolous, crustose, greenish white, 25-30(-50) µm thick, fertile areas foveolate on surface, 125-185 µm high; asci almost globose, thick walled, ascospores 2-8 ascus, colourless, muriform, transversely 7-9 septate, vertically 1-2 septate, mostly curved, 33-53 x 13.2-16.5 µm in size.

Chemistry: Thallus K+, C-, KC-, PD-.TLC: No substance

Species examined: Champhai district, Murlen National Park (West – Site No. **8**), on twigs and smooth bark, 1575m alt. 14.02.2014 M. Chinlampianga, 14-019193 (LWG).

20. *Cryptothecia verruculifera* Jagadeesh, G. P. Sinha & Kr. P. Singh **[Plate: 5/D]**
Lichenologist 41 (6): 610, 2009.

Description: Thallus corticolous, crustose, greenish white, endophloeodal, thin, evanescent; ascigenous parts of the thallus large, 2-5mm long and 1- 5mm broad, rounded, elongated or irregular, fertile areas foveolate on surface of thallus, asci almost globose, thick walled,
ascospores 4-8/ ascus, colourless, muriform, transversely 7-11 septate, vertically 1-5 septate, mostly curved, 43-69 x 11-16.5 µm in size.

Chemistry: Not detected.

Specimens examined: Champhai district, Murlen National Park (North – Site No. **2**), on twigs and smooth bark, 1250m alt. 14.02.2014 M. Chinlampianga14-021004, 021005(LWG).

Diorygma Pers.
(Graphidceae)

The genus *Diorygma*is represented by 25 species from the world and 24 species from India (Sharma & Khadilkar 2012; Kalb *et al.* 2004), out of which 3 corticolous species including one new to India is reported from the study area of Murlen National Park.

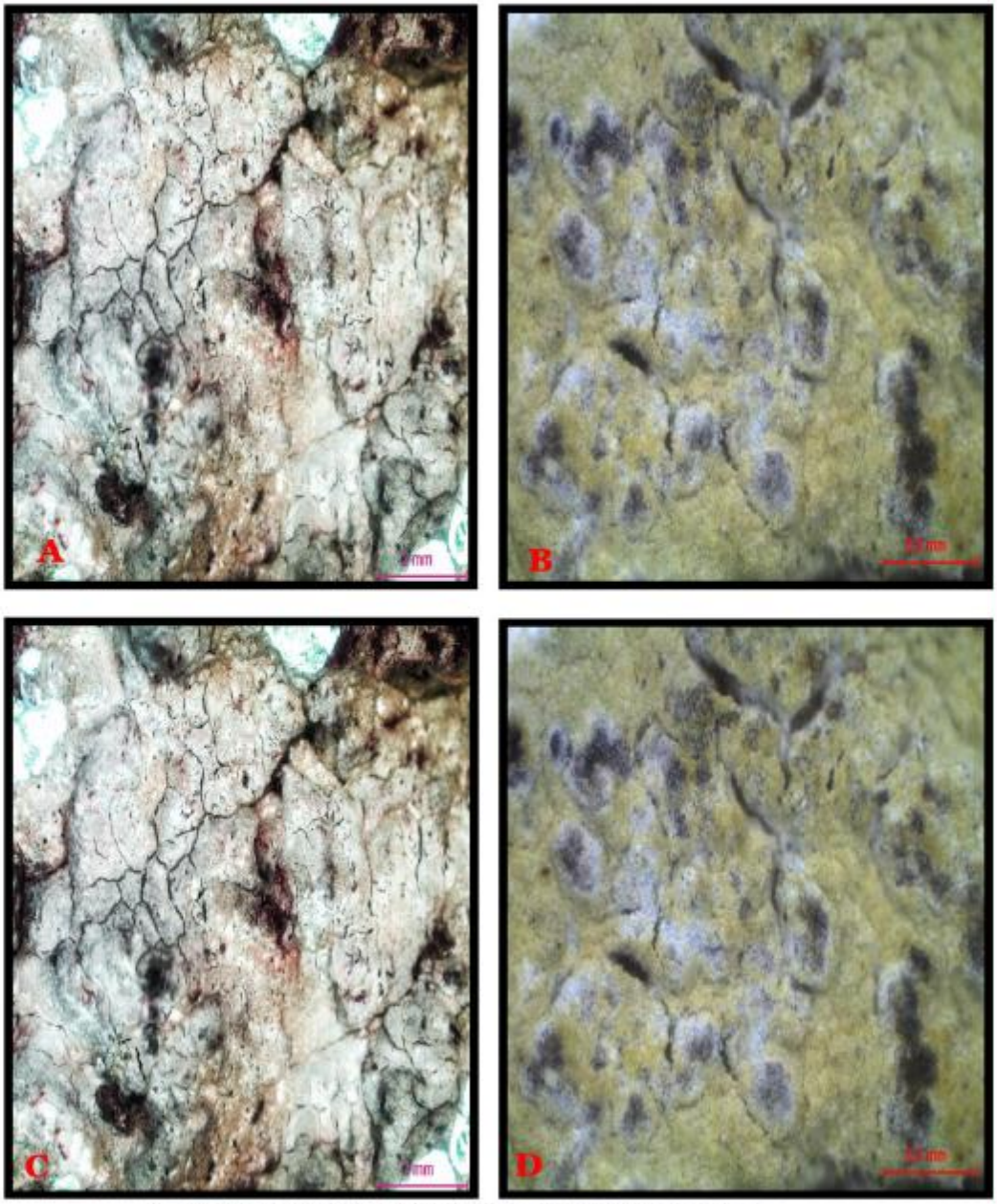
21. ***Diorygma heiroglyphicum*** (Pers.) Staiger & Kalb **[Plate : 6/A]**
Staiger & Kalb, Biblioth. Lichenol. 85: 113, 2002. *Opegrapha hieroglyphica* Pers., Ann. Wetterauischen Ges. Gesammte naturk. 2: 16, 1811.

Description : Thallus corticolous, whitish, pale grey to greenish grey; surface matt, partially granular, rough and with small warts, continuous or cracked, especially along the lirellae; ascocarps short or oblong, ± flexuous and branched, lirellae immersed in the thallus, whitish powdery; thalli margins indistinct or not visible; disc narrow to slightly open, white or creamy yellowish pruina present; excipledivergent, poorly developed; hymenium not inspersed. I + weakly to distinctly violet (lateral part); epitheciu m distinctly developed; ascospores 1/ascus, hyaline, muriform all cells of equal size, 95-150 (-170) x 30-45 µm. I+ violet, spores covered by spore wall.

Chemistry: Thallus K+, C-, KC-, PD-. Stictic acid (major) and norstictic present. **[Fig. 4.3 : (A)]**.

Specimens examined: Champhai district, Murlen National Park (West – Site No. **17**), on bark, 1664mts alt. 22.09.2014, M. Chinlampianga, 15-031626 (LWG); 14- 021017, 031432; 12-019383 (LWG).

Plate: 05 (A - D)



A. Cryptothecia lunulata (Zahlbr.) Makhija & Patw.
B. Cryptothecia verruculifera Jagadeesh, G. P. Sinha & Kr. P.
C. Cryptothecia lunulata (Zahlbr.) Makhija & Patw.
D. Cryptothecia verruculifera Jagadeesh, G. P. Sinha & Kr. P.

22. ***Diorygma junghuhnii*** (Mont. & Bosch) Kalb, Staiger & Elix, **[Plate: 6/B]**
Sym. Bot. Ups. 34(1): 157-159, 2004. *Ustalia junghuhnii* Mont. & Bosch, in Junghuhn, Plantae Junghuhnianae Fasc. IV, Lugduni-Batavorum: 477, 1855. *Graphis mendax* Nyl., Ann. Sci. Nat., Bot. 4(11): 244, 1859.

Description: Thallus corticolous, greenish or whitish grey, rough and deep cracked mainly along the lirellae; pothecia lirellate, 1-3×0.3-0.5mm, flexuous and branched, often numerous, oblong, immersed, with slightly narrow to opened discs and whitish pruina present. Exciple divergent, uncarbonised, with a thin brownish hyphal layer on the lateral partand a crack between the exciple margin andthallus. Asci hyaline, elongate, monosporous; spores hyaline, oblong, muriform, the peripheral cells have the same size with the central ones, 16-35/6-10-locular, shorter than 70-125 × 24-48µm.

Chemistry: Norstictic, connorstictic acid.

Specimens examined: Champhai district, Murlen National Park (South – Site No. **5**), on bark, 910 mts alt. 15.01.2015. M. Chinlampianga, 15-031626 (LWG); 14-031431, 031433 (LWG).

23. ***Diorygma reniforme*** (Fée) Kalb., Staiger & Elix **[Plate: 6/C]**
Bot. J. Linn. Soc. 161 : 105-121. Symbolae Botanicae Upsaliensis 34(1): 167, 2004.

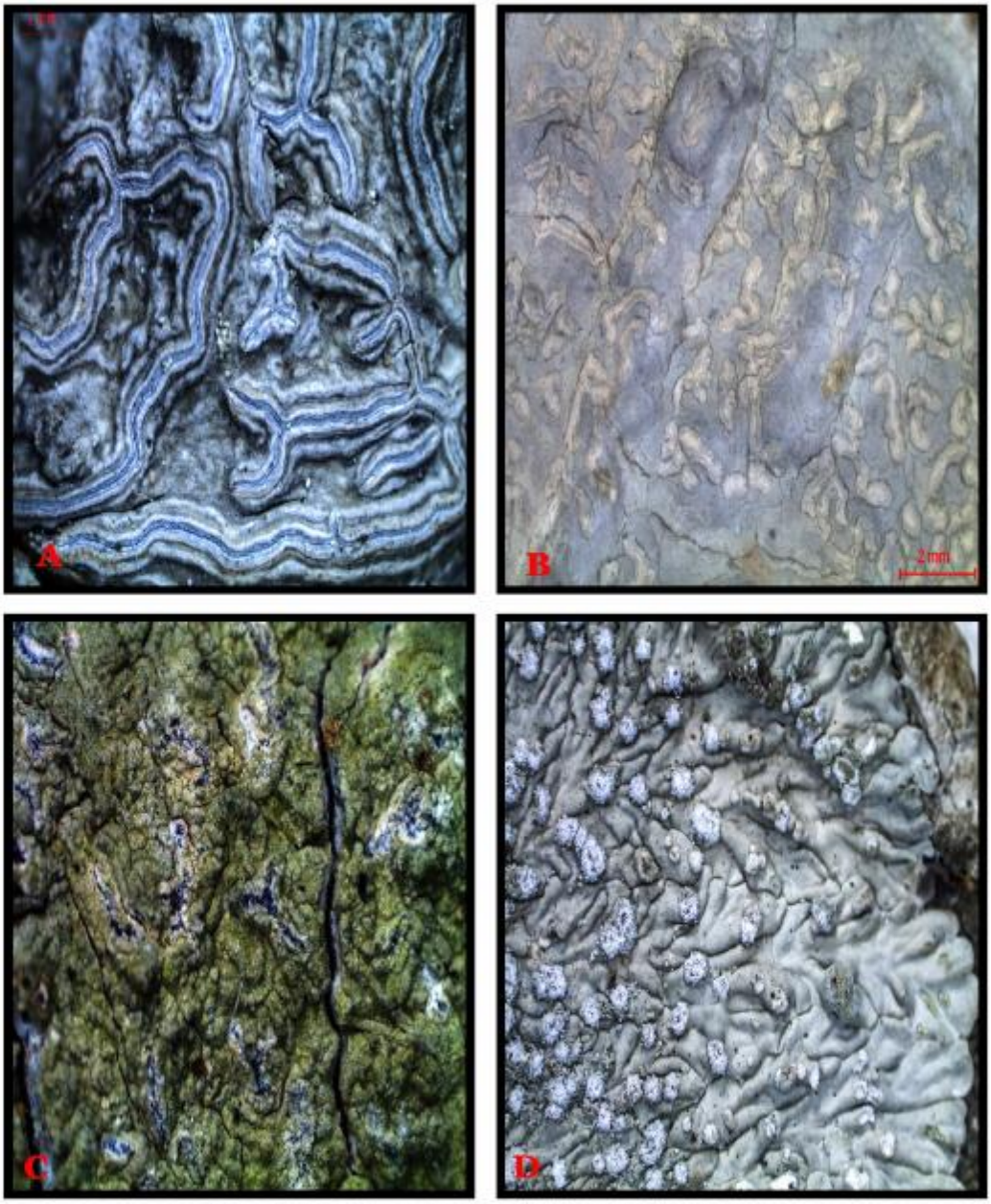
Description : Thallus crustose, corticolous, creamy white, with fine cracks; ascomata lirellate, branched, sessile, whitish, with well developed thalline margins, pruinose; hymenium not inspersed, 160-180 µm high, hyaline, I+ bluish violet; exciple basally carbonized; paraphyses anastomosing; asci one spored; ascospores muriform, hyaline, peripheral cells smaller than the central ones, 130-150 × 40-45 µm.

Chemistry: K+ yellow turning into red crystals, C-, KC-, PD+ yellow. Salazanic, protocetraric and norstictic acid present.

Specimen examined: Champhai district, Murlen National Park (North – Site No. **8**), alt.1795 m, 19.02.2014, M.Chinlampianga 14-021015 (LWG).

Comment: *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.

Plate: 06 (A - D)



A. Diorygma heiroglyphicum (Pers.) Staiger & Kalb
B. Diorygma junghuhnii (Mont. & Bosch) Kalb, Stariger & Elix
C. Diorygma reniforme (Fée) Kalb., Staiger & Elix
D. Dirinaria aegialita (Afz. in Ach.) Moore

Dirinaria (Tuck.) Clem.
(Physiaceae)

The genus *Dirinaria* comprises of 35 species are so far recorded in the world and 11 species are known to occurs in India (Awasthi 1975, 2007), of which 3 species are so far recorded from the study area.

24. *Dirinaria aegialita* (Afz. in Ach.) Moore **[Plate: 6/D]**
Bryologist, 71: 248, 1968. *Parmelia aegialata* Afzel. in Ach. Methodus: 191, 1803.

Description : Thallus corticolous, foliose, appressed to substratum, suborbicular, whitish grey to grey; lobes narrow; radiating, sorediate, soralia formed at the apex of isidiod dactyls rhizines, absent, corticiated on both surfaces; apothecia laminal, lecanorine; ascospores 2 celled, brown, thick walled, 12-19 x 5 - 88µm.)

Chemistry: Medulla K+ yellow, C-, KC-, PD-; divaricatic acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **17**), on bark, 1792 mts alt. 23.09.2014, M. Chinlampianga and A.R. Logesh, 14-021038, 021088, 021089 (LWG).

25. *Dirinaria confluens* (Fr.) D.D. Awasthi **[Plate: 7/A]**
Biblioth. Lichenol. 2: 28, 1975. *Parmelia confluens* Fr., Syst. Orb.Veget.1: 284, 1825.

Description : Thallus corticolous, foliose, upper side glaucous white to grey, lacking isidia and soredia. Apothecia to 2.5 mm in dia., ascospores (14-)16-24 x (6-) 8 - 10µm.

Chemistry: Medulla K-, C-, KC-, PD-; divaricatic acid and triterpenoids present in TLC.

Specimen examined: Champhai district, Murlen National Park (West – Site No. **9**), on twigs and smooth bark, 1575m alt. 14.02.2014, M. Chinlampianga,14-019177 (LWG).

26. *Dirinaria papillulifera* (Nyl.) D.D. Awasthi **[Plate: 7/B]**
Bryologist 67: 369. 1964, and D. Awasthi 1975 a: 62. Basionym: *Physcia papillulifera* Nylander, Acta Soc. Sci. Fenn. 26 (10): 9, 1900.

Description: Thallus corticolous, to 5 cm across; lobes 1.5 mm wide; upper side grey-white, isidiate; isidia filiform, simple or branched. Apothecia 1 mm in diam.; ascospores 12-16 x 5.5-8µm.

Chemistry: Medulla K-, C-, KC- PD-; Divaricatic acid present in TLC.

Species examined: Champhai district, Murlen National Park (East – Site No. **23**), on twigs and smooth bark, 1575m alt. 14.02.2014, M. Chinlampianga, 14-012039 (LWG).

Everniastrum Hale
(Parmeliaceae)

The total 28 species in the genus *Everniastrum*reported from the pan tropical parts of the world, India contribute 6 species so far, of which 2 species reported from the study area.

27. ***Everniastrum cirrhatum*** (Fr.) Hale ex Sipman **[Plate: 7/C]**

Mycotaxon 26: 239, 1986. *Everniastrum cirrhatum* (Fr.) Hale ex Sipman, Mycotaxon 3: 347, 1976. The Bryologist 84: 283, 1981.

Description : Thallus loosely attached to the stratum, suberect to pendulous, dichotomously lacinate lobate, 3.0- 13 cm across. Lobes canaliculated, linear elongate, much variable in width, apically tapering, (0.8) 2.0-4.0 (6.0) mm wide, 180-250 µm thick; lateral margin much involute, sometimes rolled, ciliate. Apothecia apical to laminal. Substipitate, 1.0-9.0mm in diameter, margins inflexed, entire to cracked; disk dark brown, plane to concave; amphithecium, smooth to rugose; epithecium brown, 10-20 µm thick; hymenium 45-70 µm high. Asci clavate, 8 spored, 30-55 x 12-20 µm. Spores large, oval-ellipsoid or slightly reniform, 15-18 x (5) 7-10 µm.

Chemistry: Cortex K + yellow; medulla K+ yellow turning red, C-, KC-, P+ orange.

TLC: Atranorin, salazinic and protolichesterinic acid.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **17**), on bark, 1792mts alt. 23.09.2014, M. Chinlampianga, 12-019378 (LWG). 14-031427, 031471(LWG).

28. ***Everniastrum nepalense*** (Taylor) Hale **[Plate: 7/D]**

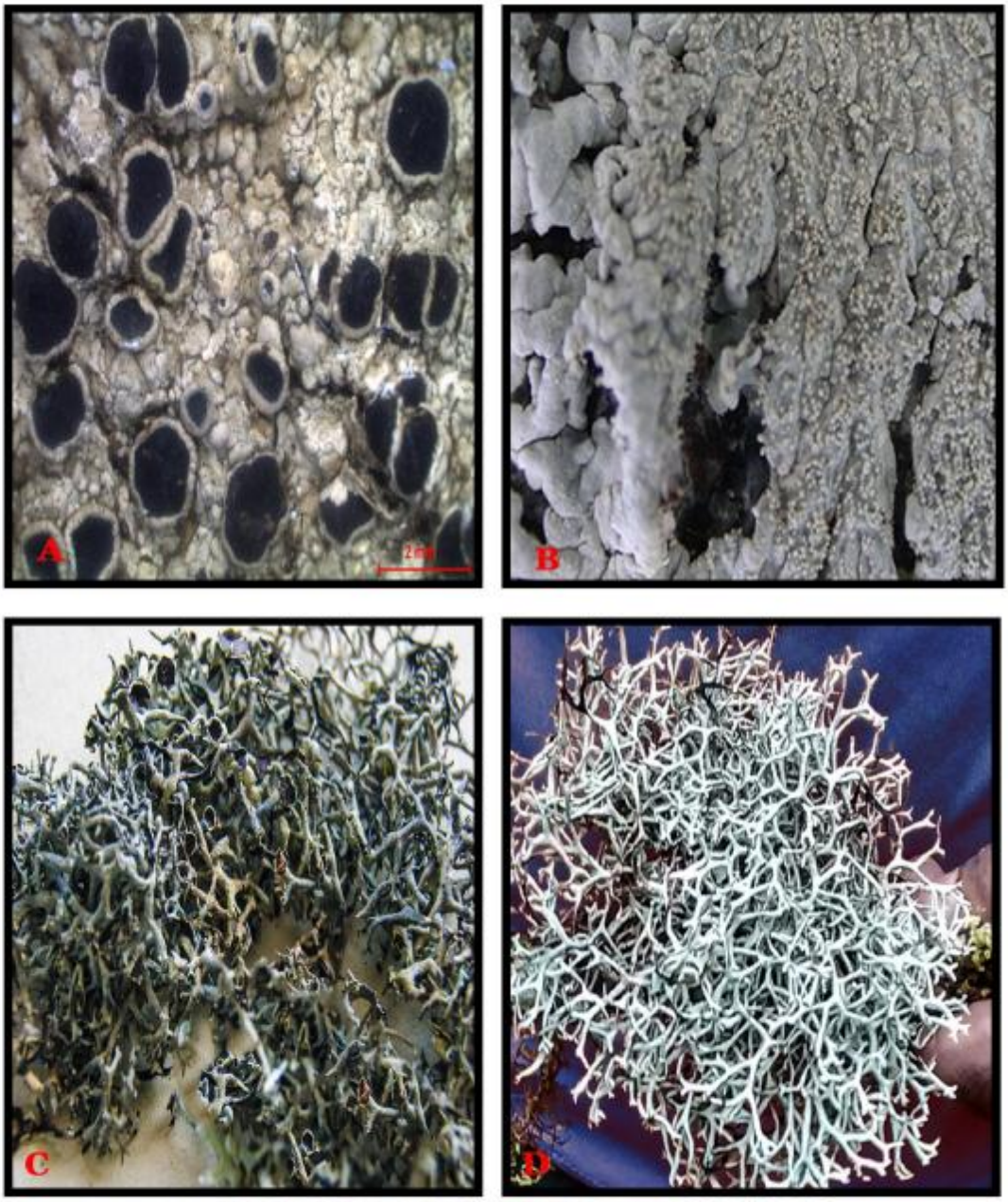
Mycotaxon 26: 241, 1986. *Parmelia nepalense* Taylor, Lond.J.Bot. 6:172, 1847; Awasthi, Biol.Mem.1:183, 1976. *Everniastrum nepalense* (Taylor) Hale, Mycotaxon 3: 348, 1976. *Cetrariastrum nepalense* (Taylor) W.Culb & Culb., The Bryologist 84: 301, 1981.

Description: Thallus corticolous, foliose; upper surface glaucose grey to dark grey, maculate, smooth, convex, sometimes rugose in older parts, rarely brownish, lacking isidia and soredia; Medulla white, 140-225 µm thick. Rhiziness laminal, short, simple to dichotomously or squarrosely branched, black, 0.5 to 1.5mm long. Apothecia laminal, sessile to substipitate, 1.0-8.0mm in diameter; margins entire to cracked; disc brown to dark tan, concave to plane or convex, imperforate; Asci clavate, 8 spored, 35-60x15-22 µm. Spores hyaline, simple, oval-ellipsoid, rarely reniform, (11)15-23x6-9(-10) µm, epispore 1.0-1.5 thick.

Chemistry: Cortex K + yellow; medulla K+ yellow-red, C-, KC-, P+ yellow-orange.

TLC: Atranorin, salazinic and protolichesterinic acid.

Plate: 07 (A - D)



A. Dirinaria confluens (Fr.) D.D. Awasthi
B. Dirinaria papillulifera (Nyl.) D.D. Awasthi
C. Everniastrum cirrhatum (Fr.) Hale ex Sipman
D. Everniastrum nepalense (Taylor) Hale

Specimen examined: Champhai district, Murlen National Park (West – Site No. **2**), 1792mts alt. 23.09.2014, M. Chinlampianga and A.R.Logesh, 14-019182 (LWG).

Fissurina Fee
(Graphidaceae)

Graphis genus comprising of 30 species in the world, of which about 20 species known from India (Staiger 2002; Sharma *et al*. 2012). The Murlen National Park exhibit the occurance of single species.

29. ***Fissurina dumastii*** (Fee) Sprengel **[Plate: 8/A]**
Essai crypt. Ecorc. Office. 40, 1824. *Graphis dumastii* (Fee) Sprengle, Syst. Veg. 4(1): 254, 1827; Zahlbr., Cat. Lich. Univ. 2: 302, 1923; Patw. & C.R. Kulk., Biovigyanam 2: 125, 1976.

Description : Thallus corticolous, crustaceouse, epiphloedal, grayish brown, smooth shiny, 60-100µm. Apothecia lirellate, lirellae dense, immersed, seems like cracks, indistinct, usually simple, sometimes furcated, flexuous, 0.5 to 3.5 mm long; apices acute; margin concolorous to thallus; disc open but narrow slit like. Crystals usually present at outer lateral sides of exciple. Asci 4-8-spored, spores colourless, 3-11-septate, elongate-ellipsoid to fusiform, spores 16-17 x (-5) 8-12 µm.

Chemistry: Thallus K-,C-, KC-, PD- ; No lichen substance in TLC.

Specimen examined: Champhai district, Murlen National Park (South – Site No. **17**), on twigs and smooth bark, 1575m alt. 14.02.2014 M. Chinlampianga 14-031440 (LWG).

30. ***Gassicurtia acidobaeomyceta*** Marbach (Physiaceae) **[Plate: 8/B]**
Biblthca Lichenol. 74: 66, 2000; Biblthca. Lichenol. 74: 214, 2000; Nordic J. Bot. 3: 517-520.

Description :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 inspersed 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.

Chemistry: Thallus K+ yellow, C-, KC-, PD-. Atranorin, thiophanic acids present.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **19**), on bark, N 23° 36' 58.2", E 93° 20' 24.2" & 2092 alt. 23. 09. 2014. M. Chinlampianga and A.R.Logesh 14-031428 (LWG).

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

31. ***Glyphis cicatricose*** Ach. **[Plate: 8/C]**

(Graphidaceae)
Syn. Meth. Lich.: 107, 1814; Zahlbr., Cat. Lich. Univ. 2: 454, 1923; D.D. Awasthi, Beih. Nova Hedwigia 17: 54, 1965; G. Pant, Geophytology 20(1): 49, 1990.

Description : Thallus corticolous, crustose, yellow to yellowish brown, smooth; stroma white to grayish-white, pruinose, (0.5-) 1-4.5 x 1-1.5 mm; apothecia round, oblong effigurate to lirellate, (0.25-) 0.5-1.5x0.25(-0.5) mm, brown with black margin; exiple brown-black, carbonized, (10-) 30-60 µm thick, K-; epithecium brown; asci clavate, 8-spored, 100-130 x 20-30 µm; spores colourless, ellipsoid, (5) 6-11 (-15) loculed, 30-70 x 8-10; locules unequal in size, lens shaped, paraphyses simple.

Chemistry: Thallus K-, Pd-, C-, KC-, TLC: No chemical substance

Specimens examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 1668 m, on bark, 24.09.2014, M. Chinlampianga and A.R. Logesh,14-021041, 031447, 031449 (LWG).

Graphis Adans
(Graphidaceae)

Graphis is a large cosmopolitan genus comprising of over 320 species in the world, of which about 115 species known from India (Lucking 2009; Lucking et al., 2009). The Murlen National Park exhibit the occurance of 7 species including 1 new species reported from India.

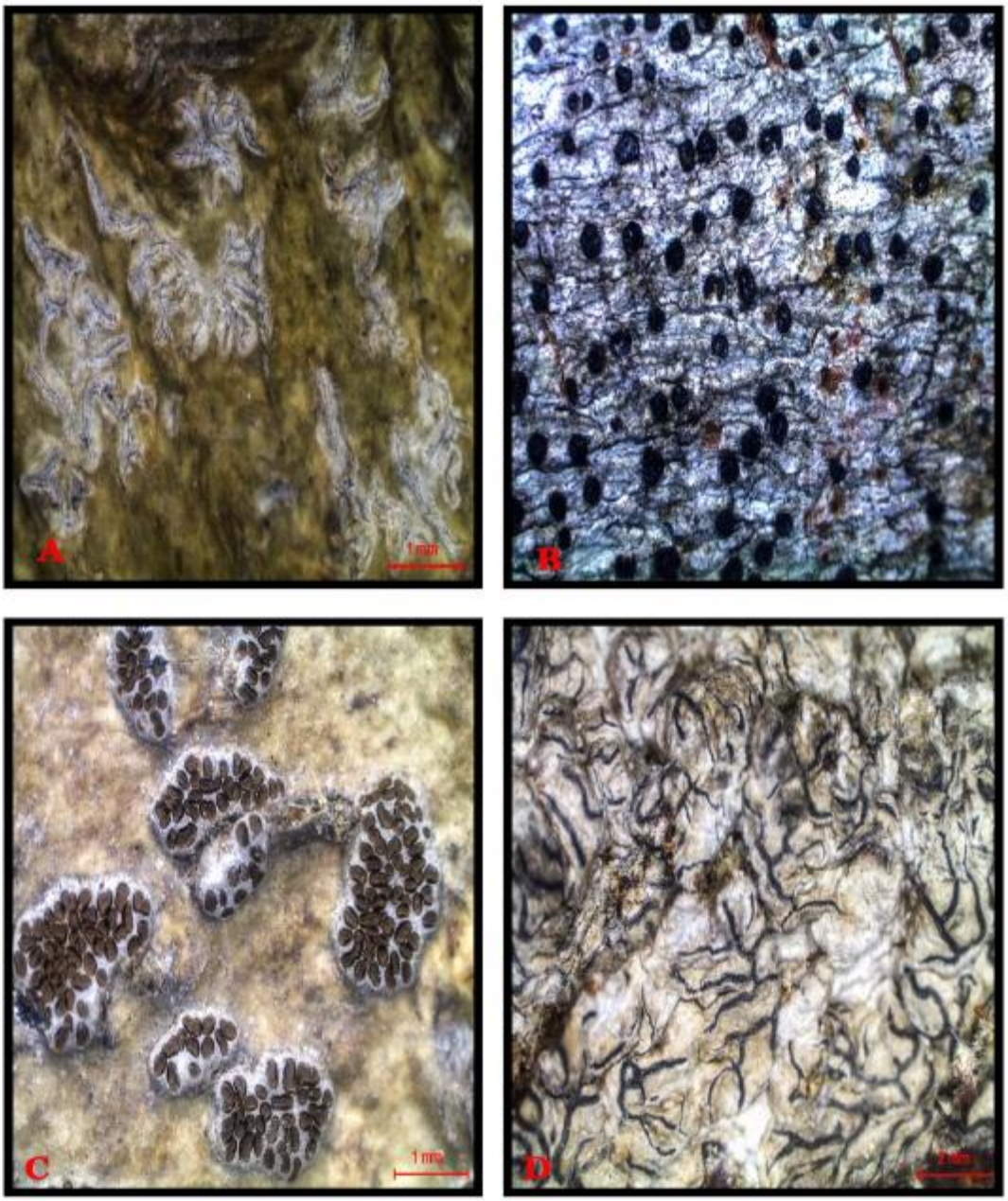
32. *Graphis arecae* Vain. **[Plate: 8/D]**
Ann. Acad. Sci. Fenn., ser. A, 15(6): 249, 1921; Zahlbr., Cat. Lich. Univ. 2: 294, 1923; Patw. & C.R. Kulk., Biovigyanam 2: 124, 1976.

Description : Thallus corticolous, crustaceous, epiphloedall, whitish grey to greenish grey, smooth to cracked, 40-90 µm thick. Apothecia lirellate, lirellae immersed to semiemergent, prominent, simple to dichotomously branched, curved and flexuous, black 1 to 6.5 mm long; ends tapering, covered on sides by thalline margin, superficially blak; disc narrow black, epruinose. Exciple dimidiate totally carbonized; labia entire, thicker at base narrow upwrd, lacking thalline cover at apices, straight to slightly convergent. Asci cylindrico-clavate, 8 spored; ascospores hyaline, ellipsoid to fusiform, transversely 5-10 locular, 22-40 x 5-8 µm in size, I+ blue.

Chemistry: Thallus K^+ yellow to red, C-, KC-, PD^+ yellow to orange; Norstictic, stictic and constictic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **18**), on twigs and smooth bark, 1575m alt. 14.02.2014, M. Chinlampianga14-031435 (LWG).

Plate: 08 (A - D)



A. Fissurina dumastii (Fée) Sprengel
B. Gassicurtia acidobaeomyceta Marbach
C. Glyphis cicatricosa Ach.
D. Graphis arecae Vain.

33. ***Graphis assimilis*** Nyl. **[Plate: 9/A]**

Nyl., Bull. Soc. Linn. Normandie, ser. 2, 2 : 109, 1868 ; Acta. Soc. Sci. Fenn. 7: 465, 1863. Zahlbr., Cat. Lich. Univ. 2 : 314, 1923; Lücking & al., Lichenologist 41(4): 448, 2009.

Description: Thallus corticolous, crustose, epiphloedal, whitish to greyish brown, smooth to cracked, uneven and somewhat shiny; apothecia lirellate, lirellae immersed to semiemergent, prominent, dense, simple to furcatingly branched, curved and irregulary flexuous, 1-7..5 mm long, slit like, black epruinose; exciple closed, totally carbonized, labia entire to slightly irregular on outer and lateral sides, convergent, covered with thalline and covered almost upto the apices; hymenium hyaline, 90-130 µm; hypothecium yellowish, thin 12-18 µm thick; asci cylindrico clavate, 8 spored; ascospores hyaline, elongate ellipsoid, transversely 6-11 locular, 25-40 x 5-7.5 µm, I+ blue violet.

Chemistry: TLC: No chemical substance found.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 1812 m, 23.09.2014, M.Chinlampianga and A.R. Logesh, 14-031464, 031466, 031456, 031459, 031462 (LWG).

34. ***Graphis duplicata*** Ach., **[Plate: 9/B]**

Ach., Syn. Meth. Lich.: 81, 1814; Zahlbr., Cat. Lich. Univ. 2: 303, 1923; D.D. Awasthi, Beih. Nova Hedwigia 17: 55, 1965; Patw. & Badhe, J. Univ. Poona 44: 54. 1973; Staiger, Biblioth. Lichenol. 85: 229, 2002; A.W. Archer, Biblioth. Lichenol. 94: 62, 2006.

Description: Thallus corticolous, crustose, surface smooth & dull.Apothecia black, conspicuous, numerous, sulcate, sessile, lirellate; lirellate upto 3 mm long; ascospore 8 per ascus, hyaline, irregularly biseriate, 30-45 µm long, 6-8mm.

Chemistry: K-,C-,KC-,Pd-; no substance in TLC.

Specimen examined: Champhai district, Murlen National Park (South- Site number **6**), on bark, 1812 m, 15.01.2015, M. Chinlampianga, 15-031604 (LWG).

35. ***Graphis granulosa*** (Müll. Arg.) Lucking **[Plate: 9/C]**

Fieldiana Botany 46(1): 81, 2008.

Description :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, ascospores -2 per ascus; ascospores regularly muriform, medium sized, 80-100 × 18-23 µm.

Chemistry: Thallus K-, C-, KC-, PD-; hypostictic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 2092 mts alt. 23.09.2014, M.Chinlampianga and A. R. Logesh, 14-031452 (LWG).

Comment : 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.

36. ***Graphis insulana*** (Muell. Arg.) **[Plate: 9/D]**
Lücking & Sipman in Lücking & al., Fieldiana, Bot.: 84, 2008; Lichenologist 41(4): 449, 2009.
Graphina nylanderi Patw. & C.R. Kulk., Norweg. J. Bot. 26(1): 47, 1979.

Description : Thallus crustose, corticolous, whitish grey; ascomata , apically thin; labia entire; excipulum laterally carbonized; hymenium inspersed with oil, muriform; lirellae immersed to erumpent, with thick lateral to complete thalline margin, elongate and irregularly branched (subserpentina morph); Ascospores large, 1-2 per ascus, 50-110 × 15- 30 µm.

Chemistry : K-,C-,KC-,Pd-; TLC: not done.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 1812 m, 23.09.2014, M.Chinlampianga and A.R. Logesh, 14-031454, 021036 (LWG).

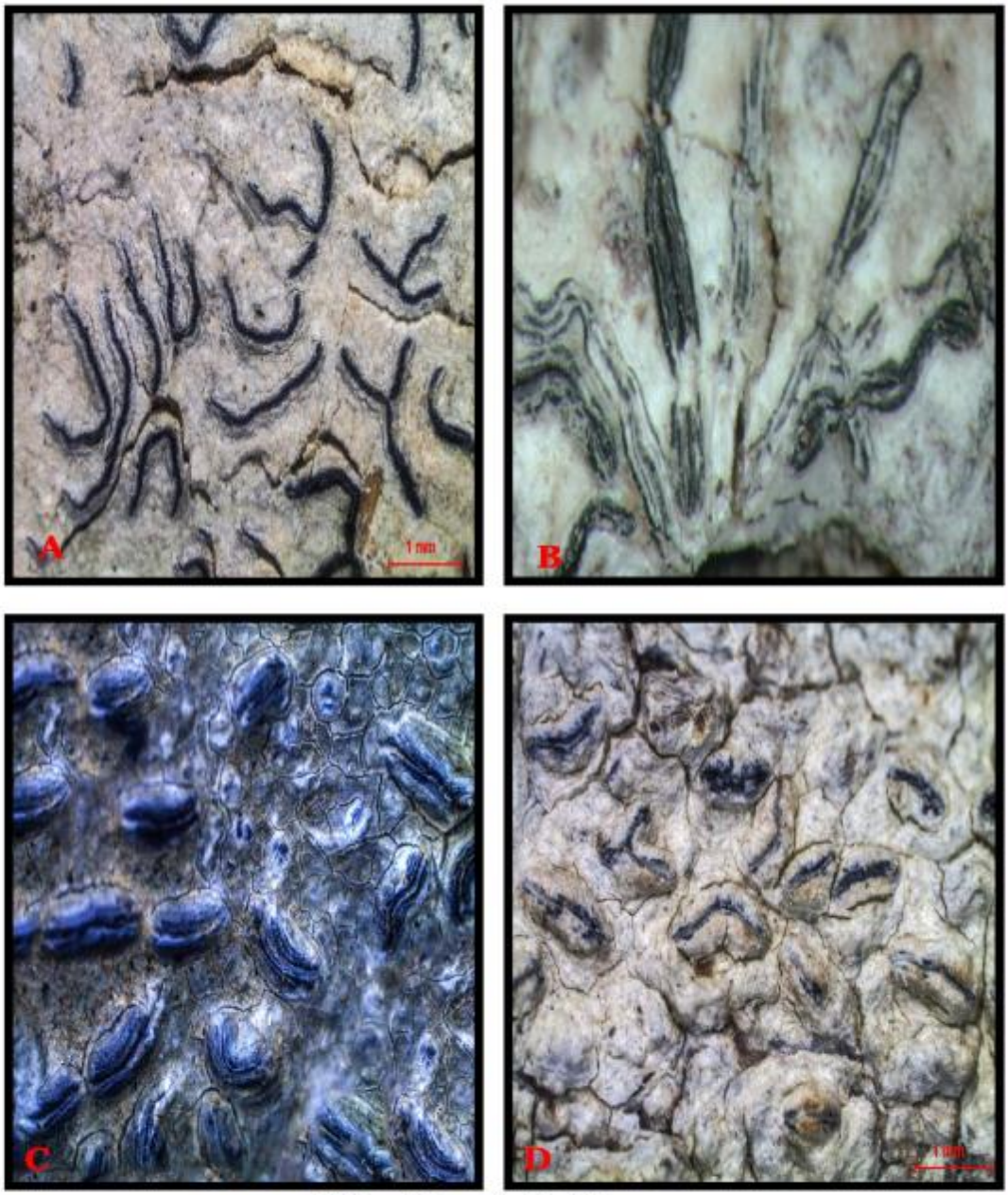
37. ***Graphis lineola*** Ach. **[Plate: 10/A]**
Ach., Lichenogr. Universalis: 264, 1810; Zahlbr., Cat. Lich. Univ. 2: 316, 1923; R. Schub. & Klem., Nova Hedwigia 11: 40, 1966; Staiger, Biblioth. Lichenol. 85: 240, 2002.

Description : Thallus corticolous, crustaceouse, epiphloedal, whitish to grey to grey, yellowish brown to brown, smooth to uneven, sometimes granular , cracked 25 – 85 µm thick; apothecia lirellate, lirellae dense, semiemergent to emergent, prominent, simple, straight to slightly curved to flexuous, 0.5-3mm long, ends round, margin thin, disc ± open, black epruinose, round; exciple open, carbonized, labia entire , convergent, not covered by thalline cover at apices; hymenium hyaline, 12-20 µm;asci cylindrico clavate, 8- spored, ascospores hyaline, elongate ellipsoid, transversely 6-10 locular, 25-40 x 4.5-7.5 µm,

Chemistry: TLC: Thallus K+ light yellow, C-,KC-,Pd-, TLC: No lichen chemical substance.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 2122 m, 20.09.2014, M. Chinlampianga and A.R. Logesh, 14-031429 (LWG).

Plate: 09 (A - D)



A. Graphis assimilis Nyl.
B. Graphis duplicata Ach.,
C. Graphis granulosa (Müll. Arg.) Luecking
D. Graphis insulana (Muell. Arg.) Luecking

38. ***Graphis proserpens*** Vain. **[Plate: 10/B]**

Bot. Tidsskr. 29(2): 132, 1909; Zahlbr., Cat. Lich. Univ. 2: 321, 1923; M. Wirth & Hale, ontr.U. S. Natl. Herb. 36(3): 98, 1963. *Graphis disserpens* Vain., Ann. Acad. Sci. Fenn., ser. A, 15(6): 202, 1921. *Graphina disserpens* (Vain.) Zahlbr., Cat. Lich. Univ. 2: 403, 1923. *Graphina nanodes* sensu Patw. & C.R. Kulk., Biovigyanam 2: 131, 1976. *Graphis sikkimensis* Nagarkar & Patw., Biovigyanam 8: 129, 1982; U. Dubey & al., Phytotaxonomy 7:24. 2007; Pinokiyo & al., Lichenologist 40(1): 52, 2008.

Description: Thallus corticolous, crustaceouse, epiphloedal, smooth to rough, uneven, brownish yellow to grey, 48-100 µm thick. Apothecia lirellate, lirellae dense, immersed to semi-emergent, black, simple to furcated, straight to curved and flexuous, 0.5-4.5 mm long, apices round to slightly tapering; margin black with longitudinal striations; exciple closed, partially carbonized; labia 4-9 sulcate, sulci black, convergent, covered with thin thalline veil. Hymenium hyaline, not inspersed, 50-90 µm high; hypothecium hyaline, 10-20 µm thick. Asci cylindrico-clavate; 8- spored; ascospores longate- ellipsoid 6-10 loular, 18-30x 5.5 µm in size, I+ blue.

Chemistry: Thallus K-,C-,KC-, PD- ; TLC: No lichen substance in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 2092 m, 23.09.2014, A.R. Logesh & M. Chinlampianga, 14-031453, 031455, 031455, 031457, 031458, 031460, 031465, 021063 (LWG).

Haematomma Massal.
(Haematommaceae)

53 species under this genus known from the world; of which only 4 species known from India (Awasthi, 1991), and from Study are of Mulen National Park 2 species are reported.

39. ***Haematomma puniceum*** (Sw. ex Ach.) Massal., **[Plate: 10/C]**

Att Inst. Veneto Sci. let., ed Arti, ser. 3, 5: 253, 1860. *Lichen punicens* Sw. in Ach., Method. Lich. 167, 1803.

Description: Thallus corticolous, crustose, effuse, corticated, esorediate. Apothecia upto 2mm diam., crowed, sessile, adnate to immersed, lecanorine, rounded, disc bright red, thalline margin persistent, well developed or less developed, epithecium K^+ violet-purple, hypothecium colourless. Ascospores always only transversely 7-15- septate, acicular 38-65 x 4-5 µm.

Chemistry: Thallus K+ yellow, C-, KC-, PD-; Anthraquinones, haematommone and triterpenes at Rf 4 present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **1**), on bark, 1812 m, 23.09.2014, M. Chinlampianga and A.R. Logesh, 14-031406, 031479, 021043, 021066, 019162; 15-031611 (LWG).

40. ***Haematomma watii*** (Stirt.) Zahlbr. **[Plate: 10/D]**
Cat. Lich. Univ. 5: 776, 1928; D.D. Awasthi, Beih. Nova Hedwigia17: 58, 1965. (Pl. 19 C).
Lecanora watii Stirt., Trans. & Proc. New Zealand Inst. 30: 383, 1898.

Description: Thallus crustose, effuse, corticated, corticolous. Apothecia sessile, adnate to immersed, lecanorine, rounded, disc red, pinkish-red to red bown, thalline margin persistent, well developed or less developed, epithecium K^+ violet-purple, hypotheciumcolourless. Spores transversely 14-20(-28)-septate, and with 1(-2) vertical septa in median region, thus submuriform, (65-) 78-96(-100) x 7-9(-11) µm, fusiform to vermiform, tapering on both ends, disc scared red, apothecia up to 2mm diam.
Chemistry: Thallus K+ yellow, C-, KC-, PD-; Anthraquinones, haematommone present in TLC
Specimen examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 1812 m, 23.09.2014, M. Chinlampianga and A.R. Logesh, 14-031401 (LWG).

Hafellia Nyl.
(Physiaceae)

The genus *Hafelia* represented only 3 species from India, 2 species known from the study area, of which 1 species reported as new to India.

41. ***Hafellia curatellae*** (Malme) Marbach **[Plate: 11/A]**
Biblioth. Lichenol. 74: 255, 2000. *Buellia curatellae* Malme, Ark. Bot. 21A (14): 18, 1927; Zahlbr., Cat. Lich. Univ. 7: 347, 1931; S.R.Singh & D.D.Awasthi, Biol. Mem. 6(2):175, 1981.

Description: Thallus ochraceous, grey or pale grey, slightly to strongly warted, slightly to strongly fissured, NIS, no or black prothallus, with norstictic acid,K+ yellow-red, UV-. Apothecia 0.4-0.6 mm diam., sessile or moderately immersed; disc flat to convex, non-pruinose; margin non-pruinose;excipulum 20-30 mu thick, ectal carbonaceous, med. carbonaceous or paler, K-, Asci not polysporous, with up to 8 spores; epithecium greenish black, black-olivaceous, olive-brown, ascospores 8/ascus, (15-)16- 18(-22) x 6-7(-8) mu, 1-(or seemingly 3-) septate, thin septa, subapically somewhat thickened walls, finely sculptured.
Chemistry: K+ yellow to green, C-, KC-, Pd-; TLC : Norstictic acid.

Plate: 10 (A - D)

A. Graphis lineola Ach.
B. Graphis proserpens Vain.
C. Haematomma puniceum (Sw. ex Ach.) Massal.,
D. Haematomma watii (Stirt.) Zahlbr.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **18**), on bark, 1812 m alt. 20.09.2014. M. Chinlampianga & A.R.Logesh, 14-031408(LWG).

42. ***Hafellia demutans*** (Stirton) Puswald **[Plate: 11/B]**
Acta Botanica Brasilica 25(4): 885-889, 2011.

Description : Thallus crustose, corticolous, smooth, white, UV-; apothecia round, sessile, disc flat without pruina, 0.4-0.7 mmin diam.; hymenium inspersed with oil; hypothecium carbona-ceous; asci consistently 8 spored; ascospores 24-33× 13-15 µm, 1-septate, thick walled.

Chemistry : Thallus K+ yellow, C-, KC-, PD+; stictic acid and atranorin present.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **1**), 1812 m alt. 20.09.2014. M. Chinlampianga and A.R.Logesh14-021068 (LWG).

Comment : 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.

43. ***Hemithecium aphanes*** (Mont. & Bosch.) M. Nakan & Kashiw. **[Plate: 11/C]**
(Graphidaceae)
Bull. Nat.Sci. Mus. Ser. B, 29 (2) : 88, 2003. *Graphis aphanes* Mont. and Bosch, - Jungh. Plant. Jungh. 4: 474, 1855.

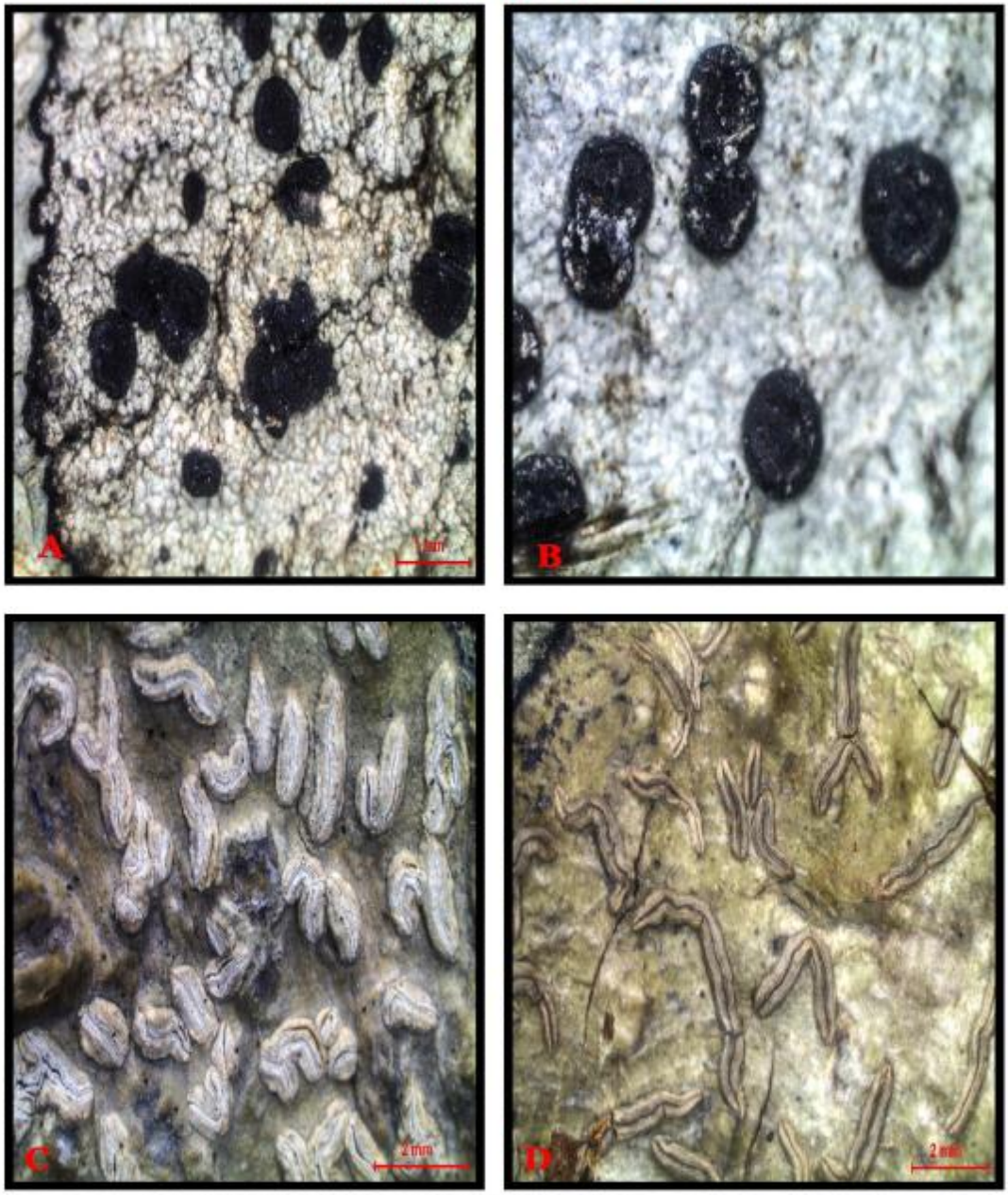
Description : Thallus corticolous, crustaceous, endophloeodal, smooth, uneven, somewhat shiny, pale yellow to greenish grey, 55-125 µm thick; apothecia lirellate, lirellae prominent, emergent, usually simple sometimes furcated, straight to flexuous sometimes curved, up to 12 mm long; ends acute and tapering; margin distinct, concolorous to the thallus; disc narrow in the form of slit, epruinose; exciple complete, yellow to brown, basally irregular, labia entire to distinctly sulcate on lateral sides, covered with thalline cover upto the apices; asci 6-8 spored, cylindrico clavate; ascospores hyaline, elongate ellipsoid, transversely 16-20 locular, 55-105 x 6-10 µm, I+ blue.

Chemistry: Thallus K+ yellow to red,C-,KC-, PD+ yellow. TLC: Nortictic and stictic acid.

Specimens examined: Champhai district, Murlen National Park (East – Site No. 19), on bark, 2092 m, 23.09.2014, M.Chinlampianga and A.R. Logesh, 14-031463, 021037, 021062, 031430, 031450, 031451 (LWG).

44. ***Hemithecium pyrrhochroa*** (Mont. et vd. Bosch.) V.Tewari & Upreti **[Plate: 11/D]**
Synm.: *Ustalia pyrrhochroa* Mont. et vd. Bosch, Jungh. Plant Junghuhn. 4: 477, 1855.

Plate: 11 (A - D)



A. Hafellia curatellae (Malme) Marbach
B. Hafellia demutans (Stirton) Puswald
C. Hemithecium aphanes (Mont. & Bosch.) M. Nakan & Kashiw
D. Hemithecium pyrrhochroa (Mont. etvd. Bosch.) V.Tewari & Upreti

Description: Thallus corticolous, crustaceous, epiphloeodal, yellowish brown, smooth. Apothecia lirellate prominent, much emergent, sparse to compact, simple to branched, straight to curved and flexuous; upto 15 mm long; ends subobtuse to round; margin thick, yellowish, longitudinally multistriate, disc close. Exciple open, light brown to brown (non-carbonized), narrow base, upper region much expanded; labia superficially multisulate and striate with black stripes in between the sulci, inner sulci convergent, outer divergent, covered with thalline veil. Asci 2-4 spores; ascospores brown, multicelled muriform, oblong-ellipsoid, transversely 18-32 locular, longitudinally 5-7 locular, 90-126 x 25-28 µm, I^+ red violet.

Chemistry: Thallus K^+ red, Pd-; TLC: no lihen substance seen.

Specimens examined: Champhai district, Murlen National Park (West – Site No. **9**), on bark, 1812 m alt. 20.09.2014. M. Chinlampianga & A.R.Logesh14-021026; 15-031605 (LWG).

Heterodermia Trevisan em. Poelt
(Physiaceae)

Out of the 95 species under the genus *Heterodermia*known from the world, India is represented by 38 species and 13 species are reported from Murlen national Park, Mizoram.

45. ***Heterodermia albidiflava*** (Kurok.) D.D. Awasthi, **[Plate: 12/A]**
Geophytology 3(1): 113, 1973. *Anaptychia albidiflava* Kurok., Beih. Nova Hedw. 6: 42, 1962.

Description : Thallus corticolous, foliose, lobate,; corticated on both sides; upper side grey; lower side dark, rhizinate; medulla yellow. Apothecia substipitate; ascospores 25-33 x 12-13 µm.

Chemistry: - Medulla K^+ red, C-, KC-, PD^+ deep yellow; zeorin present in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **19**), on bark, 1812 m alt. 20.09.2014. M. Chinlampianga & A.R.Logesh, 14-019143 (LWG).

46. ***Heterodermia boryii*** (Fée) K.P.Singh & S.R.Singh, **[Plate: 12/B]**
Geophytology 6(1): 33, 1976. *Borreera boryi* Fée Essai Crypt. Ecorc. Offic. 96. 1824.

Description: Thallus corticolous or terricolous, foliose, looely attached, greyish to partly blackish; lower side black rhizines along margins, rarely sorediate. Apothecia subpedicellate, to 5mm in diam.; margin lacinulate, black ciliate; ascospores (36-) 40-50 x (16-) 20-24µm.

Chemistry: - Medulla K^+ red, C-, KC-, PD^+ yellow; zeorin present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **19**), on bark, 1812 m alt. 20.09.2014, M. Chinlampianga & A.R.Logesh, 14-031443, 031442, 021074(LWG).

47. ***Heterodermia comosa*** (Eschw.) Follmann & Redón, **[Plate: 12/C**
Willdenowia 6:446, 1972. *Parmelia comosa* Eschw. In Martius, Icon. Fl. Crypt. 2: 26, 1828.

Description : Thallus corticolous , foliose, attached by basal part; corticated on upper side only; upper side whitish grey, with dense, concolorous cilia; lower side ochraceous, veined, often sorediate at apices. Apothecia not seen.

Chemistry: - Medulla K^+ red, C-, KC-, PD^+ yellow; zeorin present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **19**), on bark, 20.09.2014. M.Chinlampianga and A.R.Logesh 14-019183, 019170 (LWG).

48. ***Heterodermia dactyliza*** (Nyl.) Swinsc. & Krog, **[Plate: 12/D]**
Lichenologist 8:117, 1976. *Physcia speciosa* var. *dactyliza* Nyl., Syn., Lich. 1: 417, 1860.

Description : Thallus saxicolous and corticolous, foliose; upper side grey to bronish grey, lacking isidia and soredia; lower side white to brown with marginal rhizines, Apothecia to 4mm in diam.; ascospores 30-35 (-40) x 13-17 (-20)µm.

Chemistry: - Medulla K^+ red, C-, KC-, PD-; zeorin present in TLC.

Specimen examined: Champhai district, Murlen National Park (South– Site No. **6**), on bark, 1600 m alt. 20.09.2014, M. Chinlampianga, 12-019376 (LWG).

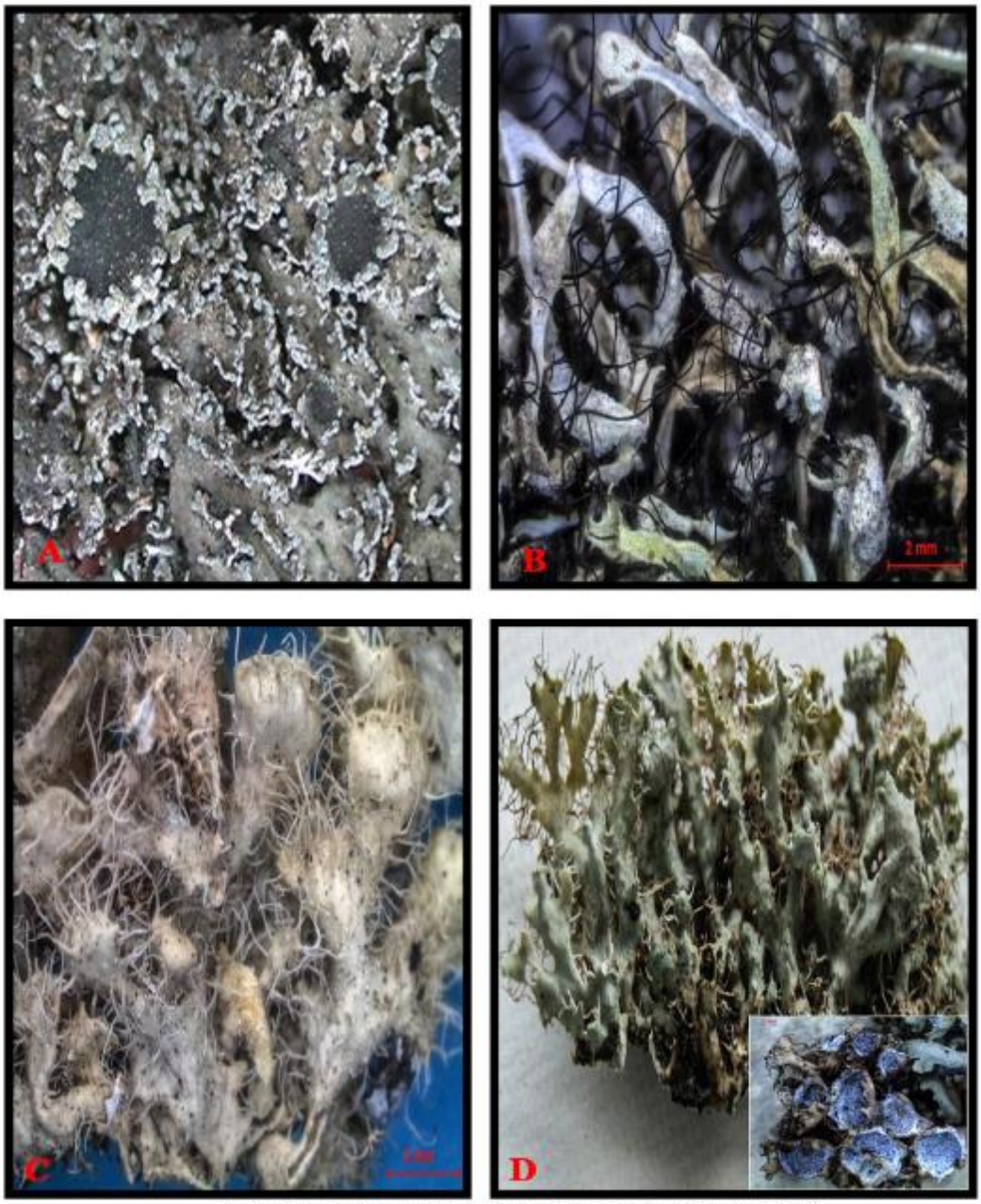
49. ***Heterodermia diademata*** (Taylor) D.D.Awasthi, **[Plate: 13/A]**
Geophytology 3: 133, 1973. *Parmelia diademata* Taylor, London J. Bot. 6: 165, 1847.

Description : Thallus corticolous, terricolous ad saxicolous, foliose; upper side grey to grey-white, lacking isidia and soredia; lower side pale brown with concolorous. Apothecia usually numerous, to 7mm in diam., ascospores (16-) 22-32 x (-40) x 10-18µm.

Chemistry: - Medulla K^+ red, C-, KC-, PD^+ pale yellow; zeorin present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **19**), on bark, 1600 m alt. 20.09.2014, M. Chinlampianga and A.R.Logesh, 14-021094, 021069, 019169; 15-031633; 12-019389 (LWG).

Plate: 12 (A - D)



A. Heterodermia albidiflava (Kurok.) D.D. Awasthi
B. Heterodermia boryii (Fée) K.P.Singh&S.R.Singh
C. Heterodermia comosa (Eschw.) Follmann &Redón
D. Heterodermia dactyliza (Nyl.) Swinsc. & Krog

50. ***Heterodermia flabellata*** (Fée) D.D.Awasthi, **[Plate: 13/B]**
Geophytology 3: 113, 1973.

Description: Thallus corticolous, foliose, closely adnate, branched; upper side grayish white, lacking isidia and soredia; lower side with rhizines. Apothecia 6mm in diam.; ascospores 30-45 x 13-18µm.

Chemistry: - Medulla K^+ purple, red, C-, KC-, PD^+ deep yellow; zeorin and unknown substace present in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **19**), on bark, 1600 m alt. 20.09.2014, M. Chinlampianga and A.R.Logesh, 14-031424(LWG).

51. ***Heterodermia hypochraea*** (Vain.) Swinsc. & Krog **[Plate: 13/C]**
Swinscow & Krog. Lichenologist 8: 119, 1976; Singh & Sinha 420: 408, 1992. Basionym: *Anaptychia hypochraea* Vainio, Bot. Mag., Tokyo 35: 59, 1921; Kurokawa 94, 1962.

Description: Thallus corticolous, rosette form, to 6 cm across, branched; lobes suberect, to 2 mm wide, corticated on upper side only; upper side greywhite, lacking isidia and soredia; lower side white to yellow-brown with marginal rhizines.

Chemistry: Medulla K + violet, C-, KC- , PD+ pale yellow; Zeorin and unknown pigment present in TLC.

Specimens examined: Champhai district, Murlen National Park (East–Site No. **19**), on bark 1600 m alt. 20.09.2014, M. Chinlampianga, 12-019382 (LWG); 14-021092 (LWG).

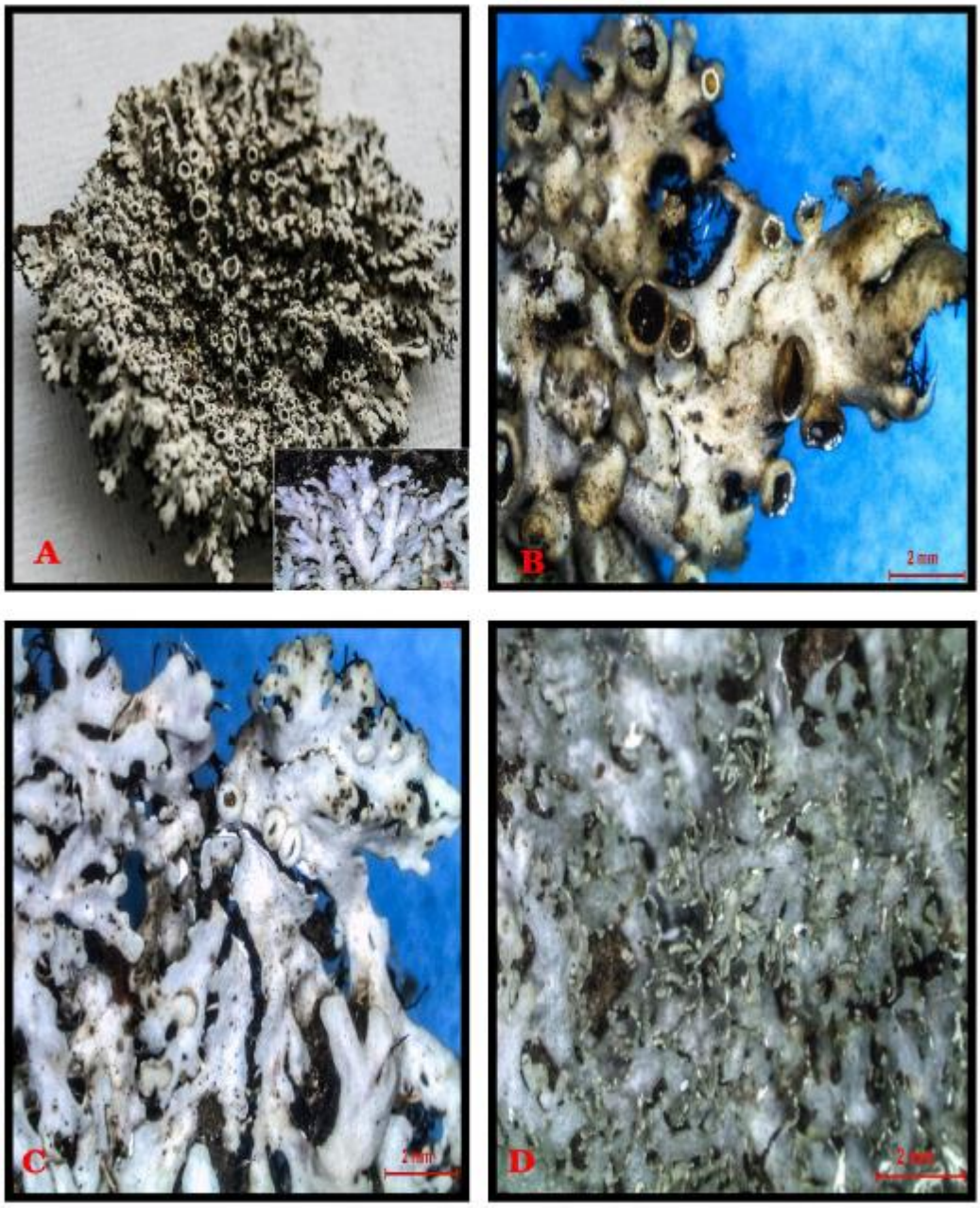
52. ***Heterodermia isidiophora*** (Nyl.) D.D.Awasthi , **[Plate: 13/D]**
Geophytology 3: 114, 1973.

Description : Thallus corticolous, foliose, corticated on upper side only; upper side white to whitish grey; lower side white, veined with marginal rhizines. Pothecia pedicellate, to 5mm in diam., disc pruinose, margin lacinulate; ascospores (20-) 25-32 x 10-15 µm.

Chemistry: - Medulla K^+ yellow, C-, KC-, PD^+ deep yellow; zeorin acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **20**), on bark, 20.09.2014, M. Chinlampianga and A.R.Logesh, 14-021073, 021052(LWG).

Plate: 13 (A - D)



A. Heterodermia diademata (Taylor) D.D.Awasthi
B. Heterodermia flabellate (Fée) D.D.Awasthi
C. Heterodermia hypochraea (Vain.) Swinsc. &Krog
D. Heterodermia isidiophora (Nyl.) D.D.Awasthi

53. ***Heterodermia japonica*** (Sato) Swinsc. & Krog **[Plate: 14/A]**
Lichenologist 8: 122, 1976. *Anaptychia dendritica* var. *japonica* M.Sato, J. Jap. Bot. 12: 427, 1936.

Description : Thallus corticolous and saxicolous, foliose, branched; upper side grayish white, sorediate on ends of short lateral lobules; lower side white with marginal rhizines. Apothecia rare, substipulate, to 8 mm in diam., margin with lacinules; ascospores 30-46 x15-20µm.

Chemistry: - Medulla K^+ yellow, C-, KC-, PD^+ deep yellow; zeorin acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **9**), on bark, 1600 m alt. 20.09.2014, M. Chinlampianga and A.R.Logesh, 14-019179, 15-031622 (LWG).

54. ***Heterodermia obscurata*** (Nyl.) Trevisan **[Plate: 14/B]**
Giorn. Bot. Ital., 1: 114, 1869. *Physia obscurata* Nyl., Acta Soc. Sci. Fenn. 7: 440, 1863.

Description : Thallus corticolous, foliose, branched; soraliate; lower side deep yellow to ochraceous brown with marginal rhizines. Apothecia rare, substipitate, to 5 mm in diam., ascospores 25-35 x 15-19 µm.

Chemistry: Medulla K^+ yellow, C-, KC-, PD^+ deep yellow; zeorin acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (East -Site No. **20**), on bark, 1600 m alt. 20.09.2014, M. Chinlampianga and A.R.Logesh, 14-021095; 12-019375(LWG).

55. ***Heterodermia podocarpa*** (Bél.) D.D.Awasthi **[Plate: 14/C]**
Geophytology 3: 114, 1973.

Description : Thallus corticolous, foliose, branched; upper side grayish, lacking soraliate; lower side white with marginal rhizines. Apothecia rare, substipitate, to 5 mm in diam., ascospores 36-51 x 16-25 µm.

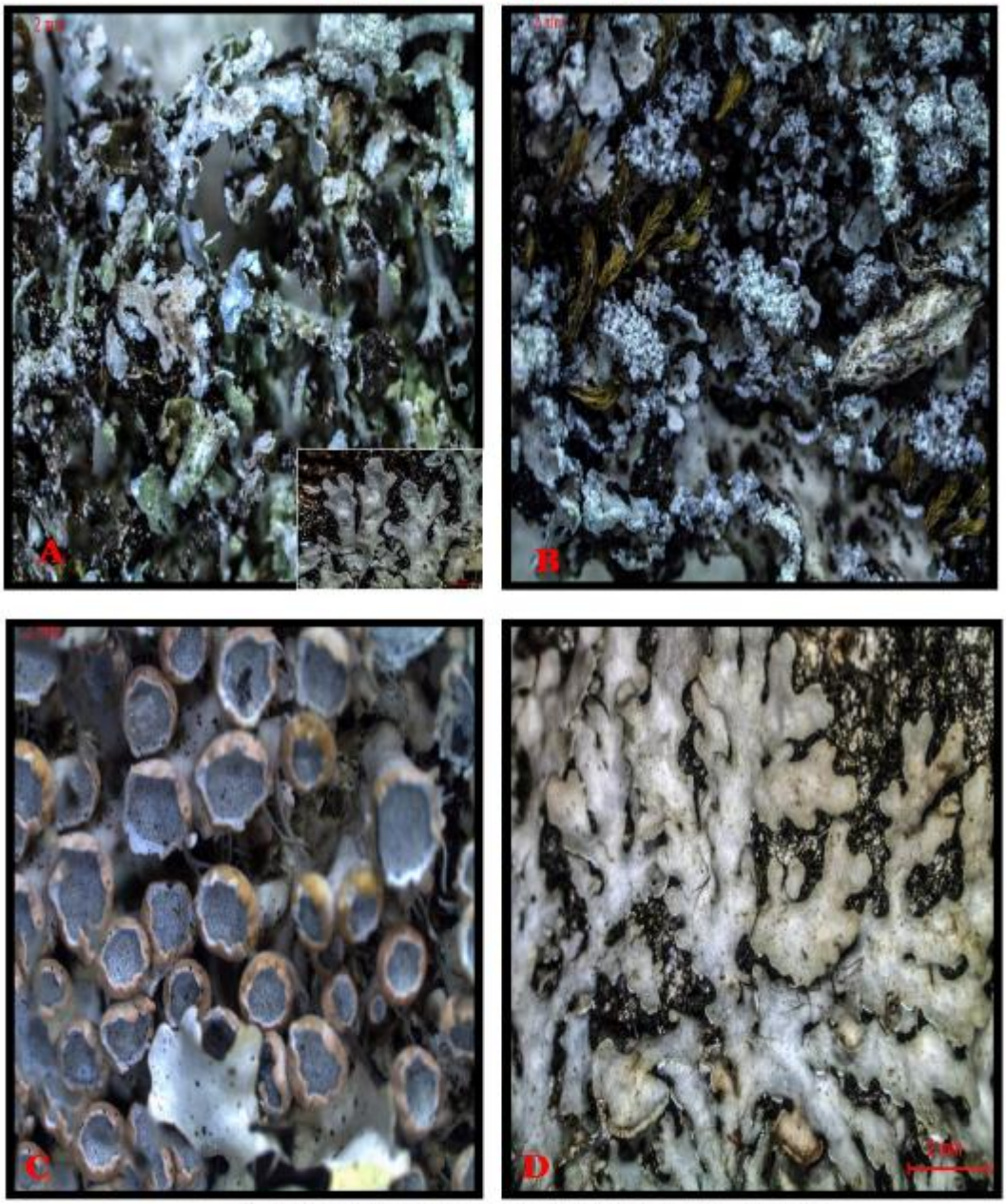
Chemistry: - Medulla K^+ yellow, C-, KC-, PD^+ yellow; zeorin acid present in TLC.

Specimen Examined: Champhai district, Murlen National Park (South – Site No. **7**), on bark, 1500 m alt. 07.07.2012. M. Chinlampianga, 12-019388 (LWG).

56. ***Heterodermia speciosa*** (Wulf.) Trevis., **[Plate: 14/D]**
Atti Soc. Ital. Sci. Nat. 11: 614, 1868. Lichen speciosus Wulf. in Jacquin, Coll. Bot. 3:119, 1789.

Description : Thallus corticolous or saxicolous, foliose; upper side grayish white, sorediate; soredia farinose; lower side brownish, rhizinate. Apothecia sessile to substipitate, to 8 mm in diam., marginally sorediate; ascospores 25-7 x 12-18 µm.

Plate: 14 (A - D)



A. Heterodermia japonica (Sato) Swinsc. &Krog
B. Heterodermia obscurata (Nyl.) Trevisan
C. Heterodermia podocarpa (Bél.) D.D.Awasthi
D. Heterodermia speciosa (Wulf.) Trevis.,

Chemistry: - Medulla K^+ yellow, C-, KC-, PD^+ yellow; zeorin acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (East–Site No.**19**), on bark, 1600 m alt. 20.09.2014, M. Chinlampianga and A.R.Logesh, 14-021076 (LWG).

57. ***Heterodermia togashi*** (Kurok.) D.D. Awasthi **[Plate: 15/A]**
Geophytology 3: 114, 1973. Basionym: *Anaptychia togashii* Kurokawa, Beih. Nova Hedwigia 6: 68, 1962.

Description : Thallus ad nate, to 10 cm across, branched, lobes to 1 mm wide, corticated on upper side only; upper side greyish to darker, lacking isidia and soredia; lower side white with marginal rhizines forming a mat beyond lobe margins. Apothecia to 8 mm in diam.; disc pruinose; margin lacinulate with cilia; cortex of reeptacle ± violet; ascospores 33-43 x 16-20) µm, with sporo-blastidia at maturity.

Chemistry: Medulla K + yellow, C-, KC-, PD+ faint yellow; Zeorin present in TLC.

Specimen examined: Champhai district, Murlen National Park (North–Site No. **3**), on bark, 1600m alt.20.09.2014, M. Chinlampianga and A.R.Logesh, 14-019170 (LWG).

Hypotrachyna (Vain.) Hale
(Parmeliaceae)

The genus *Hypotrchyna*is represented by 150 species in the world out of which 37 species are known to occur in India and 13 species are reported from the study area.

58. ***Hypotrachyna adducta*** (Nyl.) Hale **[Plate: 15/B]**
Phytologia. 28: 340, 1974. *Parmelia adducta* Nyl.Flora 68:610, 1885; Awasthi, Biol. Mem.1:164, 1976.

Description : Thallus corticolous, foliose; upper side ashy grey, lacking isidia and soredia; lower side black with dichotomously branched rhiziness; medulla white. Apothecia often crowed, cupuliform, 2mm in diam., ascospores 18-25 x 11-13 µm.

Chemistry : Medulla K-, C-, KC-,PD^+ red; protocetraric acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (West – Site No. **9**), on bark, 1450mts alt. 23.09.2014, M. Chinlampianga and . A.R.Logesh,14-019160, 019163, 019181(LWG).

59. ***Hypotrachyna awasthii*** Hale & Patwardhan, **[Plate: 15/C]**
The Bryologist 77: 637, 1974.

Description: Thallus corticolous, foliose, adnate; upper side grey, isidiate; isidia simple to branched; lower side black with simple and dichotomously branched rhizines; medulla white. Apothecia absent in specimens examined. According to Hale and Padwardhan (1974) apothecia rare, adnate, 1.0-2.5 mm in diameter; hymenium 50-60 µm. Spores simple, oval 10x8 µm. Pycnidia rarely present, black immersed. Condia bifusiform 5-6x1 µm.

Chemistry: Medula K+ yellow to red, C-, KC-, P+ red. TLC: salazinic and norstictic acid present

Specimens examined: Champhai district, Murlen National Park (West – Site No. **11**), on barks, 1430 mts alt.17.02.2014, M. Chinlampianga and A.R.Logesh,14-019159, 019195, 021075 LWG).

60. ***Hypotrachyna crenata*** (Kurok.) Hale **[Plate: 15/D]**
Phytologia 28: 341, 1974. *Armelia crenata* Kurok. in Hale & Kurokowa, Contr. US.Nat. Herb., 36: 168, 1964.

Description : Thallus corticolous, foliose, upper side pale grey, isidiate; isidia short, filiform, simple to branched; lower side blackish with sparse, dichotomously branched rhizines; Apothecia to 4mm in diam., ascospores 9-11 x 6-9 µm.

Chemistry: Medula K+ yellow to red, C-, KC-, P+ pale orange; stictic acid with or without constictic acid and norstictic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (West – Site No. **11**), on bark, 1350 mts alt. 17.02.2014, M. Chinlampianga, 14-021072 (LWG)

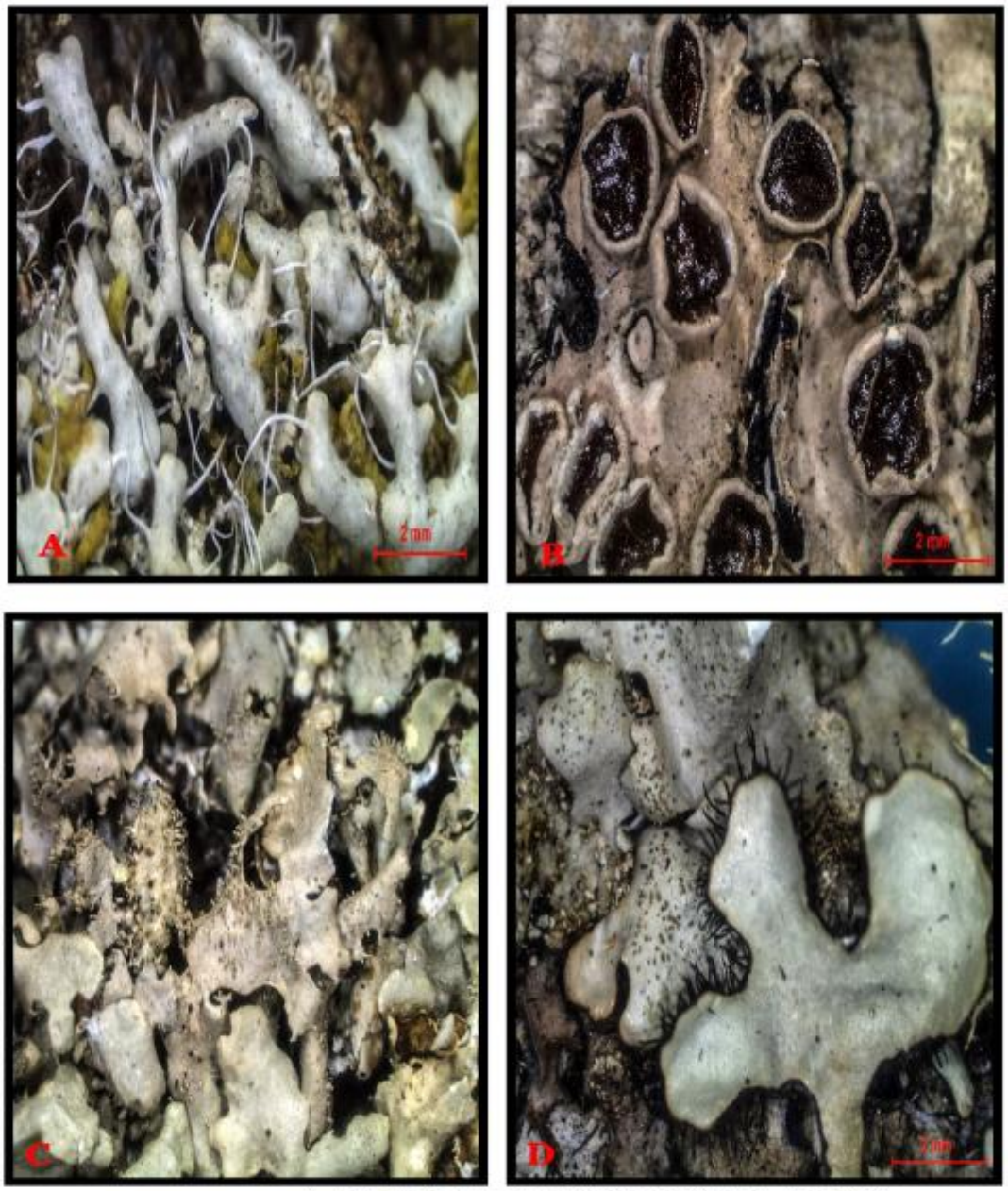
61. ***Hypotrachyna imbricatula*** (Zahlbr.) Hale, Smithson. **[Plate : 16/A]**
Contr. Bot. 25: 41, 1975. *Parmelia imbricatula* Zahlbr., Denks. Akad. Wien. Math. Nat.Kl. 83: 168: 1909; Awasthi, Biol.mem. 1: 176, 1976. *Hypotrachyna orientalis* (Hale) Hale, Phytologia 28: 341, 1974.

Description : Thallus corticolous, foliose, adnate; upper side whitish grey to darker, white macular; isidiate; isidia filiform simple or branched; lower side black with dichotomously branched rhizines; Apothecia dense, to 2mm in diam., ascospores 8-13(-16) x 5-7(-10) µm.

Chemistry: Medula K-, C-, KC^{+} orange-red PD-; barbatic, obtustatic and norobtusatic acid in TLC.

Specimen examined: Champhai district, Murlen National Park (South – Site No. 7), on rough bark, 850 mts alt. 15.01.2015, M. Chinlampianga,15-019394 (LWG).

Plate: 15 (A - D)



*A. Heterodermia togashi (*Kurok.) D.D. Awasthi
B. Hypotrachyna adducta (Nyl.) Hale
C. Hypotrachyna awasthii Hale &Patwardhan
D. Hypotrachyna crenata (Kurok.) Hale

62. ***Hypotrachyna rhabdiformis*** (Kurok.) Hale **[Plate: 16/B]**

Contr. Bot. 25: 62, 1975. *Parmelia rhabdiformis* Kurok. in Hale and Kurokawa, Contr. U.S. Nat. Herb. 36: 183,1964; Awasthi, Biol. Mem. 1:188, 1976.

Description: Thallus adnate to the substratum, about 8.0 cm across, irregularly lobed. Lobes sublinear, subimbricate, 2.0-6.0mm wide. Upper surface mineral gray, plane, shining, emaculate,isidiate. Isidia simple, cylindrical, becoming club shaped or lobulate. Medulla white. Lower surface densely rhizinate. Rhizines densely dichotomously branched. Apothecia adnate, 1.0-5.0 mm in diameter; disc brown; amphithecium isidate; hymenium 60-80 µm high. Spores colourless, simple, 15-21x 6-8 µm.

Chemistry: Cortex K + yellow; medulla K+ yellow turning red, C-, P+ orange. TLC: Atranorin, norstictic and some traces of stictic acid.

Specimen examined: Champhai district, Murlen National Park (North – Site No. **4**), on rough bark, 1600 mts alt. 19.02.2014, M. Chinlampianga,14-019164 (LWG).

63. ***Hypotrachyna sublaevigata*** (Nyl.) Hale **[Plate: 16/C]**

Smiths. Contr. Bot. 25: 66, 1975 p. 64. Basionym: *l'arl17eli£l tiliacea* var. *slIblaevigata* Nylander. Syn. Lich. I: 383, 1860. Synonym: *Parmelia sublaevigata* (Nyl.), Nylander. Ann. Sci. Nat. Bot. Scr. 5. 7: 306, 1867.

Description : Thallus corticolous (ramulicolous), adnate, to 8 cm across, lobate; lobes short, 2-5 mm wide, apically subrotund; upper side pale grey to darker (often red in herbarium) lacking isidia and soredia; lower side black, with short, dichotomously branhed rhizines; medulla white, Apothecia to 5 mm in diam,; ascospores 8-10 x 5-7 µm.

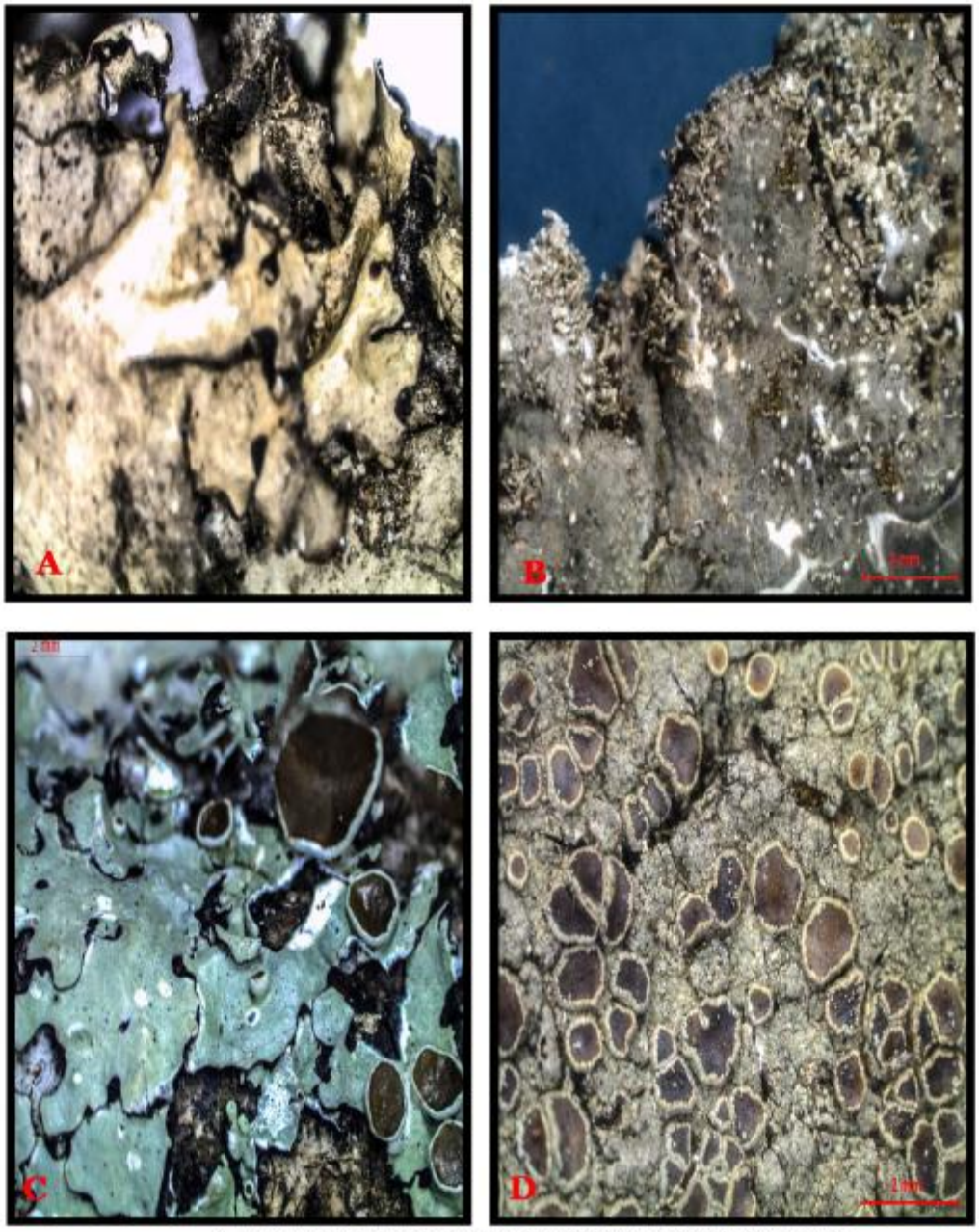
Chemistry: Medulla K + yellow turning red, C-, KC-, PD+ orange-red; Salazinic, norstictic and stictic acids present in TLC.

Specimen examined: Champhai district, Murlen National Park (South – Site No. **7**), on bark, 1600 m alt. 20.09.2014, M. Chinlampianga and A.R.Logesh, 12-019384(LWG).

Lecanora Ach.
(Lecanoraceae)

Total 552 species are widely distributed in the world, of which India represented about 90 species and Nayaka (2004) provided a detailed account of about 76 species in India (Lumbsch 1994; Nayaka 2004; Saag *et al*., 2009) and 7 species are reported from the study area.

Plate: 16 (A - D)



A. Hypotrachyna imbricatula (Zahlbr.) Hale, Smithson
B. Hypotrachyna rhabdiformis (Kurok.) Hale
C. Hypotrachyna sublaevigata (Nyl.) Hale
D. Lecanora achroa Nyl.

64. ***Lecanora achroa*** Nyl. **[Plate: 16/D]**

In Crombie, *J. Bot.* 14: 263, 1876.

Description : Thalus corticolous, crustose, yellowish grey-greenish grey; prothallus brownish black. Apothecia numerous, sessile, 0.2 – 1.0 mm in diam.; disc orangebrown; ascospores 8 per ascus, ellipsoid to broadly ellipsoid, 10-17 x 6-9

Chemistry: Thallus K+ yellow, C-, KC-,PD+ yellow; atranorin, 2'-*O*-methylperlatoric and usnic acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (West – Site No. **11**), on bark, 1500 m alt. 20.09.2014, M. Chinlampianga and A.R.Logesh, 14-1022, 031482 (LWG).

65. ***Lecanora alba*** Lumbsch **[Plate: 17/A]**

In Lumbsch, Feige & Elix, *Bryologist* 98 (4): 565, 1995.

Description : Thallus corticolous, crustose, yellowish grey to greenish white or whitish grey; prothalllus blackish brown. Apothecia numerous, sessile, 0.5-1.2 mm diam.; disc red brown to brown; ascospores per ascus 8, ellipsoidal, 9-13 x 5-8 µm.

Chemistry: Thallus K+ yellow, C+ orange, KC-, PD+ yellow; atranorin, 2'-*O*- arthothelin and usnic acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (West – Site No. **11**), on bark, 1500 m alt. 24.09.2014, M. Chinlampianga and A.R.Logesh, 14-021009, 031483, 31487(LWG).

66. ***Lecanora chlarotera*** Nyl. **[Plate: 17/B]**

Bull. Soc. Linn. Normandie, ser. 2, 6: 274, 1872.

Description : Thallus corticolous, crustose, yellowish grey to yellowish brown; prothallus absent. Apothecia numerous, 0.3-1.7mm in diam.; ascospors 8 per ascus, ellipsoidal, 12-16 x 7-10µm.

Chemistry: Thallus K+ yellow,, C-, KC-,PD- ; atranorin present in TLC.

Specimen examined: Champhai district, Murlen National Park (West – Site No. **19**), on bark, 1500 m alt. 24.09.2014, M. Chinlampianga and A.R.Logesh, 14-021013(LWG).

67. ***Lecanora concilianda*** Vain **[Plate: 17/C]**

Acta Soc. Fauna Fl. Fenn. 7: 85, 1890.

Description : Thallus corticolous, crustose, thin, grey to grayish white, rough; prothallus whitish grey. Apothecia numerous, sessile, constricted at base, 0.5-1.7 mm in diam.; disc red-brown to dark red-brown; ascospores 8 per ascus, ellipsoidal, 11-14 x 6-10 µm.

Chemistry: - Thallus K^+ yellow, C-, KC-, PD-; atranorin and 2'-*O*-methylperlatolic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (West – Site No. **12**), on bark, 1500 m alt. 24.09.2014, M. Chinlampianga and A.R.Logesh, 14-021011(LWG).

68. ***Lecanora coronulans*** Nyl. **[Plate: 17/D]**

Flora 59: 510, 1876; Zahlbr., Cat. Lich. Univ. 5: 436, 1928; Upreti & S. Chatterjee, Feddes Repert.108: 577, 1997. Synm: *Lecanora coronulata* Nyl. Hue., Nouv. Arch. Mus. Ser. 3 (3): 66, 1891, *Lecanora melanocardia* Vain, acta Soc, Fauna Flora Fenn. 7: 86, 1890.

Description : Thallus crustose, verrucolose to verrucose, whitish grey to yellowish grey; isidia & soredia absent; prothallus whitish gre. Apothecia numerous, crowed, sessile, 0.3-1.2 mm in diam., disc red brown to dark brown, epruinose; margin slightly prominent, entire, verrucose to flexuose, concolours with the thallus. Cortex indistinct, 10-15µm thick, amphi-thecium with small and large crystals; Epithymenium brown, red brown to dark brown, egranular, lacking crystals, hypothecium upper part yellow to reddish brown, lower part orange to dark red brown; ascus clavate, 52-60x 8-12 µm; ascospores 8 per ascus, ellipsoid to broadly ellipsoidal, 9-12 x5-7 µm.

Chemistry: Thallus and apothecial margin K-,C-,K-, Pd-, TLC & HPLC: major substance atranorin, protoconstipatic acid & zeorin. Trace/minor: chloroatranorin, constipatic acid, dehydroconstipatic acid.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **20**), on bark, 1500 m alt. 24.09.2014. M. Chinlampianga and A.R.Logesh,14-031488,021059, 031489, 031490 (LWG).

69. ***Lecanora fimbriatula*** Stirton. **[Plate : 18/A]**

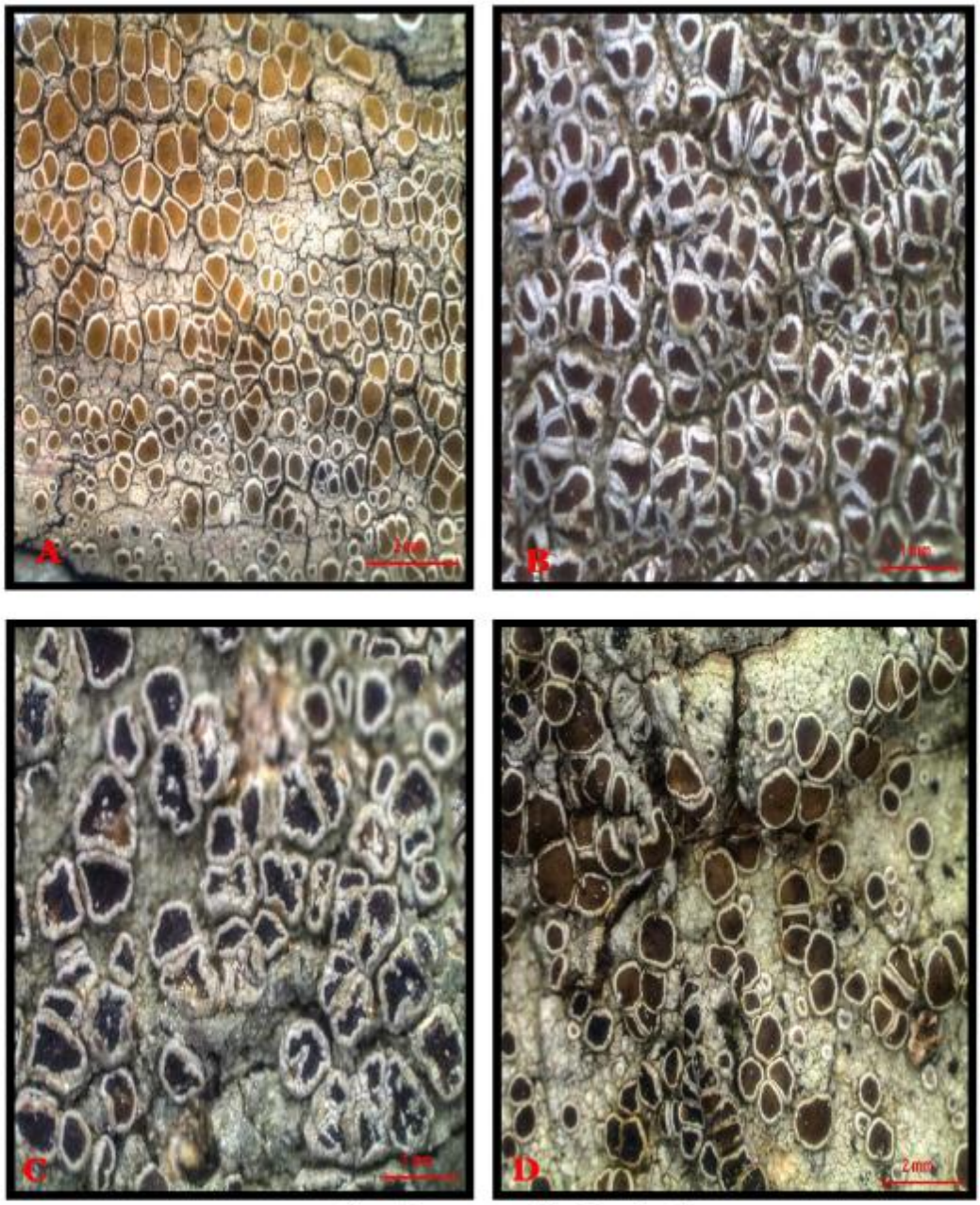
Proc. Roy. Soc. Glasgow 11: 311, 1879; Zahlbr., Cat. Lich. Univ. 5: 452, 1928; D.D. Awasthi, Beih. Nova Hedwigia 17: 62, 1965; Upreti & S. Chatterjee, Feddes Repert. 108: 578, 1997.

Description : Thallus corticolous, crutose, rimose-areolate to verruculose, whitish grey; prothallus whitish grey to blackish brown. Apothecia sessile, 0.3-1.0 mm diam., disc black, epruinose; margin thick; ascospore 8 per ascus, oval-ellipsoidal, 9-15 x 6-8µm.

Chemistry: Thallus K^+ yellow, C-, KC-, PD-; atranorin, chloroatranorin, and 2' –O-methylperlatolic acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **20**), on bark, 1500 m alt. 24.09.2014, M.Chinlampianga andA.R.Logesh,14-031484, 031485 (LWG).

Plate: 17 (A - D)



A. *Lecanora alba* Lumbsch
B. *Lecanora chlarotera* Nyl
C. *Lecanora concilianda* Vain
D. *Lecanora coronulans* Nyl

70. *Lecanora helva* Stizenb. **[Plate: 18/B]**

Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1888/1889: 218, 1890; Zahlbr, Cat. Lich. Univ. 5: 472. 1928; Nayaka & al., Phytotaxonomy 2: 58, 2002.

Description : Thallus corticolous, crustose, thin or thick, continuous of rimose areolate, smooth to verruculose, yellowish white to yellowish green. Apothecia numerous, 0.3-0.9mm diam., disc pale brown to orange; ascospores 8 per ascus, ellipsoid, 8-14 x 4-7µm.

Chemistry: Thallus K^+ yellow, C-, KC-, PD^+ pale yellow to orange; atranorin and 2' –O-methylperlatolic acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **20**), on bark, 1500 m alt. 24.09.2014. M. Chinlampianga and A.R.Logesh, 14-031486;15-031628 (LWG).

Lecidea Ach.
(Lecideaceae)

Over 100 species has been reported under the genus *Lecidea* in the world, of which 18 species are known to occur from India (Singh, 1981) and single has been reported from the study area.

71. *Lecidea granifera* (Ach.) Vain. in Hiern **[Plate: 18/C]**

Cat. Afr. Pl. 2(2): 424, 1901; Zahlbr., Cat. Lich. Univ. 3:768, 1925; D.D. Awasthi, Beih. Nova Hedwigia 17: 66, 1965. *Lecanora granifera* Ach., Syn. Meth. Lich.: 164. 1814. *Huilia granifera* (Ach.) Kr.P. Singh, Geophytology 11(2): 249, 1981.

Description : Thallus corticolous, crustose, greenish-grey to brownish, verrucose. Apothecia numerous, upto 2mm diam., disc reddish brown, smooth, flat to slightly convex; ascospores 8 spored, 50-65 x 12-20µm.

Chemistry: Thallus K^+deepyellow, C-, KC^+ yellow, PD-: atranorin present in TLC.

Specimens examined: Champhai district, Murlen National Park (East-Site No. **20**), on bark, 1500 m alt. 24.09.2014, M.Chinlampianga and A.R.Logesh,14-021049, 021040, 021051, 031053, 021079, 031409, 021051(LWG).

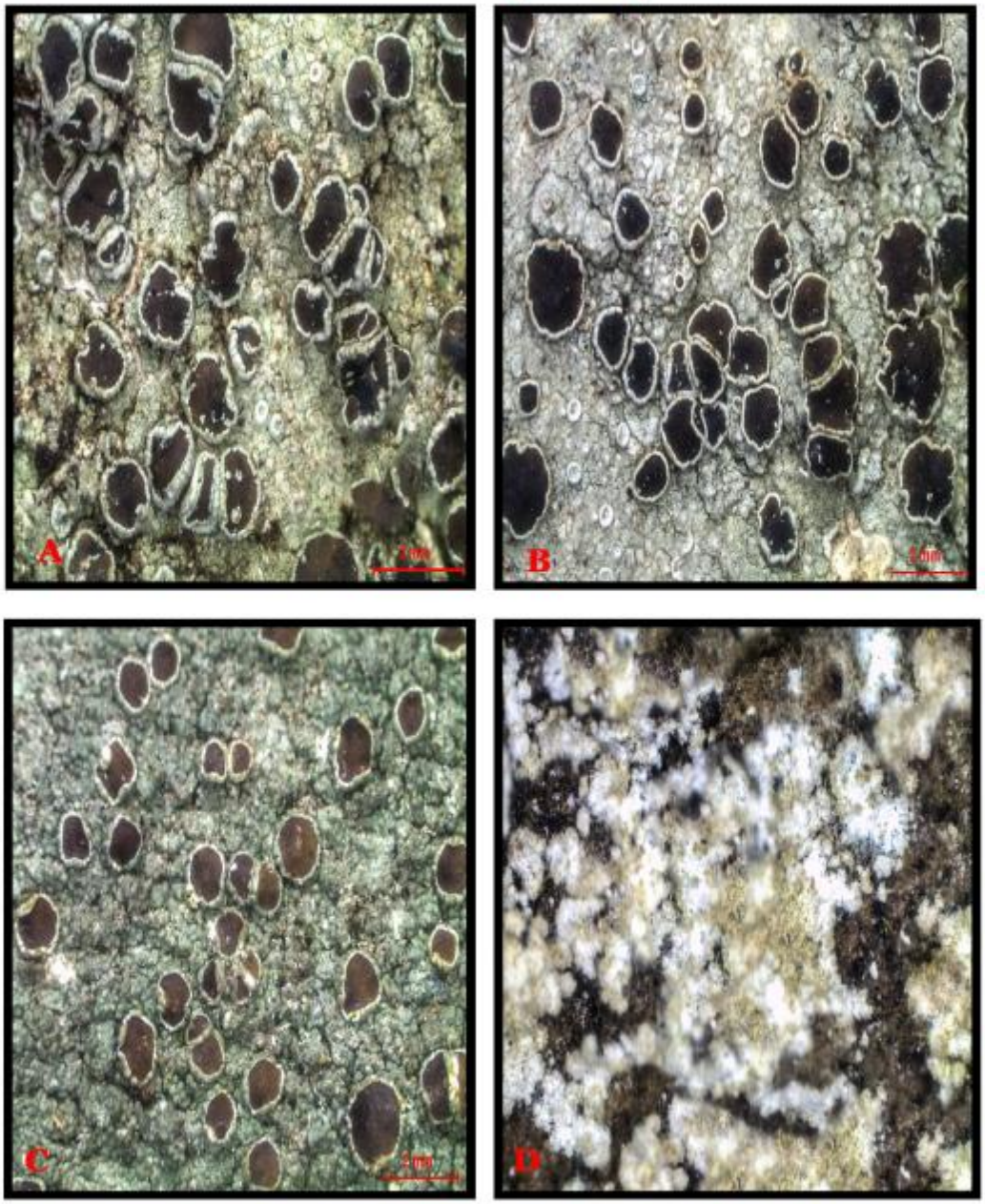
Lepraria Ach.
(Stereocualaceae)

The genus *Lepraria* contains 20 species in the world of which only 2 species are known in India, and 1 species is known to occur in the study area.

72. *Lepraria lobificans* Nyl., **[Plate: 18/D]**

Flora 56: 196. 1873; Zahlbr., Cat. Lich. Univ. 7: 767. 1931; Nayaka & al.,Biol. Mem. 28(1): 31. 2002. *Leproloma lobificans* Nyl. Biostel, Nouv. Flore lich. 2: 318, 1902.

Plate: 18 (A - D)



A. Lecanora fimbriatula Stirton.
B. Lecanora helva Stizenb.
C. Lecidea granifera (Ach.) Vain
D. Lepraria lobificans Nyl.,

Description: Thallus corticolous, saxicolous and terricolous, leprose, soft, pale to blue- grey, upto 100µm. Young thalli with a ± delimited margin and sometimes with very small and insdistinct lobes.Undesirable pale; no dark hyphae seen.

Chemistry: Thallus K^+ yellow, C-, PD^+ orange; TLC: zeorin, atranorin, constictic and stictic acid.

Specimen examined: Champhai district, Murlen National Park (West-Site No.**12**), on bark, 1500 m alt. 24.09.2014, M. Chinlampianga and A.R.Logesh, 14-021031(LWG).

Leptogium (Ach.) Gray.
(Collemataceae)

The total 150 known from the world, Awasthi (2007) described in detail 35species of *Leptogium*. Of which 3 species reported from the study area.

73. ***Leptogium askotense*** D.D. Awasthi **[Plate: 19/A]**
Awasthi & Akhtar, Norw. 1. Bot. 24: 63. 1977.

Description : Thallus corticolous, sometimes terricolous or saxicolous, adnate, to 4cm across; lobes orbicular, to 20 mm wide; upper side dark brown to greyblack,wrinkled, lacking isidia; lower side paler, with pale brown tomentum composed of elongate, cylindrical hyphal cells. Apothecia subpedicellate,stalk 2 mm long, tubular; disc reddish brown; thalline exciple with dense white hyphal hairs; cortex of thalline exciple single cell layered at base, to 3 cell layered at margin; ascospores muriform with 3-7 transverse and 1 (-2) longitudinalsepta, ellipsoid, acute at ends, 25-53 x 9-15 µm.

Chemistry: not detected.

Specimen examined: Champhai district, Murlen National Park (East -Site No. **23**), on bark, 1250 m alt. 24.09.2014, M. Chinlampianga, 14-021078, 019180(LWG).

74. ***Leptogium denticulatum*** Nyl. **[Plate: 19/B]**
Ann.Sci.Nat. Bot.ser.5.7:302, 1867.

Description : Thallus corticolous, terricolous,muscicolous or saxicolous, adnate, to 3.5cm across; lobes orbicular, 2-10mm wide; margins isidiate, lobulate; upper side lead – grey to darker, slightly wrinkled, with 2mm wide, squamiform isidia; lower side paler, etomentose apothecia rare, to 1mm in diameter; cortex of thalline exciple multicell layered at base, few cell layered at margin; proper exciple euparaplectenchymatous throughout; ascospores muriform with 3-5 transverse and 0-1 longitudinal septa, ellipsoid, acute at ends, 15-28 x 6-12µm.

Chemistry: No lichen substances present in TLC

Specimen examined: Champhai district, Murlen National Park (East- Site No. **21**), on bark, 1250 m alt. 21.02.2012. M. Chinlampianga, 12-021073(LWG).

75. ***Leptogium ulvaceum*** (Pers.) Vain. **[Plate: 19/C]**
Acad. Sci. Fenn. ser. A, 15 (6): 38, 1921; Malme 19, 1924. D. Awasthi & Akhtar, 1979: 203.Basionym: *Collema ulvaceum* Persoon in Gaudichaud, Yoy. Uran.Bot.: 203, 1826.

Description : Thallus corticolous, loosely adnate, to 4 cm across; lobes orbicular, to15 mm wide, 80-170 Ilm thick; upper side dark grey, rough rugulose, lackingisidia; lower side smooth, etomentose. Apothecia sessile to substipitate, to2 mm in diam.; thalline exciple creamish or thalline; cortex ofthalline exciplemulticell layered at base, 1 (-3) cell layered at margin; proper excipleeuparaplectenchymatous up to centre; ascospores muriform, with 4-8transverse and 1-2 longitudinal septa, ellipsoid,.16-32 x 10-13 µm.

Chemistry: Not detected.

Specimens examined: Champhai district, Murlen National Park (South-Site No.7), on bark, 850 m alt. 15.01. 2015. M. Chinlampianga,15-031613, 14-021053(LWG).

Lobaria
(Lobariaceae)

About 70 speies of the genus *Lobaria*are known from the world, of which Awasthi (2007) provided a detailed account of 14 species from Indian subcontinent.The study area represented by one species.

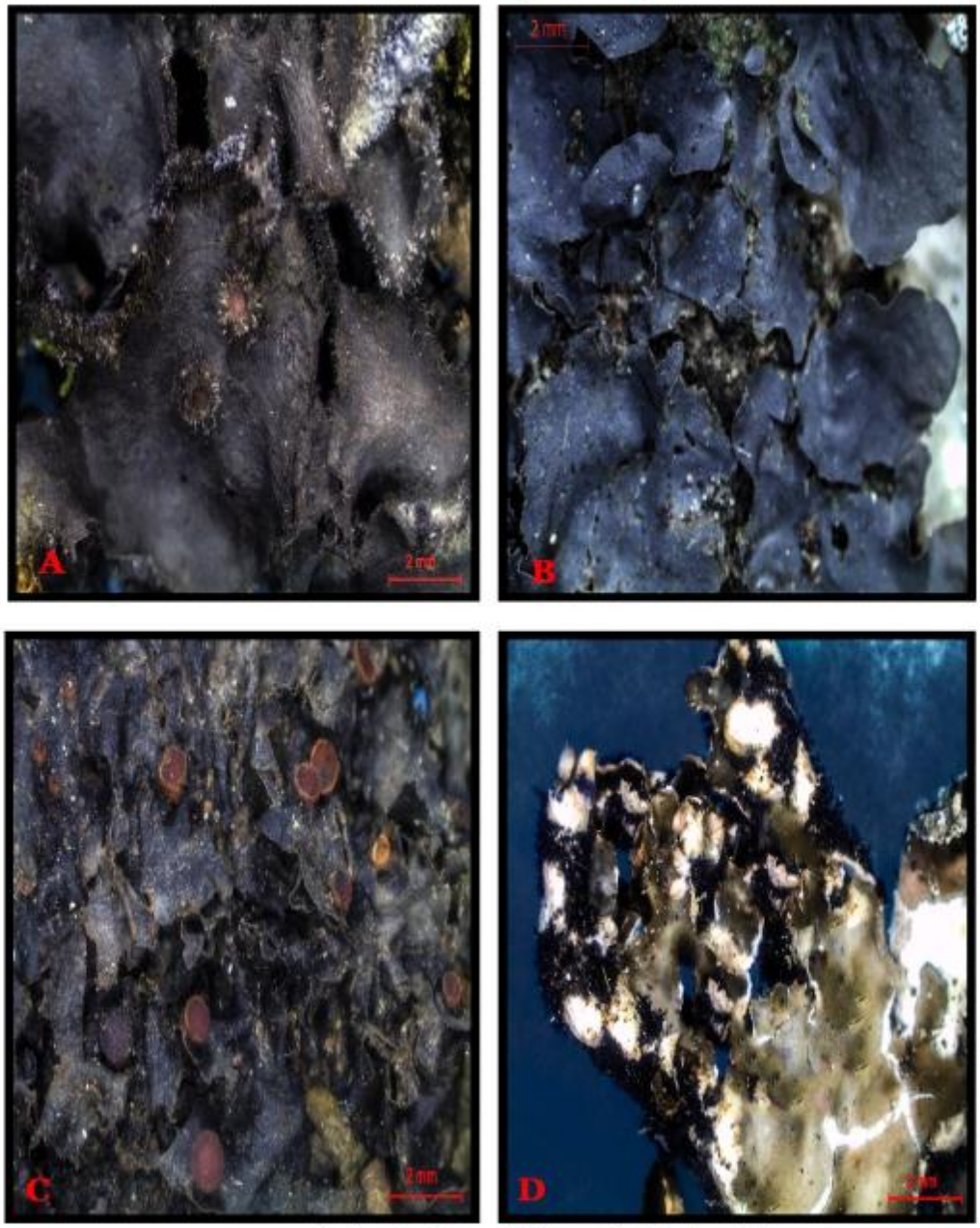
76. ***Lobaria retigera*** (Bory) Trev., **[Plate : 19/D]**
Lichenotheca veneta: no. 75, 1869. *Lichen retigera* Bory, Voyag. Princip. Iles Mers. d' Afr. 1: 392, 1804.

Description : Corticolous, terricolous or saxicolous, foliose; upper side pale brown to darker at margins; isidia usually on ridges, granular, cylindrical, simple to coralloid; lower side dark brown to black, tomentose sparsely rhizinate in grooves. Apothecia on ridges, to 4mm in diam.; ascospores 3-septate, fusiform, 24-50 x 5-8µm.

Chemistry: Medulla K-, C-, KC-, PD-: triterpenoids and thelephoric acid is present in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **21**), on bark, 1500 m alt. 24.09.2014, M. Chinlampianga & A.R.Logesh,14-031404(LWG).

Plate: 19 (A - D)



A. Leptogium askotense D. D. Awasthi
B. Leptogium denticulatum Nyl.
C. Leptogium ulvaceum (Pers.) Vain
D. Lobaria retigera (Bory) Trev

Lopadium Korb.
(Ectolechiaceae)

The genus *Lopadium* represented is 50 species in the world, out of which 9 species were known from India and, 2 species are reported from Murlen National Park, Mizoram.

77. ***Lopadium ionexcipulum*** Patw. & Makhija **[Plate: 20/A]**
Indian J. Bot. 4: 24, 1981. *Brigantiaea ionoexcipula* (Patw. & Makhija) D.D. Awasthi in D.D. Awasthi & Preeti Srivast., Proc. Indian Acad.Sci., Pl. Sci. 99(3): 167, 1989.

Description: Thallus crustose to warty verrucose, muscicolous, saxicolous, corticolous. Photobiont a protococcoid green green alga. Apothecia round, lecideine, sessile, hypothecium colourless or dark, hymenium I^+ blue. Paraphyses simple or branched, not anastomising, apices calyptrate in the strict sense of the genus. Asci 1-2-8-spored, spores colourless, muriform. **Chemistry**: Atranorin, zeorin and an unidentified substance in TLC.

Specimen examined: Champhai district, Murlen National Park (South-Site No.**10**), on bark, 1500 m alt. 15.01.2015, M. Chinlampianga, 15-019152(LWG).

78. ***Lopadium leucoxanthum*** (Spreng.) Zahlbr. **[Plate: 20/B]**
Sitzungsber. Kaiserl. Akad. Wiss. Wien, Math. -Naturwiss. Cl. 3: 398, 1902; Zahlbr., Cat. Lich. Univ. 4: 306, 1926; D.D. Awasthi, Beih. Nova Hedwigia 17: 73, 1965. *Lopadium granulosum* Patw. & Makhija, Indian J. Bot. 4(1): 24, 1981.

Description : Thallus saxicolous, thin, greenish-grey, apothecia 0.4 – 0.5 mm diam., disc brown-red, exciple olive-brown, hypothecium olive-brown, hymenium 150-160 µm high, asci 8-spored, spores (25-)35-45 x 10 µm, with 7 transverse and 1 vertical septa in central part forming 9-12 angular locules.

Chemistry: Atranorin, zeorin and a yellow spot at Rf value 0.72.

Specimen examined: Champhai district, Murlen National Park (West-Site No.**12**), on bark, 1500 m alt. 24.09.2014, M. Chinlampianga andA.R.Logesh, 14-019184 (LWG).

Mycobilimbia Zahlbr.
(Porpidiaceae)

79. ***Mycobilimbia hunana*** (Zahlbr.) D. Awasthi in D. Awasthi & R.Mathur **[Plate: 20/C]**
Proc. Indian Acad. Sci.Pl. Sci. 97(6): 501, 1987. *Bacidia hunana* Zahlbr. In Hand. Mazz., Symb. Sin. 3: 113,1930; D.D. Awasthi, Beih. Nova Hedwigia 17: 28, 1965.

Description : Thallus terricolous sometimes saxicolous, cracked; surface grey, grnulose; apothecia single or in groups, 0.2-0.8 mm in diam., plane to convex; disc dark brown to black, epruinose;

margin entire, pale yellow; exciple red-brown, 54-77µm thick at margin, K+ violet-brown, fading below; epithecium red-brown, 12-14 µm thick, K-; asci cylindrico-clavate, 8-spored; ascospores colorless, oblong-ellipsoid to rarely fusiform, both ends rounded, sometimes one end slightly tapering than the other, transversely 3-septatr, 21-28x6-9 µm; paraphyses colourless, simple.

Chemistry: Thallus K-, C-, KC-, Pd-, no lichen substance in TLC.

Specimen examined: Champhai district, Murlen National Park (South-Site No. **10**), on bark, 1500 m alt. 21.02.2012. M. Chinlampianga, 12-019387(LWG).

Myelochroa (Ach.) Elix & Hale
(Parmeliaceae)

The genus Myelochroa comprises of 25 species in the the world, out of which Awasthi (2007) provided detailed account of 11 species from India and 3 species are reported from Murlen National Park, Mizoram.

80. ***Myelochroa perisidians*** (Nyl.) Elix & Hale **[Plate: 20/D]**

Mycotaxon 29: 241, 1987; D.D. Awasthi, Comp. Macrolich. India, Nepal & Sri Lanka : 294, 2007.
Parmelia perisidians Nyl., Acta Soc. Sci. Fenn. 26: 6, 1900; D.D. Awasthi, Biol. Mem. 1: 185, 1976.
Parmelina perisidians (Nyl.) Hale, Phytologia 28: 483, 1974.

Description : Thallus corticolous rarely saxicolous, foliose; upper side pale grey, isidia, cylindrical, simple to branch isidia; lower side rhizinate; medulla yellow. Apothecia adnate, constricted at base, 1.0-4.0 mm diameter; disc brown; margins crenate , amphithecium isidiate; epithecium brown, 10-12 µm thick; hymenium colourless, 55-70 µm high. Asci clavate, 8 spored, 45-50 x 10-12 µm. Spores 9-13x6-7 µm.

Chemistry: Medulla K^+, C^+, KC^+, PD-; Atranorin, leucotylin and Zeorin , secalonic acid A, present in TLC.

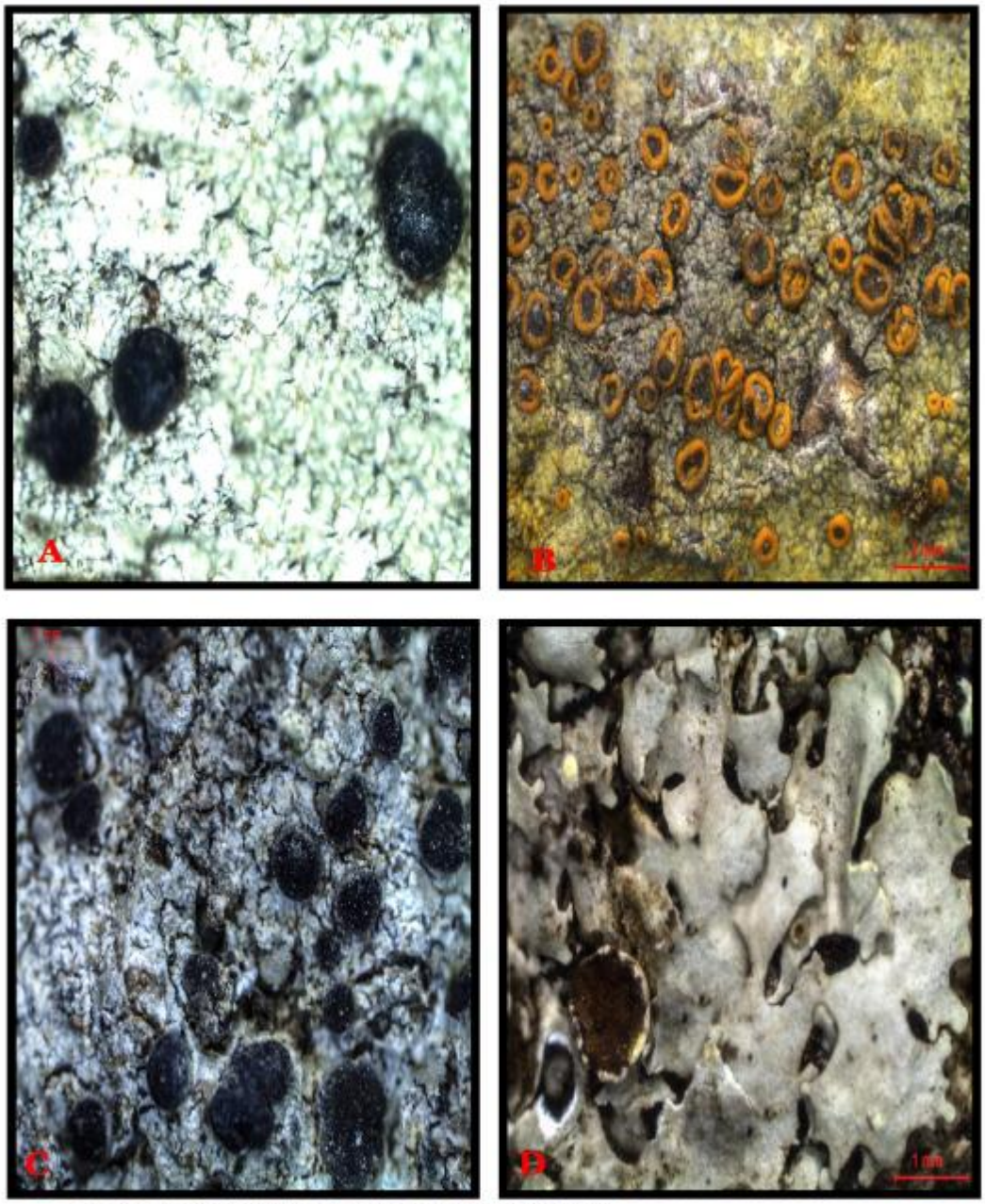
Specimen examined: Champhai district, Murlen National Park (West- Site No. **12**), on rough bark, 1100 mts alt. 17.02.2014, M. Chinlampianga,14-019158 (LWG)

81. ***Myelochroa xantholepis*** (Mont. & Bosch.) Elix & Hale **[Plate: 21/A]**

Mycotaxon 29: 241, 1987; D.D. Awasthi, Comp.Macrolich. India, Nepal & Sri Lanka : 296. 2007.
Parmelia xantholepis Mont. & Bosch, Pl. Jungh.: 428, 1855; D.D. Awasthi, Biol. Mem. 1: 199, 1976.
Parmelina xantholepis (Mont. & Bosch) Hale, Phytologia 28: 483, 1974.

Description : Thallus corticolous, foliose; upper side grey, lacking isidia and soredia; lower side rhizinate; medulla yellow. Apothecia to 3 mm in dia.; scospores 8-13 x 5-8 µm.

Plate: 20 (A - D)



A. Lopadium ionexcipulum Patw. & Makhija
B. Lopadium leucoxanthum (Spreng.) Zahlbr.
C. Mycobilimbia hunana (Zahlbr.) D. Awasthi in D. Awasthi & R. Mathur
D. Myelochroa perisidians (Nyl.) Elix & Hale

Chemistry: Medulla K +,C^+, KC^+ yellow, PD- ; secalonic acid A, leucotylic acid, leucotylin, zeorin, and related terpenoides present in TLC.

Specimens examined: Champhai district, Murlen National Park (West -Site No. **12**), on rough bark, M. Chinlampianga and A.R. Logesh,14-019192; 031402, 031434 (LWG).

82. ***Myriotrema microporum*** (Mont.) Hale **[Plate: 21/B]**

Mycotaxon 11: 134, 1980; A. Frisch, Biblioth. Lichenol. 92: 177, 2006. *Thelotrema microporum* Mont., Ann. Sci. Nat., Bot., ser. 3, 10: 130, 1848. *Thelotrema crassula* Nyl., Ann. Sci. Nat., Bot., ser. 4, 11 : 258, 1859. *Ocellularia crassula* (Nyl.) Zahlbr., Cat. Lich. Univ. 2: 588, 1923.

Description: Thallus, thick areolate fissured dark dull-grey, numerous small apothecia, a ± fused proper exiple, 8 spores per asci, transversely 2-4 septate hyaline ascospores of 10-18 x 5-8 µm, and the presence of psoromic chemosyndrome.

Chemistry: Not detected.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **21**), on rough bark, 1850 mts alt. 22.09.2014, M. Chinlampianga and A.R. Logesh, 14-031477 (LWG)

Normandina Nyl.,
(Verrucariaceae)

The study area represented the occurrence of one species under the genus *Normandina*.

83. ***Normandina pulchella*** (Borrer) Nyl **[Plate: 21/C]**

Ann. Sci. Nat. Bot. ser. 4, 5 : 382, 1861. Upreti & al., Phytotaxonomy 8: 114, 2008. *Verrucaria pulchella* Borrer in Hook. & Sowerby., Engl. Bot., Suppl. 1: tab. 2602, fig. 1, 1831.

Description : Thallus corticolous, squamulose, scattered or partly becoming contiguous forming dense colonies in irregular patches, squamules plane to concave, concentrically ridged, undivided or with distinct marginal lobes, 1-2mm wide, 30-70 µm thick, sometimes becoming leprose; upper surface glaucous, pale-grey to greenish-grey, soredia farinose to granular, 20-50 µm in diam., photobiont layer distinct, 35-60 µm thick, composed of hyphae with mostly globose or ellipsoid cells arranged in a net like structure surrounding groups of algal cells; lower surface ecorticate, tomentose, pale. Apothecia absent.

Chemistry: - Medulla K^+ yellow, C-, KC-, PD- ; Zeorin acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **21**), on rough bark, 1890 mts alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-031476;15-031609 (LWG).

Pannaria Del. in Bory
(Panariaceae)

The genus Pannaria is represented by 6 species in India (Awasthi, 2007) and single species is known from the study area.

84. ***Pannaria emodi*** P.M. Jorg., **[Plate: 21/D]**
Lichenologist 33(4): 297, 2001; Upreti & al., Nova Hedwigia 81(1-2): 105, 2005; D.D. Awasthi, Comp. Macrolich. India, Nepal & Sri Lanka: 305, 2007.

Description : Thallus corticolous, squamulose – folise; prothallus inconspicuous; lobes to 1 mm wide; upper side brownish. Apothecia to 2mm diam., ascospores 10-12 x 6-8µm.

Chemistry: Thallus K-, C-, KC-, PD^+ yellow; panarin present in TLC.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **21**), on rough bark, 1350 mts alt. 20.09.2014, M. Chinlampianga and A.R. Logesh,14-021070, 031410(LWG)

Parmeliella Elix & Hale
(Pannariaceae)

This genus comprises of only 4 species in the world and all belong to exist in India, out which one species reported from the study area.

85. ***Parmeliella papillata*** P.M.Jørg. **[Plate: 22/A]**
Biblioth. Lichenol. 78: 133-134, 2001; Upreti & al., Nova Hedwigia 81(1-2): 109, 2005.

Description : Thallus corticolous, squamulose, upper surface gray-brown, isidiate, isidia laminal to marginal, dense, cylindrical, simple to coralloid branched, hypothallus black. Apothecia not seen.

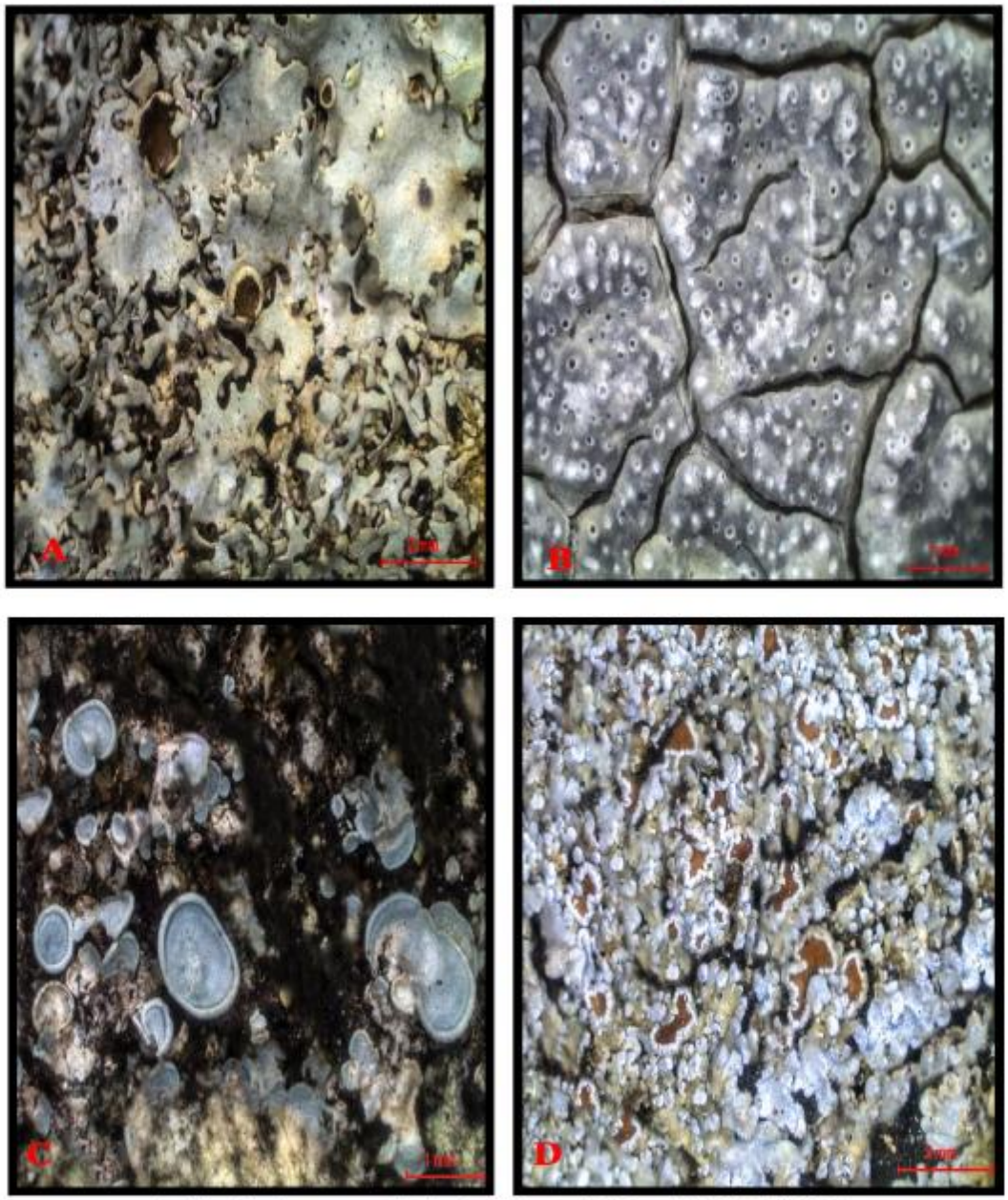
Chemistry: Thallus K-, C-, KC-, PD- ; no lichen substance present in TLC.

Specimen examined: Champhai district, Murlen National Park (East -Site No. **23**), on rough bark, 1850 mts alt. 24.09.2014, M. Chinlampianga & A.R. Logesh, 14-031439 (LWG).

Parmotrema Massal.
(Parmeliaceae)

*Parmotrema*is a widely distributed genus in the world from tropical to temperate region comprising 350 species, out of which 51 species are distributed in Indian sub-continent (Divakar & Upreti 2005), 6 species are reported from Murlen National Park, Mizoram.

Plate: 21 (A - D)



A. Myelochroa xantholepis (Mont. & Bosch.) Elix& Hale
B. Myriotrema microporum (Mont.) Hale
C. Normandina pulchella (Borrer) Nyl
D. Pannaria emodi P.M. Jørg

86. ***Parmotrema hababianum*** (Gyeln.) Hale **[Plate: 22/B]**

Phytologia 28: 336, 1974; D.D. Awasthi, Comp. Macrolich.India, Nepal & Sri Lanka : 341, 2007. *Parmelia hababiana* Gyeln., Repert. Spec. Nov. Regni Veg. 29: 288, 1931; Hale, Contr. U. S. Natl. Herb.36: 325, 1965; D.D. Awasthi, Biol. Mem.1: 211, 1976.

Description: Thallus corticolous, foliose; loosely attached to substratum, membranaceous, 8.0-10 cm across. Lobes rotund, 5.0-15 mm wide, 80-150 µm thick; margin crenate sparsely ciliate. Cilia 0.5-2.0 mm long. Upper surface mineral gray, pale gray to gray, smooth, emaculate to faintly maculate, rarely distintly maculate, sorediate. Medulla white, 50-85 µm thick. Lower surface brown to brown black, wth 4.0-8.0 mm wide, ivory, light brownish or mottled, erhizinate, smooth and shining marginal zone. Rhizines sparse, present in scatterd groups, simple 1.0-2.0 mm long.

Chemistry: Cortex K + yellow; medulla K-, C-, KC+ reddish, P-. TLC: Atranorin and protolichesterinic acid.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **21**), on rough bark, 1856 mts alt. 20.09.2014, M. Chinlampianga and A.R.Logesh,14-031425, 031424 (LWG).

87. ***Parmotrema reticulatum*** (Taylor) Choisy **[Plate: 22/C]**

Bull. Mens. Soc. Linn. Soc. Bot. Lyon. 21: 175, 1952; *Parmelia reticulata* Taylor, Fl. Hibern. 2: 148, 1836; D.D. Awasthi, Beih. Nova Hedwigia 17: 87, 1965 & Biol. Mem.1: 217, 1976. *Rimelia reticulata* (Taylor) Hale & A. Fletcher, Bryologist 93: 28, 1990.

Description : Thallus corticolous and saxicolous, foliose; upper side grey to darker, densely white maculate; soredia either capitates on short lacinules of palmate lobes or marginal to submarginal on rounded or involute lobes; lower side centrally black, medulla white. Apothecia rare, to 5mm in diam., perforate or not; ascospores 15-18 x 6-10µm.

Chemistry: Medulla K^+ yellow then red,C-, KC-, PD^+ orange – red; salazinic acid and consalazinic acids present in TLC.

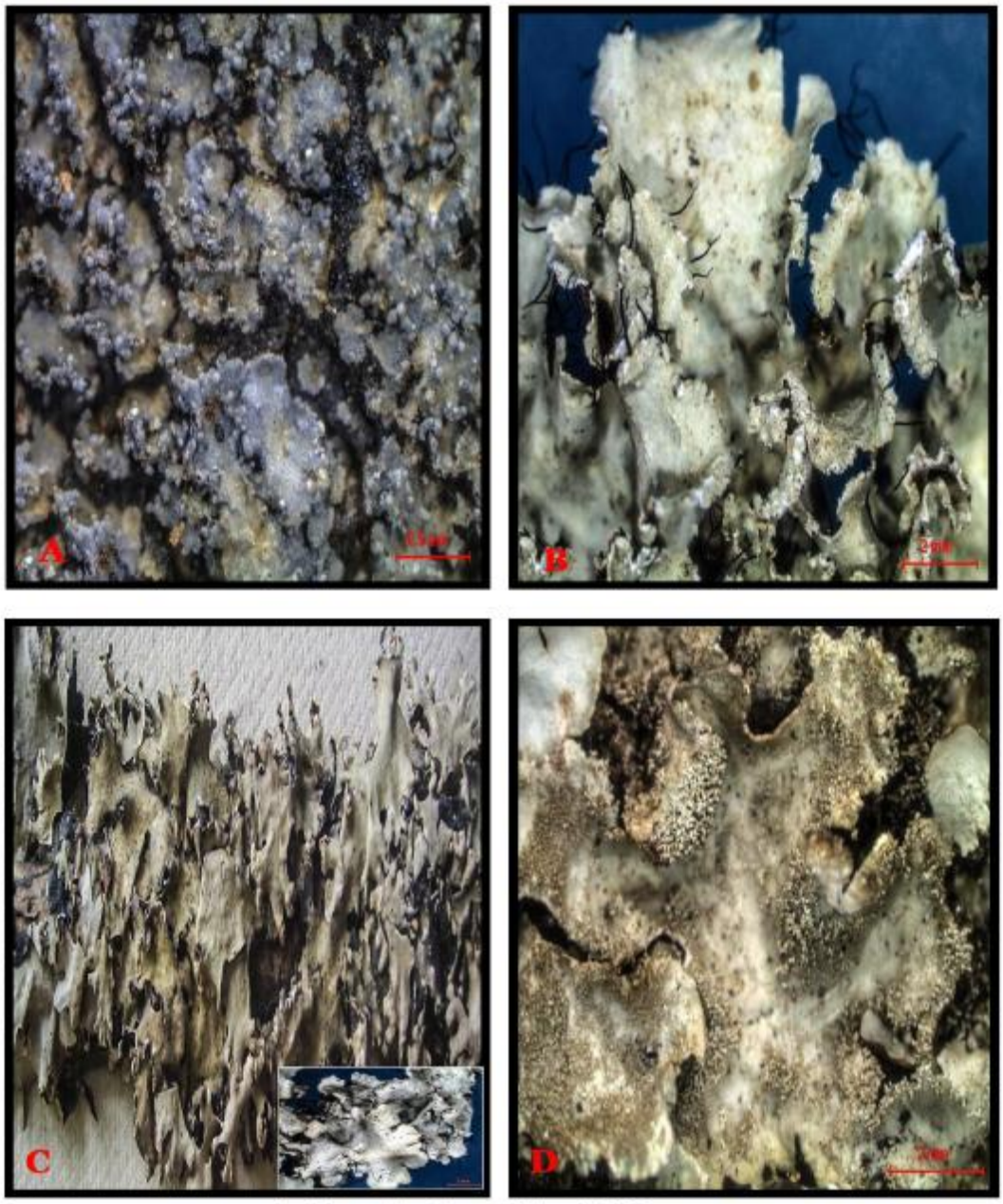
Specimens examined: Champhai district, Murlen National Park (West- Site No. **12**), on rough bark, 1525 mts alt. 17.02.2014, M. Chinlampianga,14-019172,019196, 02105, 031413, 031469, 031481, 019154; 15-03168, 031621;13-019499 (LWG).

88. ***Parmotrema saccatilobum*** (Taylor) Hale **[Plate: 22/D]**

Phytolagia 28: 339, 1974. *Parmelia saccatiloba* Tayl., Lond. J. Bot. 6: 174, 1874; Hale, Contr. U.S Nat. Herb. 36: 262, 1965; Awasthi, Biol. Mem. 1: 219, 1976.

Description : Thallus closely adnate to the substratum, 5.0-8.0 cm across. Lobes rotund, 4.0-7.0 mm wide, 150-225 µm thick; older lobes broadly convolute and saccate; margins entire to crenate,

Plate: 22 (A - D)



A. Parmelinela papillata P.M.Jørg
B. Parmotrema hababianum (Gyeln.) Hale
C. Parmotrema reticulatum (Taylor) Choisy
D. Parmotrema saccatilobum (Taylor) Hale

eciliate. Upper surface mineral gray to gray, dull, emaculate becoming rugose and reticulate cracked in centre, isidiate. Isidia moderately densely, laminal, simple, granular to filiform, rarely branched, often black tipped, upto 0.5 mm high. Medulla white, 100-140 µm thick. Lower surface black, with 2.0-4.0 mm wide, tan, erhizinate, shining marginal zone. Rhizines sparse, simple, upto 1.0mm long. Apothecia and pycnidia absent in the specimens examined.

Chemistry: Cortex K + yellow; medulla K-,C-,KC+ reddish, P+ red. TLC: Atranorin and protocetraric acid.

Specimen examined: Champhai district, Murlen National Park (East-Site No.**21**), on bark, 1860 m. alt. 23.09.2014, M. Chinlampianga and A.R.Logesh, 14-031480 (LWG).

89. ***Parmotrema stuppeum*** (Taylor) Hale **[Plate: 23/A]**

Phytologia 28: 339,1974. Permelia stuppea Tayl., Lond.J.Bot.6: 174, 1847; Hale, Contr. U.S Nat. Herb. 36: 308, 1965; Awasthi, Biol, Mem. 1: 221, 1976.

Description : Thallus loosely adnate to substratum, rather large , 10-15 cm across. Lobes rotund, 8.0m- 20mm wide, 150-200 µm thick; margins subascending, irregular, crenate – dentate, ciliate. Cilia sparse to dense, simple, 1.0-3.0 mm long. Upper surface mineral gray to gray, dull, smooth, emculate, often reticulately cracked in older parts, sorediate. Medulla white, 100-125 µm thick. Lower surface black, with a broad, 4.0-6.0 mm wide, erhizinate, dark brown to tan, shining marginal zone. Rhizines sparse, occur in patches in the central part, simple, 1.0-2.0 mm long. Apothecia and pycnidia not seen in the specimen examined.

Chemistry: Cortex K + yellow; medulla K+ red, C-, KC-, P+ deep yellow to orange.Atranorin, slazinic acid and salazinic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (West-Site No.**12**), on bark, 1525 mts alt. 17.02.2014,M. Chinlampianga , 14-021029 (LWG).

90. ***Parmotrema tinctorum*** (Nyl.) Hale **[Plate: 23/B]**

Phytologia 28: 339, 1974. *Parmelia tictoria* Nyl., Flora 55: 547, 1872; Hale, Contr. U.S. Nat. Herb. 36: 264, 1965; Awasthi, Biol. Mem. 1: 223, 1976.

Description: Thallus corticolous and saxicolous, foliose; loosely attached to the stratum, membranaceous to coriaceous, upto 8.0-30cm across. Lobes irregular, 10-20 (30)mm wide, 150-200 µm thick; apices rotund; margins entire to crenate, eciliate upper side grey to darker; isidia granular to filiform becoming coralloid or rarely flattened; lower side centrally black, wide marginal zone tan to

brown, nude; medulla white. Apothecia rare, to 10mm in diam., imperforate, concave sometimes radially splitted, dark brown; amphithecium rugose, densely; ascospores (13-) 15-18 x 6-9 (-10)µm. Pycnidia not see in the specimen examined.

Chemistry: Medulla K-. C^+ red, KC^+ red, PD^+ orange; lecanoric acid and traces of orsellinic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (West- Site No. **12**), on bark, 1300 mts alt. 17.02.2014, M. Chinlampianga, 14-019155, 019173, 021048, 031412; 15-031625 (LWG).

91. ***Parmotrema tsavoense*** (Krog. & Swinsc.) Krog. & Swins. **[Plate: 23/C]**
Bull. Brit. Mus. (Nat.Hist.) Bot. 2: 220, 1981. Krog & Swinscow, Lichenologist 15: 130, 1983; Divakar & Upreti, Lichenologist 35(1): 25, 2003; D.D. Awasthi, Comp. Macrolich. India, Nepal & Sri Lanka : 355, 2007. *Parmelia tsavoensis* Krog & Swinscow, Bull. Brit. Mus. (Nat. Hist.), Bot. 9: 220, 1981.

Description : Thallus tightly attached to the substratum, ca. 5.0 cm across. Lobes rotund, 2.0-3.0 mm wide, 150-200 µm thick; margins entire, eciliate, black rimmed, lateral margin imbricate and ascending. Upper surface pale gray to gray, emaculate, smooth, shiny towards periphery, dull in the centre, dactylate. Medulla white, 90 - 120µm thick. Lower surface black, with upto 3.0mm wide dark brown to tan, erhizinate, shiny marginal zone. Rhizines sparse, distribute in groups in the centre, simple, short, upto 1.0 mm long. Apothecia not seen in the specimen examined.

Chemistry: Cortex K + yellow; medulla K-, C-, KC+ rose, P-. TLC: Atranorin, physodic and oxyphysodic acid.

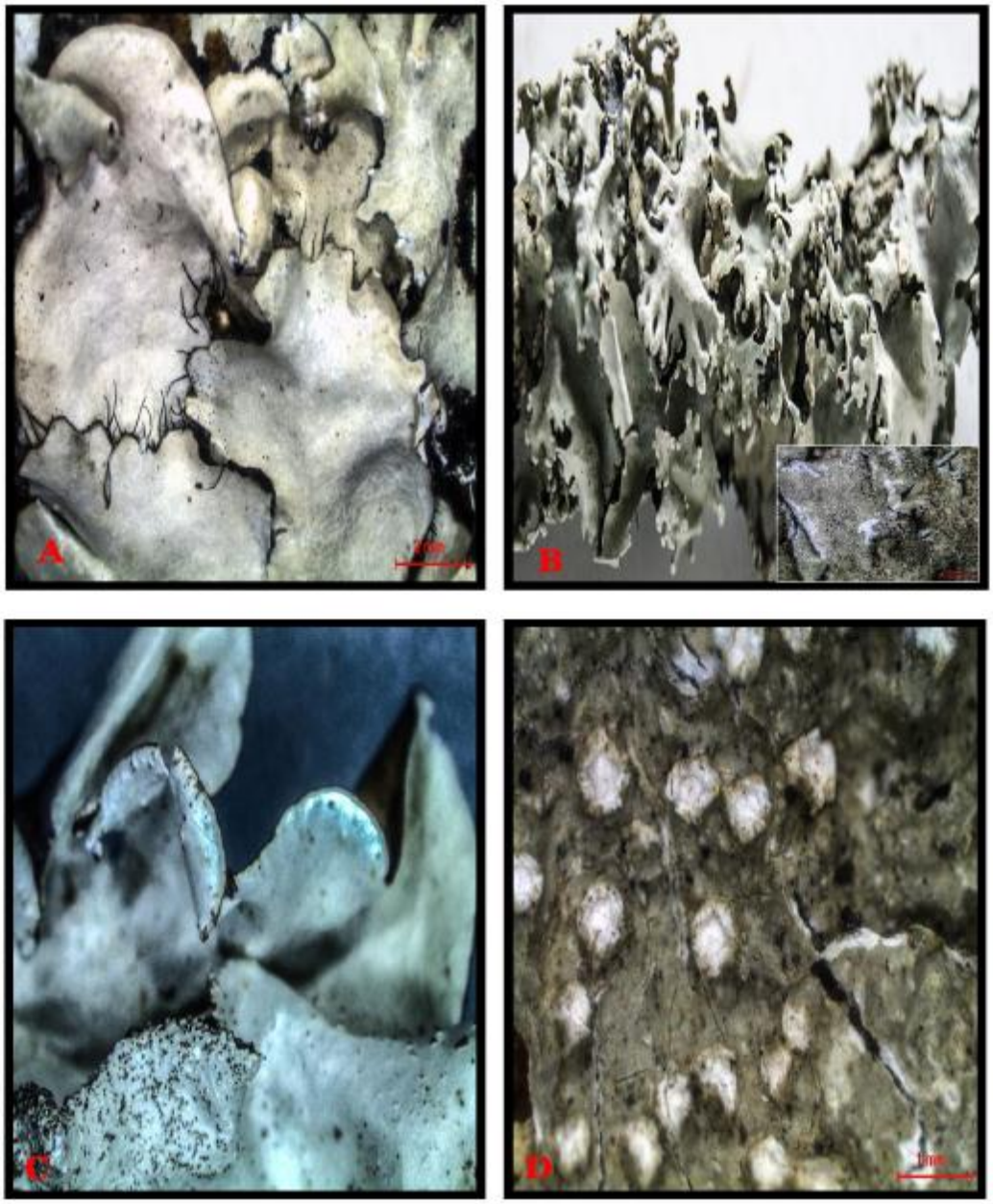
Specimen examined: Champhai district, Murlen National Park (East- Site No. **21**), on bark, 1675 mts alt.20.09. 2014, M. Chinlampianga and A.R.Logesh ,14-031528 (LWG)

Pertusaria DC in Lam. et DC
(Pertusariaceae)

Out of total *Pertusaria* species is a large cosmopoitant of genus about 525 in the world. 54 species under of *Pertusaria* species in India (Awasthi, 1991; Archer, 1997) and 6 species are reported from the study area of Murlen National Park, Mizoram.

92. ***Pertusaria albescens*** (Huds.) M.Choisy & Werner **[Plate: 23/D]**
Cavanillesia 5: 165, 1932.*Lichen albescens* Huds., Fl. Angl., ed. 1 : 445, 1762; Zahlbr., Lich Univ. 5: 187-364, 1928. *Pertusaria discoidea* (Pers.) Malme, Svensk. Bot. Tidskr. 20: 57, 1926; R. Schub. & Klem., Nova Hedwigia 11: 49, 1966.

Plate: 23 (A - D)



A. Parmotrema stuppeum (Taylor) Hale
B. Parmotrema tinctorum (Nyl.) Hale
C. Parmotrema tsavoense (Krog. & Swinsc.) Krog. & Swins
D. Pertusaria albescens (Huds.) M. Choisy & Werner

Description : Thallus corticolous, crustose; upper surface smooth to coarsely warted, often rimose-cracked; soralia rounded, variable, typically concave and marginate; disc-like, paler than thallus. Apothecia to 4mm diam., very rare, usually several fused in large soredite- pruinose warts concave, white thalline margines; discs densely white pruinose; ascospores 170-300 x 50-115 µm.

Chemistry: Thallus K-,C-,KC-,PD-; no lichen substance in TLC.

Specimens examined: Champhai district, Murlen National Park (South - Site No. **20**), on rough bark, 1300 mts alt.20.09.2014, M. Chinlampianga & A.R. Logesh 14-02183, 031420 (LWG)

93. ***Pertusaria amara*** (Ach) Nyl **[Plate: 24/A]**

Bull. Soc. Linn. Normandie, ser. 2, 6: 288, 1872; Zahlbr., Cat. Lich. Univ.5: 121, 1925; D.D. Awasthi, Biblioth. Lichenol. 40: 210, 1991. *Variolaria amara* Ach., Kongl. Vetensk. Acad. Nya Handl. 30: 163, 1809.

Description ; Thallus corticolous, crustose; whitish grey to grey to yellowish-grey, smooth to verrucose often smaller, the soredia are typically smaller , sometimes punctiform, 0.5 – 1.5 mm diam. Apothecia very rare, ascospores 1 per ascus, 130-150 x 40-05 µm.

Chemistry: Thallus K^+ reddish- purple, C-, KC^+ rose- violet, PD^+ red; picrolichenic and hypothamnolic acids present in TLC.

Specimens examined: Champhai district, Murlen National Park (East-Site No. **21**), on rough bark, 1450mts alt.24. 09.2014, M. Chinlampianga & A.R. Logesh,14-031416;15-031606 (LWG).

94. ***Pertusaria leucosorodes*** Nyl. **[Plate: 24/B]**

Lich. Jap.: 56. 1890; Zahlbr., Cat. Lich. Univ. 5: 172, 1928; D.D. Awasthi, Beih. Nova Hedwigia 17: 93. 1965 & Biblioth. Lichenol. 40: 209, 1991.

Description : Thallus corticolous, crustose, granular, yellowish grey, verruce, corticated, sorediate , soralia white, raised, soralia whitish, coarse granular, forming wide sorediate disc; apothecia not known.

Chemistry: Thallus K+ yellow to red, C-, KC- PD+ orange-red; Thanolic, protocetraric and stictic acids in TLC.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **22**), on bark, 1650 mts alt. 22.09.2014, M. Chinlampianga, 14-021087, 019153, 021084, 031422 (LWG).

95. ***Pertusaria multipunctata*** (Turner) Nyl. **[Plate: 24/C]**
Lich. Scand. 179, 1861; Zahlbr., Cat. Lich. Univ. 5: 181, 1928; D.D. Awasthi, Beih. Nova Hedwigia 17: 93, 1965 & Biblioth. Lichenol. 40: 210, 211, 1991. *Variolaria multipuncta* Turn., Trans. Linn. Soc. London 9: 137, 1806.

Description : Thallus corticolous, crustaceous, thin to moderately thick, grey; upper surface ± rimosecracked, with sorediate warts, 0.5-1.5 (-2) mm diameter; apothecia frequent, (1-) 2-3 (-5) ± concealed within each sorediate wart; disc pale to blackish brown, veiled in soredia; ascospores elongate, ellipsoid to cylindrical, 90-170 x 30-70 µm.

Chemistry: Thallus and soredia K+ yellow, Pd + orange-red, C-, KC+ yellow. TLC: Physodalic and protocetraric acid.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **23**), on bark, 2092m alt, 24.09.2014, M. Chinlampianga & AR. Logesh 14-031415, 031419 (LWG).

96. ***Pertusaria pustulata*** (Ach.) Duby **[Plate: 24/D]**
Bot. Gall. 2(2): 673, 1830; Zahlbr., Cat. Lich. Univ. 5: 207, 1928; D.D. Awasthi & Kr.P. Singh, Geophytology 5(1): 111, 1975; D.D. Awasthi, Biblioth. Lichenol. 40: 215, 1991.

Description : Thallus corticolous, crustose, yellow-brown; fertile verrucae 0.5-1.0 mm diam., convex at apex; asci 2 spored, ascospores 60-125 x 28 µm. Sometimes inner wall radially postulate.

Chemistry: Thallus K^+ reddish, C-, KC-, PD- ; norstictic, stictic and constictic in TLC.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **22**), on rough bark, 1460 mts alt. 18.09.2014, M. Chinlampianga and AR. Logesh, 14-031417, 021082, 021085, 031421; 13-019500 (LWG)

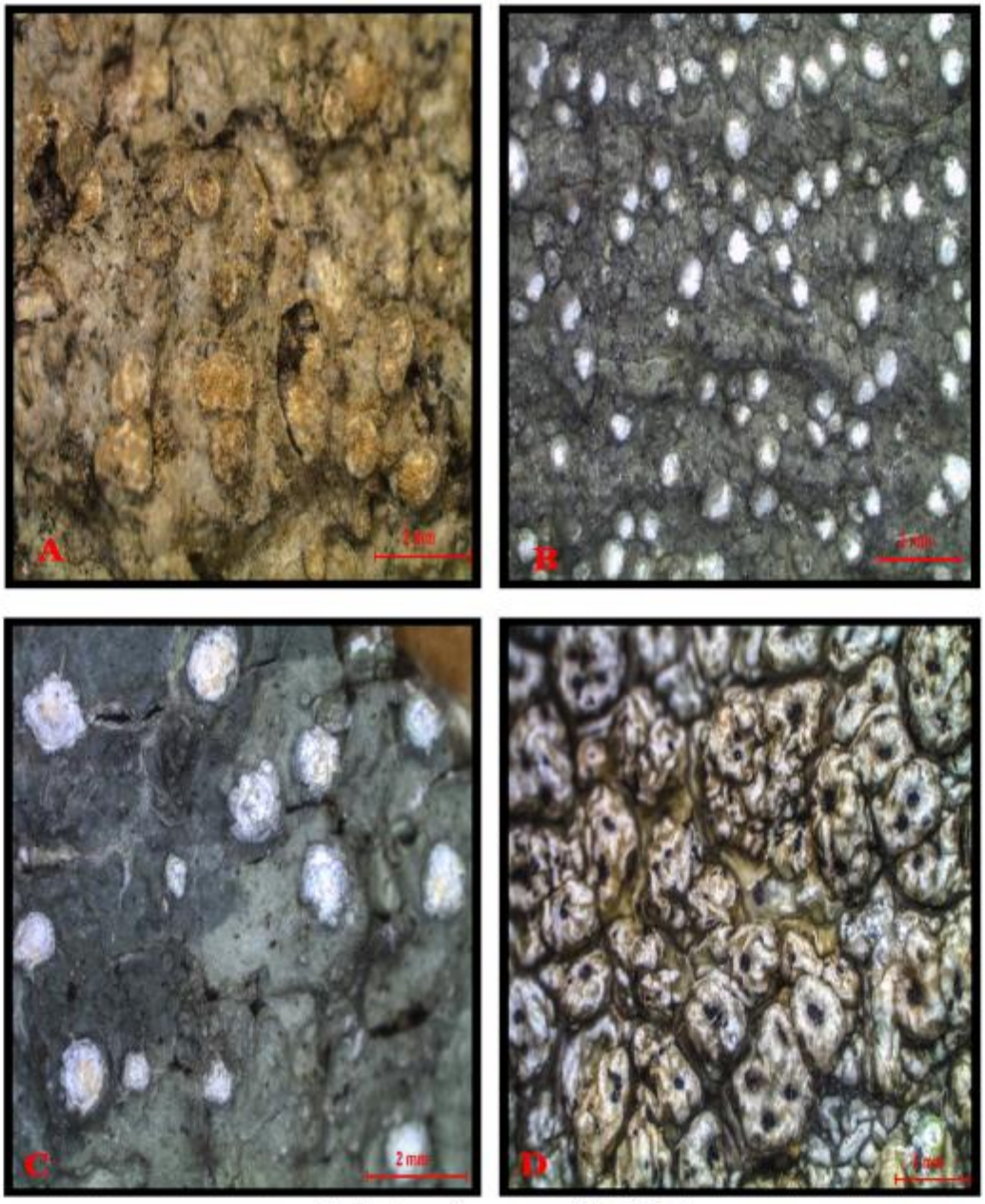
97. ***Pertusaria quassiae*** (Fée) Nyl., **[Plate: 25/A]**
Ann. Sci. Nat., Bot., ser. 4, 15: 45. 1861; Zahlbr., Cat. Lich. Univ. 5: 209.1928; D.D. Awasthi, Biblioth. Lichenol. 40: 212. 1991. *Porina quassiae* Fée, Essai Crypt. Ecorc. : 81. 1824.

Description: Thallus corticolous, crustose, whitish to yellowish – grey, verrucae. Apothecia pertusariate, ostiole region also tubercle; ascospores, 2-4 per ascus, double walled, 68-160 (-180) x 32-60µm.

Chemistry: Thallus K^+ deep yellow, C-, KC-, PD^+ orange ; norstictic, stictic and constictic present in TLC.

Specimens examined: Champhai district, Murlen National Park (West- Site No. **12**), on rough bark, 1250 mts alt. 22.09.2014, M. Chinlampianga and A.R. Logesh, 14-021021, 02186 (LWG).

Plate: 24 (A - D)



A. Pertusaria amara (Ach)Nyl
B. Pertusaria leucosorodes Nyl
C. Pertusaria multipunctata (Turner) Nyl.
D. Pertusaria pustulata (Ach.) Duby

Phaeographis Müll. Arg.
(Graphidaceae)

Total 29 species listed under the genus *Pheographis* from India by BSI, only one is reported from the study area.

98. *Phaeographis dendroides* (Leight.) Müll. Arg. **[Plate: 25/B]**
Flora 65: 208, 1882; Zahlbr., Cat. Lich. Univ. 2: 370, 1923; Patw. & C.R. Kulk., Curr. Sci. 46 (20): 720, 1977; Kr. P. Singh & D.D. Awasthi, Bull. Bot. Surv. India, 21(1-4):102, 1979.

Description: Thallus crusts pores se, effuse, epi- or endo-phloedal, rarely epilithic. Apothecia dendroid branched, 3-15mm long, apices obtuse or attenuated, disc pruinose, labia divergent, spores 4-8 septate, oblong-ellipsoid, 24-34(-45) x 9 -11 (-13) µm.

Chemixtry: Thallus K^+ red, P^+ yellow-orange; TLC: no lichen substance found.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **22**), on rough bark, 1812 mts alt.20.09.2014, M. Chinlampianga and A.R. Logesh,14-031526 (LWG).

Phlyctis (Wallr.) Flot.,
(Phlyctidaceae)

Total 12 species are reported from world, out of which two species are known from India and the study area exhibits the occurrence of these two species.

99. *Phlyctis karnatakana* S. Joshi & Upreti **[Plate: 25/C]**
The Bryiologist 113(4): 726, 2010.

Description: Thallus corticolous, crustose, whitish-grey, subleprose, ecorticated, irregular patches, cracked. Apothecia numerous, mostly aggregated, round to irregular in margins, granular, semiimmersed, uneven, 0.3-0.4mm in diam., disc black, plane, slightly pruinose, 0.06-0.2 mm diam. Margin concolorous to thallus, straight to incurve, entire to eroded in older apothecia. Exciple indistinct to absent. Hypothecium pale-yellow to pale-brown, 15-20mm thick, K-,I-. Paraphyses, slender, simple, conglutinate, apices anastomosing, 1-1.5mm diam. Asci 8-spored, clavate, thin walled, 75-80 x 15-25mm K-,I^+ red. Ascospores hyaline, fusiform, cresent shaped, transversely 7-septate, I-, 20-30 x 5-7mm.

Chemistry: Thallus K^+ red, C-, KC-, Pd^+ yellow-orange; Norstictic acid detected in TLC.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **23**), on rough bark, 1700 mts alt.22.09.2014, M. Chinlampianga and A.R. Logesh, 14-031445, 019157, 031445; 15-031601 (LWG).

100. ***Phlyctis polyphora*** Stirton **[Plate: 25/D]**

Proc. Roy. Soc. Glasgow 13: 184, 1881.

Description : Thallus corticolous, crustose, whitish to pale or pale red, thin. Apothecia 0.4-1.2mm diam., pruinose. Hypothecium hyaline to yellowish. Asci 3-8 spored. Ascospores muriform, hyaline, oblong- fusiform 16-32 transverse and 1-2 vertical septate, 60-110 x 7.5-9.5µm.

Chemistry: Thallus K-,C-,KC-,Pd - ; No lichen substance in TLC.

Specimen examined: Champhai district, Murlen National Park (West - Site No. **12**), on bark, 1550mts alt.17.02.2014., M. Chinlampianga, 14-019191 (LWG).

Comment: It is endemic to India (Singh & Sinha, 2010) and rediscovered from the study area.

Phyllopsora Mull. Arg.
(Biatoraceae)

About 60 species of the genus *Phyllopsora*are known from the world, out of which Awasthi (2007) provided a detailed account of 5 species from India, the study area represent the occurance of 3 species and reported 1 as new species to India

101. ***Phyllopsora albicans*** Müll. Arg. Sq **[Plate: 26/A]**

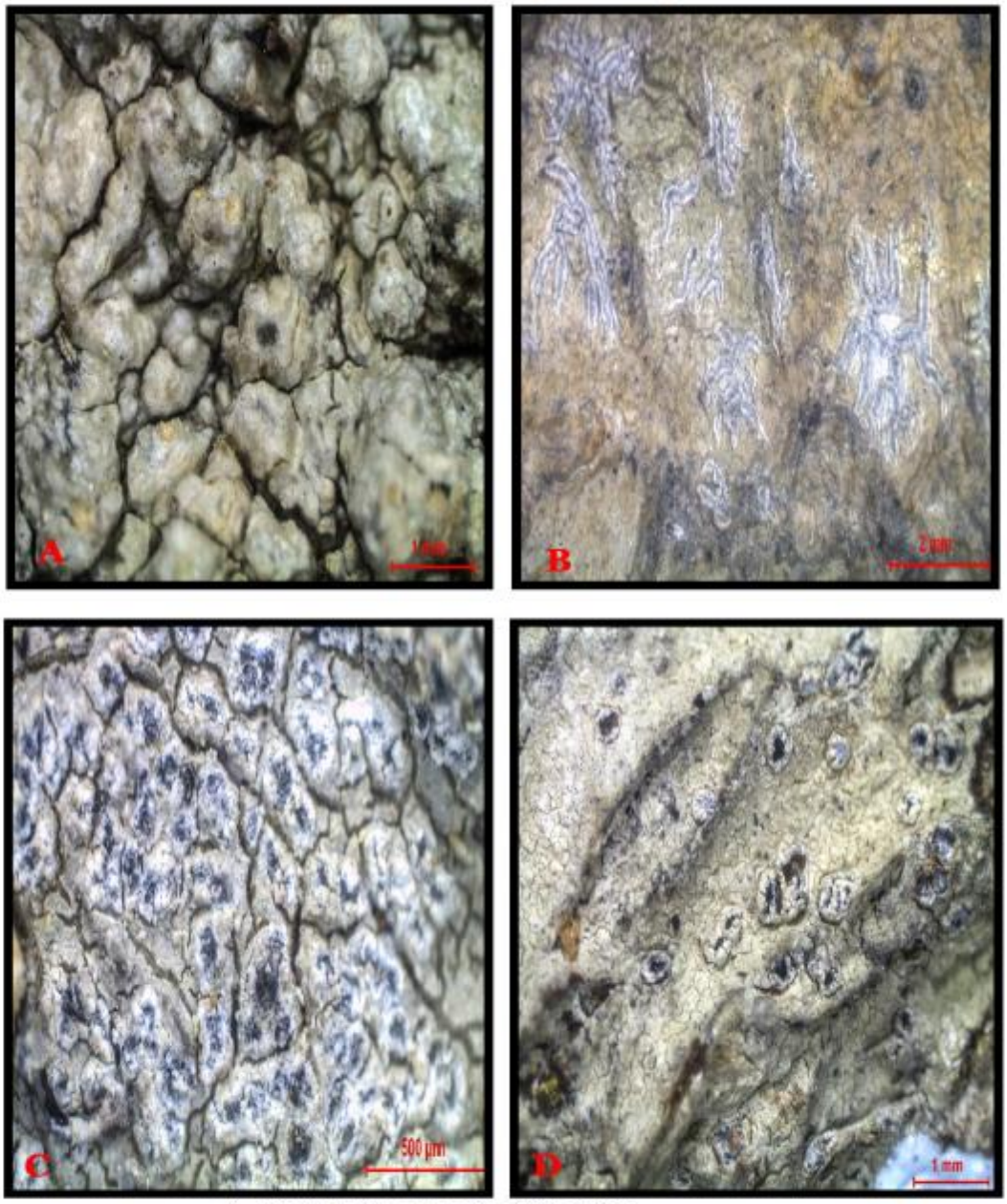
Bull. Soc. R. Bot. belb. 32; 132 (1893)

Description: Thallus squamulose. Ascending, mainly imbricate, elongate, incised to deeply divided, 0.3-1.0mm wide; upper surface glabrous to slightly pubescent, pale green to dark green, plane to convex, margin pubescent. Isidia absent. Cortex 1-2 type, 12-20 µm thick, medulla containing crystals, dissolving in K. Apothecia rare, upto 1.5 mm diam, disc plane to convex, reddish brown; margin-raised. Exciple reddish-brown; epihynium hyaline, hyamenium colourless to pale yellow; hypothecium golden yellow and containing crystals which dissolve in K. Ascospores hyaline, simple to narrowly ellipsoidal to baciliform, 6-10x1-2 µm. Pycnidia not seen.

Chemistry: Thallus K-, C-, KC-, Pd^{+} yellow-orange; Argopsin and panarin present in TLC.

Specimen examined: Champhai district, Murlen National Park (West- Site No. **24**), on bark, 1450 mts alt.17.02.2014, M. Chinlampianga, 14-021007 (LWG).

Plate: 25 (A - D)



A. Pertusaria quassiae (Fée) Nyl
B. Phaeographis dendroides (Leight.) Müll. Arg.
C. Phlyctis karnatakana S. Joshi &Upreti
D. Phlyctis polyphora Stirton

102. ***Phyllopsora buettneri*** (Mull. Arg.) Zahlbr. **[Plate: 26/B]**
Muller Argoviensis, Bull. Herb. Boiss. 2, Append: 1, 1894.

Description: Thallus squamulose or placodioid; prothallus white, reddish or reddish brown; lobes often fibrillose at margins; upper side greenish or greenish brown, with or without isidia; heteromerous, corticated on upper side only. Apothecia laminal; disc red or red-brown; exciple proper; hypothecium colourless to brown; asci dome-shaped, amyloid apex, 8-spored; ascospores colourless, acicular to fusiform, indistinctly transversely septate.

Chemistry: Thallus K+, C-, KC-, Pd+ orange; TLC: Pannarin and zeorin present.

Specimen examined: Champhai district, Murlen National Park (West- Site No. **12**), on rough bark, 1250 mts alt.17.02.2014, M. Chinlampianga,14-019165(LWG)

103. ***Phyllopsora corallina*** (Eschw.) Müll. Arg. **[Plate: 26/C]**
Bot. Jahrb. Syst. 20: 264, 1894; Zahlbr., Cat. Lich. Univ. 4: 397, 1926; D.D. Awasthi, Beih. Nova Hedwigia 17: 98, 1965; Upreti & al., Biblioth. Lichenol. 86: 186, 2003; D.D. Awasthi, Comp. Macrolich. India, Nepal & Sri Lanka : 379, 2007. *Lecidea corallina* Eschw. in Mart., Fl. Bras. Enum. Pl. 1(1): 256, 1833.

Description: Thallus corticolous; prothaflus red; squamules 0.1-0.5 mm wide; upper side yellowish brown; isidiate; isidia coralloid. Apothecia 0.5-1mm in diam.; ascospores7-10x2.5-µm.

Chemistry: Thallus K-, C-, KC-, Pd-; TLC: atranorin present.

Specimen examined: Champhai district, Murlen National Park (East-Site No.**23**), on rough bark, 1812 mts alt. 20.09.2014, M. Chinlampianga and A.R. Logesh, 14-021065 (LWG).

104. ***Phyllopsora soralifera*** Timdal **[Plate : 26/D]**
Lichenologist 40(4): 358, 2008.

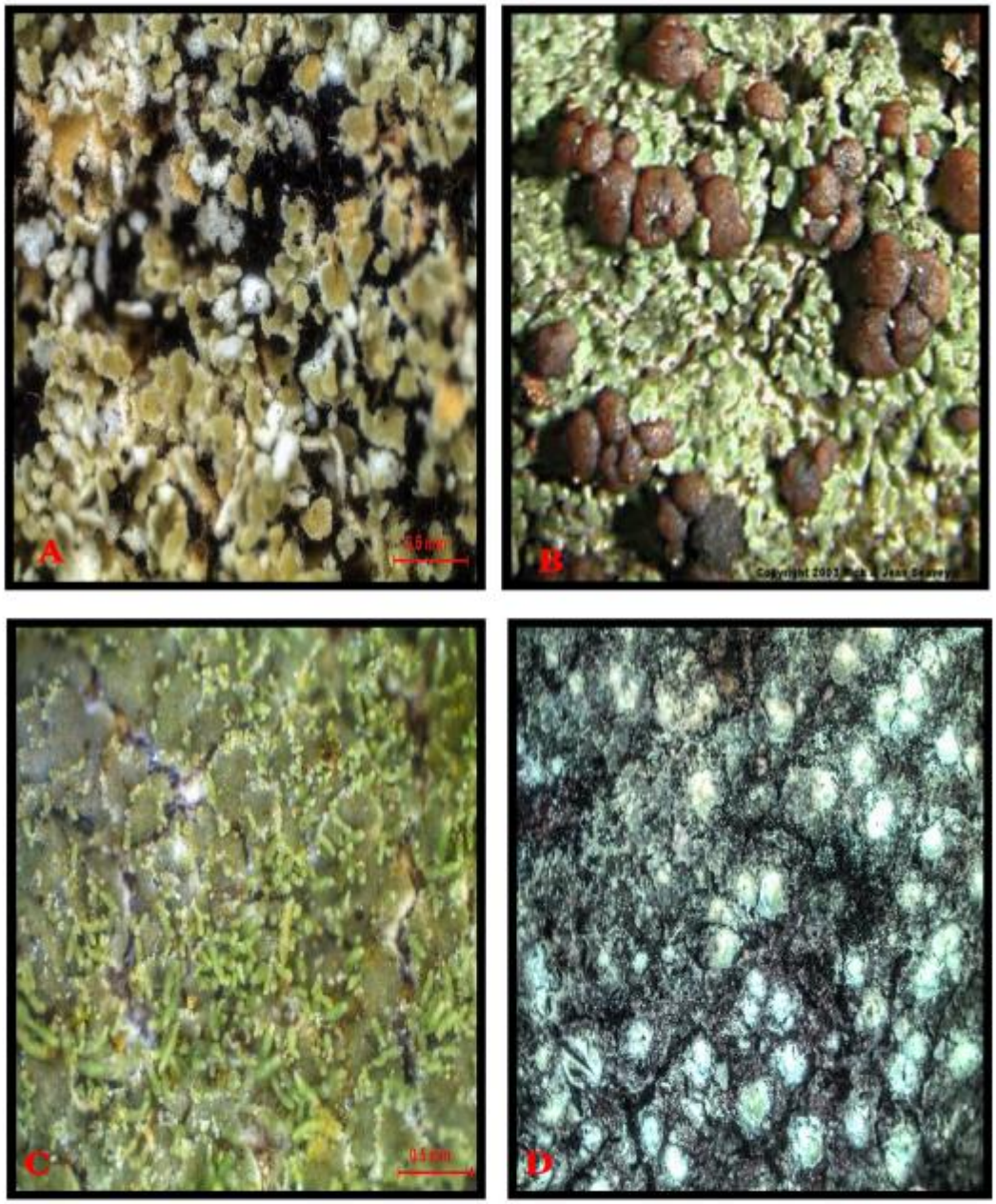
Description : Thallus squamulose, sorediate, closely adnate, rounded to elongate, sometimes indistinct, ascending, 0.1-0.3 mm wide, isidia absent, prothallus indistinct; soredia present on the squamules, cortex of type 2; apothecia absent.

Chemistry: K-, C-, KC-, PD-; No chemical substances observed in TLC.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **22**), 1792 alt. 23.09.2014, M. Chinlampianga and A.R.Logesh, 14-031436 (LWG).

Comment: This species is report as **new record** to Indian lichen flora. It is close to *Phyllopsora catervisorediata* Mishra, Upreti & Nayaka, in sorediate condition of the squamules and cortex type 2, but *P. catervisorediata* differs in having atranorin as a secondary substance.

Plate: 26 (A - D)



A. Phyllopsora albicans Müll. Arg. Sq
B Phyllopsora buettneri (Mull. Arg.) Zahlbr.
C. Phyllopsora corallina (Eschw.) Müll. Arg
D. Phyllopsora soralifera Timdal

Physcia Schreber Michaux
(Physiaceae)

The total 73 species of *Physia* known to occur in the world, 17 species from India (Awasthi, 2007, out of which 4 species are reported from Murlen National Park, Mizoram.

105. ***Physcia aipolia*** (Ehrh. ex. Humb.) Fürnr. **[Plate: 27/A]**
Naturh. Topogr. Regensburg 2: 249, 1839; D.D. Awasthi, Beih. Nova Hedwigia 17: 98, 1965 & Comp. Macrolich. India, Nepal & Sri Lanka : 383, 2007. *Lichen aipolius* Ehrh. ex Humb., Flor. Friburg. Spec.: 19, 1793.

Description : Thallus corticolous, foliose, to 5 cm across; lobes 1-1.5 (-3) mm wide; upper side whitish grey to darker, densely white-maculate, lacking isidia andsoredia; lower side pale brown; lower cortex prosoplectenchymatous. Apothecia to 3 mm in diam., pruinose; ascospores 16-26 (-29) x 7-11µm.

Chemistry: - Medulla K^+ yellow, C-, KC-, PD- ; Zeorin acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **22**), on bark, 1540 mts alt.24.09.2014, M.Chinlampianga and A.R. Logesh,14-021058 (LWG).

106. ***Physcia dilatata*** Nyl. **[Plate: 27/B]**
Syn. Lich. 1(2): 423, 1860; Jatta, Malpighia 19: 177, 1905; *Physcia askotensis* D.D. Awasthi, Proc. Indian Acad. Sci. 45: 131, 1957.

Description : Thallus corticolous, foliose, rarely saxicolous, (2-) 5-10 cm across; lobes 2-5(-10) mm wide; upper side whitish grey to grey, pruinose, lacking isidia and soredia; lower side grey to darker; lower cortex paraplectenchymatous. Apothecia to 1.5 mm in diam; ascospores (18-) 21-32 x 10-13(-15) µm.

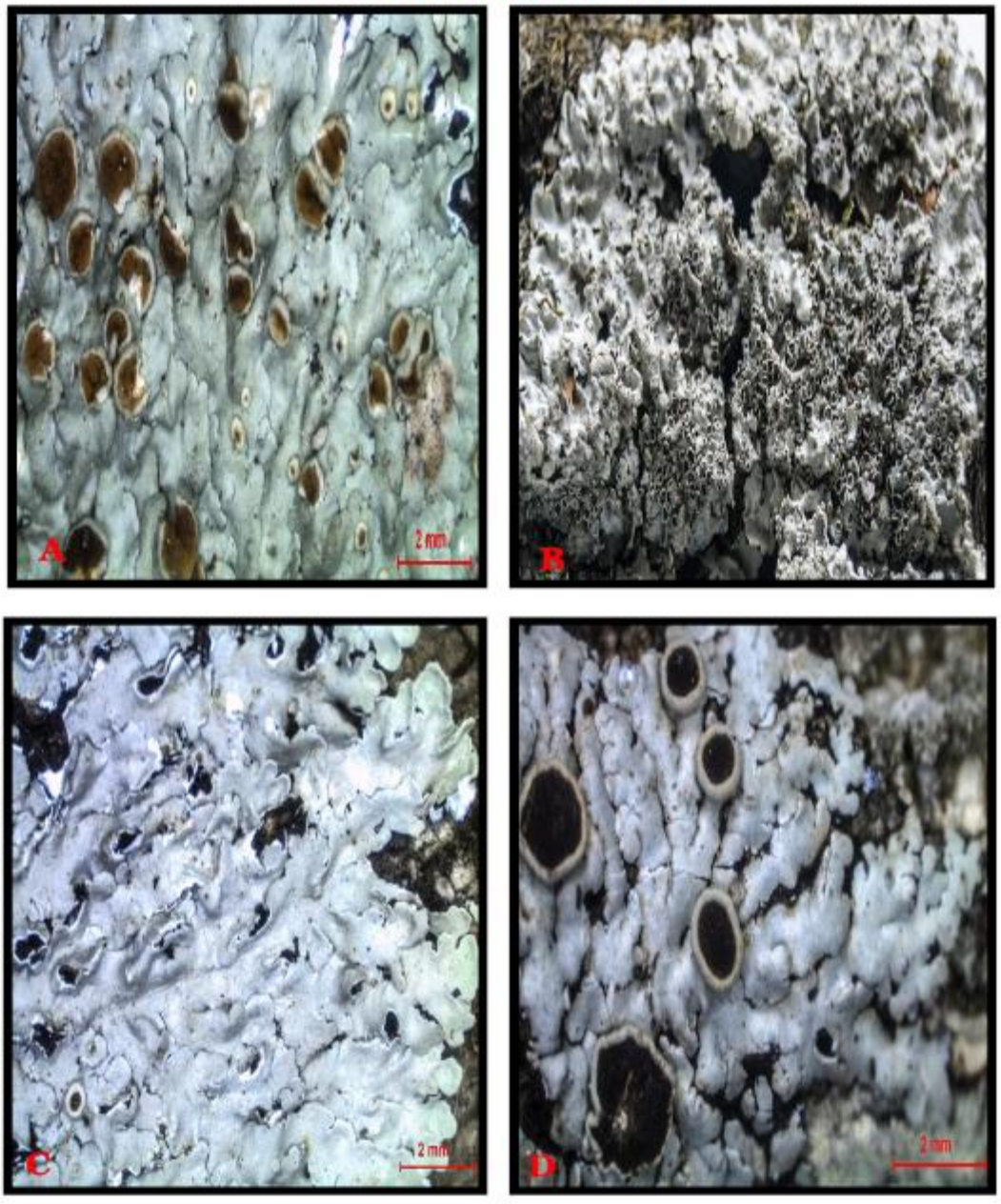
Chemistry: - Medulla K^+ yellow, C-, KC-, PD- ; Zeorin acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (East-Site No. **22**), on rough bark, 1460 m alt. 23.09.2014, M. Chinlampianga and A.R. Logesh, 14-031472(LWG).

107. ***Physcia integrata*** Nyl. **[Plate: 27/C]**
Syn. Lich. 1(2): 424, 1860; Zahlbr., Cat. Lich. Univ. 7: 636, 1931; D.D. Awasthi, Beih. Nova Hedwigia 17: 99, 1965, Comp. Macrolich. India, Nepal & Sri Lanka : 387, 2007.

Description : Thallus corticolous, rarely saxicolous, to 5 cm across; lobes 1 - 2 mm wide, rarely minutely lobulate in central part; upper side greyish, lacking isidia and soredia; lower side black; lower cortex paraplectenchymatous. Apothecia to 2 mm in diam.; ascospores *Pachysporaria-type,* 18-28 x 8-12µm.

Plate: 27 (A - D)



A. Physcia aipolia (Ehrh. ex. Humb.) Fürnr.
B. Physcia dilatata Nyl.
C. Physcia integrata Nyl
D. Physcia stellaris (L.) Nyl.

Chemistry: Medulla K+ yellow, C-, KC-, PD-; Leucotylin and zeorin present in TLC.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **22**), on rough bark, 1460 m alt. 25.09.2014, M. Chinlampianga and A.R. Logesh, 14-021098 (LWG).

108. ***Physcia stellaris*** (L.) Nyl. **[Plate: 27/D]**

Actes Soc. Linn. Bordeaux 21: 307, 1856; Moberg 71, p. 72, 1977; Zahlbr., Cat. Lich. Univ. 7: 681. 1931; D.D. Awasthi, Beih. Nova Hedwigia 17: 101, 1965 & Comp. Macrolich. India, Nepal & Sri Lanka : 389, 2007. *Lichen stellaris* L., Sp. Pl.: 1144, 1753.

Description : Thallus corticolous, to 5 cm across; lobes to 3 mm wide; upper side yellowish grey to grey, lacking isidia and soredia; lower side pale brown; lower cortex prosoplectenchymatous. Apothecia to 4 mm in diam.; ascospores 16-22 (-24) x 7-11µm.

Chemistry : Medulla K-, C-,KC-, PD- ; No lichen substance in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **22**), on rough bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-031473, 021099 (LWG).

Porina Mull. Arg.
(Porinaceae)

World wide 336 species reported while occurance of over 61 species known in the genus *Porina*from India (Upreti, 1994), Murlen National Park, Mizoram represent 2 species for the country.

109. ***Porina americana*** Fee **[Plate: 28/A]**

Essai Crypt. Ecorc. : 83, tab. 1, fig. 12 & tab. 20, fig. 4. (pr.p.), 1824; Zahlbr., Cat.Lich. Univ. 1: 365, 1922; D. D. Awasthi, Beih. Nova Hedwigia 17: 102, 1965; Makhija & al., J. Econ. Taxon. Bot. 18(3): 528, 1994.

Description: Thallus corticolous, oliveeceous-green, smooth to verruculose. Perithecia immersed in thalline verrucae, the verruce 1.0-2.0 mm diam., Perithecia 0.8-1.2 mm diam, hemispherical, completely covered by thallus and concolorous or area around ostioles naked and black; ostioles dot-like; outer layer black, brown wthin; centrum globose to ovate, with oil globules; I-, expipulum orange; asci 230-250 x 35 -40 µm; ascospores 11(-12)-septate, fusiform, 89-92 9-100)x16-20(-23) µm; epispore 2 µm thick. Pycnidia not seen.

Chemistry: K-, C-, KC-, PD-; no lichen substance detected in TLC.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **22**), on thick bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-031411 (LWG).

110. ***Porina subcutanea*** Ach. **[Plate: 28/B]**

Syn. Meth. Lich.: 113, 1814; Zahlbr., Cat. Lich. Univ. 1: 405, 1922; D.D. Awasthi, Beih. Nova Hedwigia 17: 103, 1965; Makhija & al., J. Econ. Taxon. Bot. 18(3): 542, 1994.

Description : Thallus corticolous, greenish grey, smooth, slightly verruculose, epiphoedal, forming a thin continuous film on the bark; perithecia 0.5-1.2 (-1.5) mm in diameter; subglobose, com-pletely covered with thallus, area around ostioles brown black; ostiole indistinct; involu-crellum incurving within excipulum, black at top, brown within; centrum globose, with oil globose, I-; excipulum yellow to pale yellow; asci 160-240 x 30-45µm; ascospore 7-9(-11) septate , oblong- ellipsoid, 60-85 x 12-20 µm; epispore 2.5 µm thick.

Chemistry: TLC: No chemical substance observed in the specimen.

Specimens examined: Champhai district, Murlen National Park (East – Site No. **22**), on bark, 1792m alt. 24.09.2014, M. Chinlampianga and AR. Logesh, 14-021057, 021407 (LWG).

Punctelia Korg.
(Parmeliaceae)

About 30 species of the genus *Punctelia*are distributed in the world, of which Awasthi (2007) provided detailed account of 4 species in India. The area represents the occurrence of 1 species.

111. ***Punctelia rudecta*** (Ach.) Krog **[Plate: 28/C]**

Nord. J. Bot. 2: 291, 1982. Swinscow & Krog 1988: 260. Basionym: *Parmelia rudecta* Acharius, Syn. Lich.: 197, 1814

Description : Thallus corticolous or saxicolous, 6-8 (-10) cm across, crisp to fragile;lobes 3-6 mm wide; upper side grey to dark, pseudocyphellae punctiform to elongate; isidia simple, coralloid and lacinulate; lower side pale brown.Apothecia rare, to 5 mm in diam; ascospores 10-17 x 5-1 0 ~m.

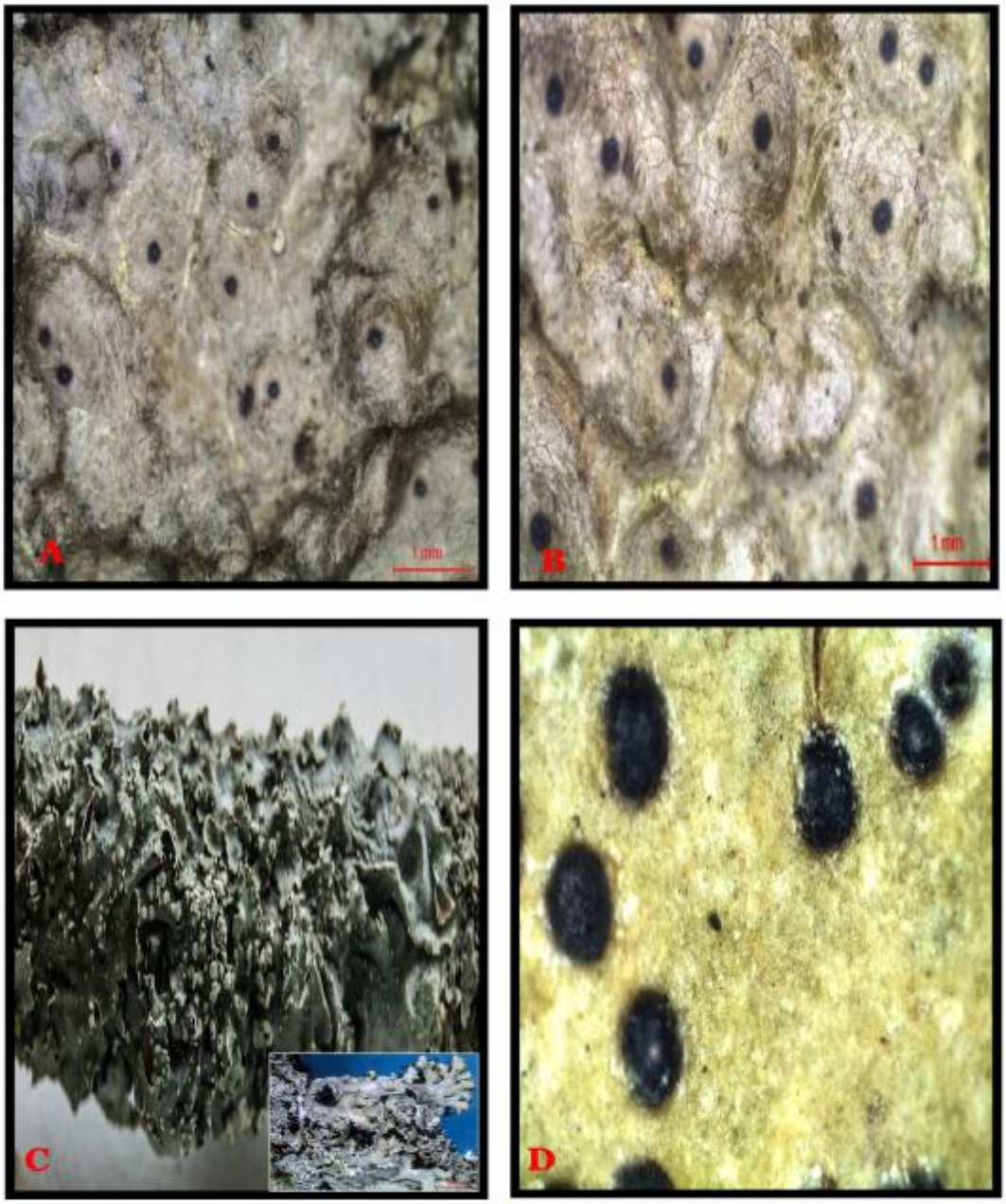
Chemistry: Medulla K-, C+ red, KC+ red, P-. Lecanoric acid present.

Specimen examined: Champhai district, Murlen National Park (South - Site No. **14**), on rough bark, 1460 m alt. 15.01.2015, M. Chinlampianga, 15-031630(LWG).

Pyrenula Ach.
(Pyrenulaceae)

About 200 species of *Pyrenula*are widely distributed in tropical to temperate regions of the world. 92 species of *Pyrenula* reported in India (Upreti, 1998) and 2 species are reported from eastern part of Murlen National Park, Mizoram.

Plate: 28 (A - D)



A. Porina americana Fée
B. Porina subcutanea Ach.
C. Punctelia rudecta (Ach.) Krog
D. Pyrenula complanata (Mont.) Trevis

112. ***Pyrenula complanata*** (Mont.) Trevis. **[Plate: 28/D]**

The Lichenologist 44(1): 5-53, 2012. *Pyrenula introducta* (Stirt.) Zahlbr., Cat. Lich. Univ. 1: 433, 1922. *Verrucaria interducta* Stirt., proc. Phil. Soc. 13: 191, 1881.

Description: Thallus corticolous, crustose, pseudocyphellate, sometimes cracked areolate or smooth-slightly verruculose, hypothallus indistinct. Ascocarp solitary or 2-5 aggregated, verruca forming, 0.6 – 1.0mm in diam., ostioles indistinct; perithecium black and carbonaceous; ascospores 8 per ascus, uni or biseriate in ascus, brown, 4- locular, oblong-ellipsoid, 31-50 x 12-20 µm.

Chemistry: Thallus K-, C-, KC-, PD-; no lichen substance in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **23**), on rough bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-019146 (LWG).

113. ***Pyrenula zeylanica*** Upreti & A. Singh **[Plate: 29/A]**

Geophytology 18: 76, 1988; Upreti, J. Hattori Bot. Lab. 68: 276, 1990; Kr.P. Singh & al., Phytotaxonomy 6: 92, 2006.

Description: Thallus epiphloedal, yellow- brown to brownish grey, undulate-verrucose, thalline verruca sterile or fertile, fertile ones 1-12 carpous, irregular in outline, convex to hemispherical, upto 2.0 mm across, top of verruca presently ± oculate condition around ostiole of each ascocarp; ascocarp upto 0.4 mm in diameter, ca. 350 µm high, completely embedded in thalline verrucae except a small area around ostiole covered with corticiform layer of thallus, dull black, carbona-ceous, ± uniformly thick all round; centrum I-, without oil globules; paraphysoid threads simple; asci clavate, 8 spored, 110-125 x 22-30µm; spores uni- or biseriate in ascus, brown, 4 locular, oblong fusiform, 21 – 40 x 10-15 µm.

Chemistry: K-,C-,KC-,Pd-: TLC: No lichen substance observed in the specimen.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **23**), onbark, 1560 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-021144 (LWG).

Pyxine Fr.

(Physciaceae)

The lichen genus Pyxine is represented by 60 species from the world, 29 species from India (Awasthi 2007) and occurrence of 3 species is reported from the study area of Murlen National Park, Mizoram.

114. ***Pyxine cocoes*** (Sw.) Nyl. **[Plate: 29/B]**

Mem.Soc. Imp. Sci. Nat. Cherbourgh 5: 108, 1857; D.D. Awasthi, Phytomorphology 30: 367. 1980 & Comp. Macrolich. India, Nepal & Sri Lanka: 417, 2007. *Lichen cocoes* Sw., Nov. Gen. Sp. Pl.: 146, 1788. *Physcia endoxantha* Stirt., Proc. Roy. Soc. Glasgow 13: 184, 1881.

Description: Thallus corticolous, to 6 cm across; lobes; 0.5-1 (-2) mm wide; upper side yellowish grey; maculae laminal and marginal turning into pseudocyphellae and then into soralia; medulla stramineous. Apothecia to 1 mm in diam; thalline margin soon blackened and excluded; internal stipe brown, K + red-violet; ascospores (12) 16-20 x 6-8(-10) µm. Upper cortex UV+ yellow.

Chemistry: Thallus K-, C-, P-. Lichexanthone and triterpenes present.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **14**), on rough bark, 1460 m alt. 15.01.2015, M. Chinlampianga, 15-031624, 031627 (LWG).

115. ***Pyxine subcinerea*** Stirt. **[Plate: 29/C]**

Trans. & Proc. New Zealand Inst. 30: 397, 1898; D.D. Awasthi & M. Joshi, Geophytology 7(1): 96, 1977; D.D. Awasthi, Phytomorphology 30: 379, 1980.

Description : Thallus corticolous, to 7 cm across; lobes 1-2 mm wide; upper side greyish; margins intermittently pseudocyphellate; pseudocyphellae developing into soralia and spreading on to lamina; soredia white to stramineous; medulla yellow.

Apothecia 1-2 mm in diam., exciple pseudothalline in young stages, later black; internal stipe not well differentiated; ascospores 12-20 (22) x 6-8 µm. Upper cortex UV+ yellow; medulla K-, C-, P-. Lichexanthone in cortex and triterpenes in medulla.

Chemistry: - Medulla K-, C-, KC-, PD- ; Lichenxanthone and triterpines present in TLC.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **23**), on rough bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh,14-021096 (LWG).

Ramalina Ach.
(Ramalinaceae)

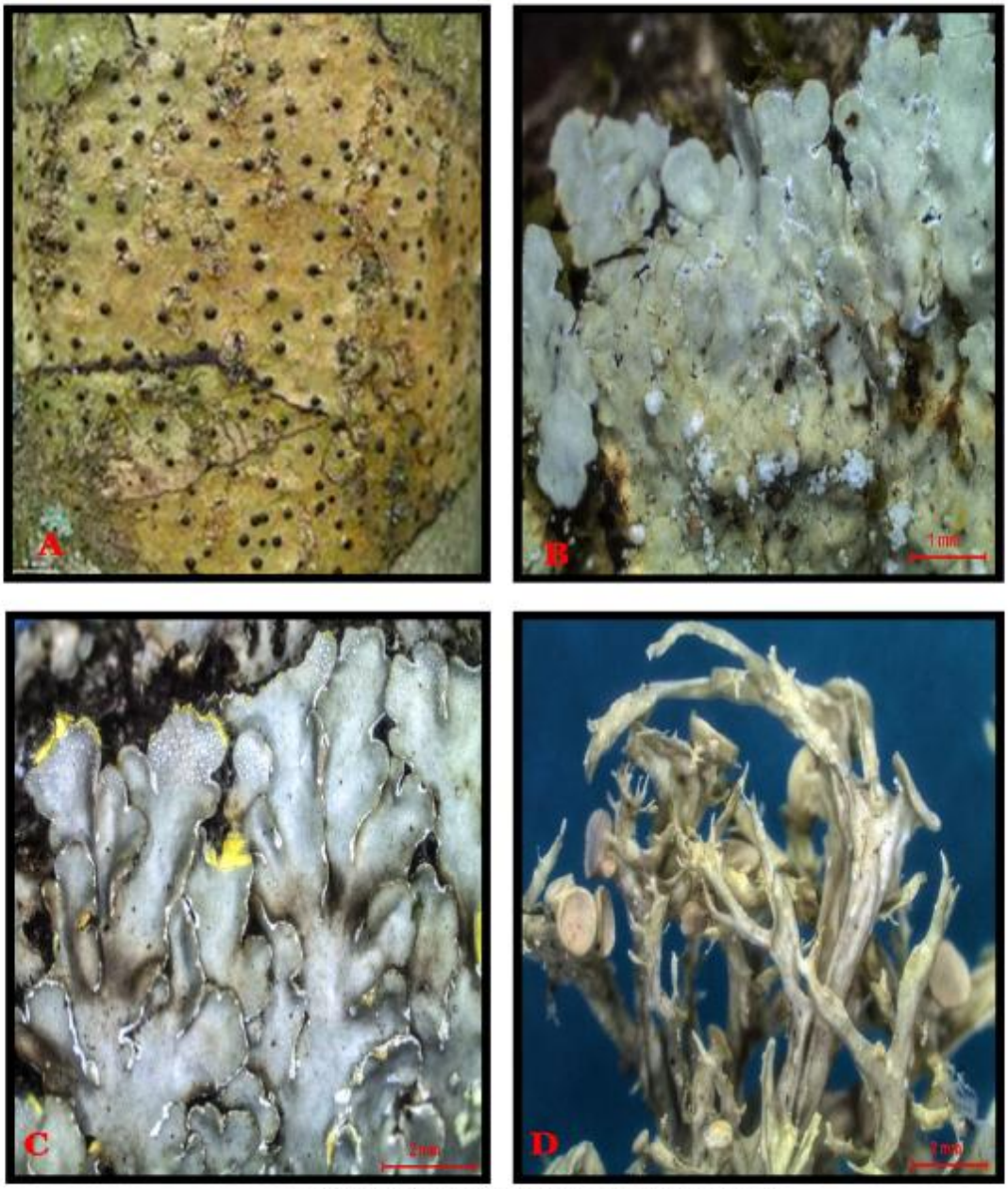
Ramalina is a large genus consisting 200 species widely distributed in temperate and subtropical region of the world, of which 23 species of *Rammalina* are known from the Indian subcontinent and 3 species are known to represent from western side of the study area.

116. *Ramalina conduplicans* Vain. **[Plate: 29/D]**

Ann. Soc. Zool. Bot. Fenn 1(3): 35, 1921; D.D. Awasthi, Beih. Nova Hedwigia 17: 109, 1965 & Comp. Macrolich. India, Nepal & Sri Lanka : 430, 2007; G. Pant & D. D. Awasthi, Indian J. Forest. 26(3): 303, 2003.

Description : Thallus corticolous, rarely saxicolous, 3-5(-10) cm long, erect to decumbent, greenish grey to yellowish brown, branched; branches uniformly 2-3 (-7) mm wide; upper side smooth, scarcely pseudocyphellate; lower side rugose, with raised, round to oblong, prominent

Plate: 29 (A - D)



A. Pyrenula zeylanica Upreti & A. Singh
B. Pyxine cocoes (Sw.) Nyl.
C. Pyxine subcinerea Stirt.
D. Ramalina conduplicans Vain

pseudocyphellae; soredia absent; chondroid tissue uneven in thickness, distinctly cracked into hyphal bundles; medulla solid. Apothecia 2-7 mm in diam.; ascospores straight or curved, 10-17 x 3-6 µm.

Chemistry: Medulla K^+ yellow, C-, KC-, PD^+ red; usnic and salazinic acids present in TLC.

Specimes examined: Champhai district, Murlen National Park (West-Site No. **13**), on rough bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh,14-019166, 021093, 031467, 031468, 031470 (LWG).

117. ***Ramalina hossei*** Vain. **[Plate: 30/A]**

Ann. Soc. Zool. Bot. Fenn. 1(3): 36, 1921; Kashiw., Bull. Natl. Sci. Mus. Tokyo, B, 14(4): 129-133, 1988; G. Pant & D.D. Awasthi, Indian J. Forest. 26(3): 306, 2003; D.D.Awasthi, Comp.Macrolich. India, Nepal & Sri Lanka: 432, 2007.

Description :Thallus saxicolous , fruticose, tufted, erect, to 6 cm tall, yellowish grey to brownish, branched; branches to 2 mm wide, nervose; marginal pseudocyphellae turning into soralia; minute spinules from rim of soralia; soredia granular; chondroid tissue cracked; medulla solid. Apothecia to 1 mm in diam.; ascospores straight to slightly curved, 13-16 x 4-6µm.

Chemistry: Medulla K^+ yellow, C-, KC-, PD-, Usnic acid and sekikaic acid aggregate in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **23**), on rough bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh,14-031444(LWG).

118. ***Ramalina sinensis*** Jatta **[Plate: 30/B]**

Nuov Giorn. Bot. Ital. 9: 462, 1902; D.D. Awasthi, Beih. Nova Hedwigia 17: 111, 1965 & Comp. Macrolich. India, Nepal & Sri Lanka : 435, 2007; G. Pant & D.D. Awasthi, Indian J. Forest. 26(3): 311, 2003.

Description : Thallus corticolous, fruticose, erect to decumbent, 4-5 (-10) cm long, and 4-5 cm wide, ± entire to palmately variously lobed, lobes sometimes fenestrate,yellowish green to greyish; upper side longitudinally wrinkled and pseudocyphellate; lower side ridged with white decorticate areas (pseudocyphellae) and alternate corticate areas; chondroid tissue uniform not cracked; medulla solid. Apothecia to 9 mm in diam.; ascospores ellipsoid-fusiform 10-13(-17) x 3-6 µm.

Chemistry: Medulla K-, C-, KC-, PD-, no lichen substance in TLC.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **23**), on rough bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-031441(LWG).

Ramboldia Kanvilas & Elix
(Lecanoraceae)

The genus *Ramboldia* is represented by 9 species from the world, out of which 3 species are reported from India and 3 corticolous species, from which one species (***Ramboldia subnexa*** (Stirt.) Kantvilas & Elix) is recorded as **new species** to Inian Lichen flora which is reported from Murlen National Park, Mizoram, India.

119. ***Ramboldia russula*** (Ach.) Kalb & al. in Kalb & al. **[Plate: 30/C]**
Nova Hedwigia 86: 37, 2008. *Lecidea russula* Ach., Methodus: 61, 1803; Zahlbr., Cat. Lich. Univ. 3: 823, 1925. *Pyrrhospora russula* (Ach.) Hafellner in Kalb & Hafellner, Herzogia 9: 86, 1992.

Description: Thallus corticolous, crustose to squamulose, pale grey to brown. Apothecia round, sessile to sunken, disc red-brown, asci 8-spored, ascospores (-4) 6-8 (-10) x 2-4µm.

Chemistry: Medulla K-, C-,KC-,PD- ; no lichen substance present in TLC.

Specimen examined: Champhai district, Murlen National Park (South – Site No. **15**) , on rough bark, 790 m alt. 26.09.2014, M. Chinlampianga and A.R. Logesh, 14-019380(LWG).

120. ***Ramboldia sorediata*** Kalb. **[Plate: 30/D]**
Lichenol. 78: 161 (2001).

Description: 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 inspersed with oil granules dissolve in K; ascospores ellipsoidal, 6-9 × 2-4 µm.

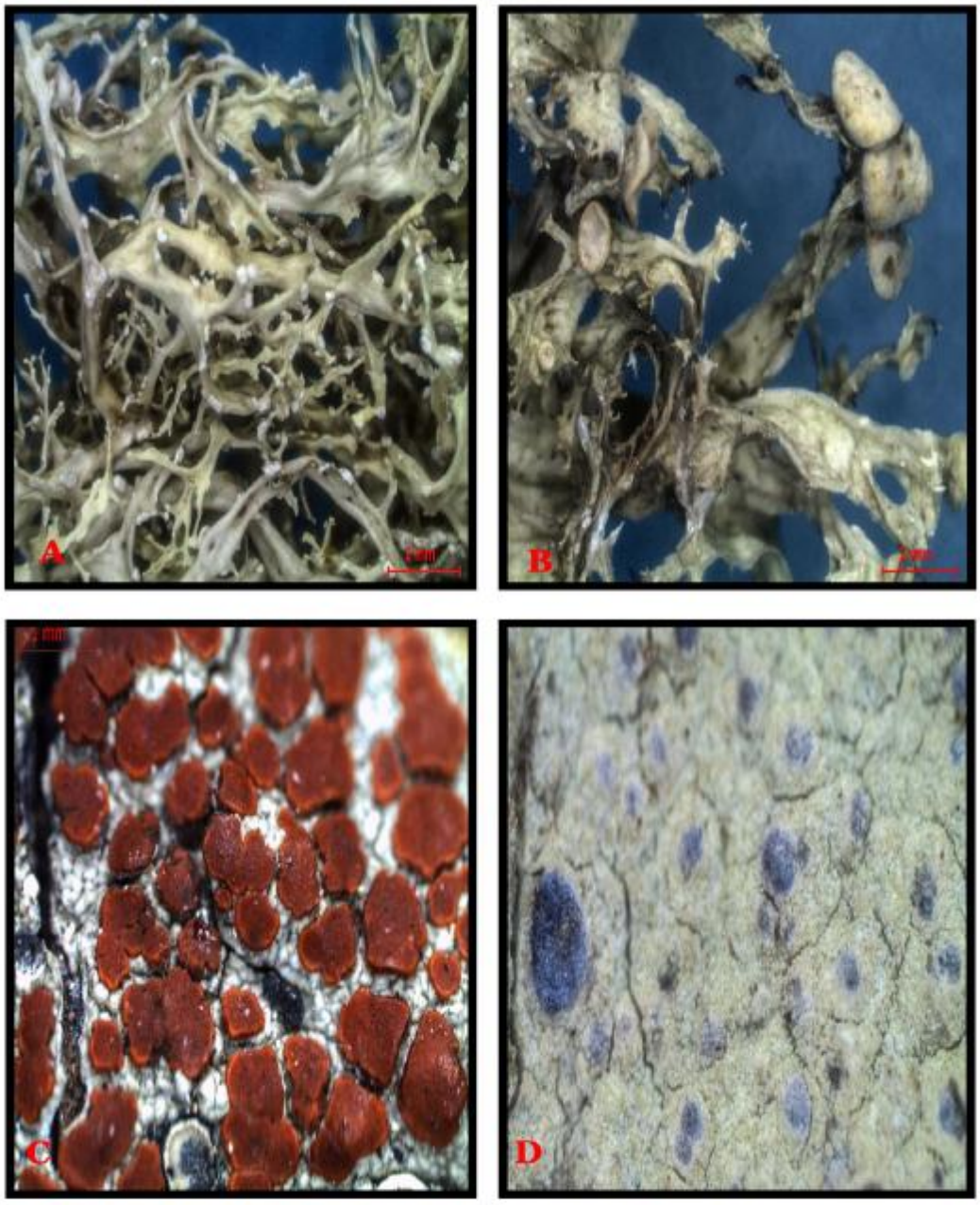
Chemistry: Thallus K+ yellow, C-, KC-, PD-; thamnolic acid and traces of usnic acid present.

Specimen examined: Champhai district, Murlen National Park (North-Site No. **25**), on bark, 1450 m alt. 19.02.2014. M. Chinlampianga, 14-021030 (LWG).

121. ***Ramboldia subnexa*** (Stirt.) Kantvilas & Elix **[Plate: 31/A]**
Syn. *Hafellia subnexa* Marbarch; *Lecidea subnexa* Nyl. Bryologist 97: 296, 1994; Bibliotheca lichenological 74: 285, 2000.

Description : 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 8-10 × 3-4 µm.

Plate: 30 (A - D)



A. Ramalina hossei Vain.
B. Ramalina sinensis Jatta.
C. Ramboldia russula (Ach.) Kalb & al. in Kalb & al.
D. Ramboldia sorediata Kalb.

Chemistry: Thallus K+ yellow, C-, KC-, PD-; thamnolic acid present.

Specimen examined: Champhai district, Murlen National Park (West- Site No. **13**), on bark, 1625 m alt. 17.02.2014, M. Chinlampianga, 14-021032 (LWG).

Comment: 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.

Relicina (Hale &Kurok.) Hale
(Parmeliaceae)

Ouf of about 50 species known from the world, 6 species, reportedfrom southern part of India (Awasthi, 2007), and the sudy area represent occurrence of 2 species, one being recored as new species to India.

122. ***Relicina sublanea*** (Kurok.) Hale **[Plate: 31/B]**

Phytologia 28: 485, 1974; Hale 1975b: 30, p. 29. Basionym: *Parmelia sublanea* Kurokawa in Hale & Kurokawa, Contr. U.S. Nat. Herb. 36:146, 1964.

Description : 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., ecoronate; ascospores 7- 9 x 4-5µm.

Chemistry : Medulla K-, C-, KC-, PD+ orange; protocetraric acid present in TLC.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **23**), on bark, 2092 mts alt., 24.09.2014, M. Chinlampianga and A. R. Logesh, 14-031478; 15-031616 (LWG).

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

123. ***Relicina sydneyensis*** (Gyeln.) Hale **[Plate: 31/C]**

Phylogia 28: 485, 1974. *Parmelia sydneyensis* Gyeln., Ann. Mycol. 36: 292, 1938. *Parmelia subturgida* Kurok., J.Jap.Bot. 40: 268, 1965.

Description : Thallus closely adnated to the substratum, 3.0-5.0 cm across. Lobes sublinear to linear elongate, dichotomously branched, 1.0-2.0 mm wide; margins bulbate ciliate.

Cilia black, tapered to strongly inflated. Upper surface yellow green, smooth, flat shiny at lobe apices, weakly maculate, isidiate. Isidiate simple, cylindrical, sparingly branched. Medulla white.

Lower surface pale brown throughout, sparsely rhizinate. Rhizines simple, mostly towards centre, brown to brown black. Apothecia not seen.

Chemistry: Cortex K + yellow; medulla K+ yellow turning red,, C-, KC+ rose, P+ orange;

Usnic acid, stictic acid, norstictic acid, atranorin, physodic and oxyphysodic acid, etc., present in TLC.

Specimens examined: Champhai district, Murlen National Park (West – Site No. **13**), on bark, 1525mts alt. 17.02.2014, M. Chinlampianga, 14-021003, 021002, 019175 (LWG).

Relicinopsis
(Parmeliaceae)

Out of five species known from the world, 3 species are reported by D. Awasthi (2007) from India and Sri Lanka and only single species of the genus *Relicinopsis*reported from eastern part of the study area.

124. ***Relicinopsis malaccensis*** (Nyl.) Elix & Verdon **[Plate: 31/D]**

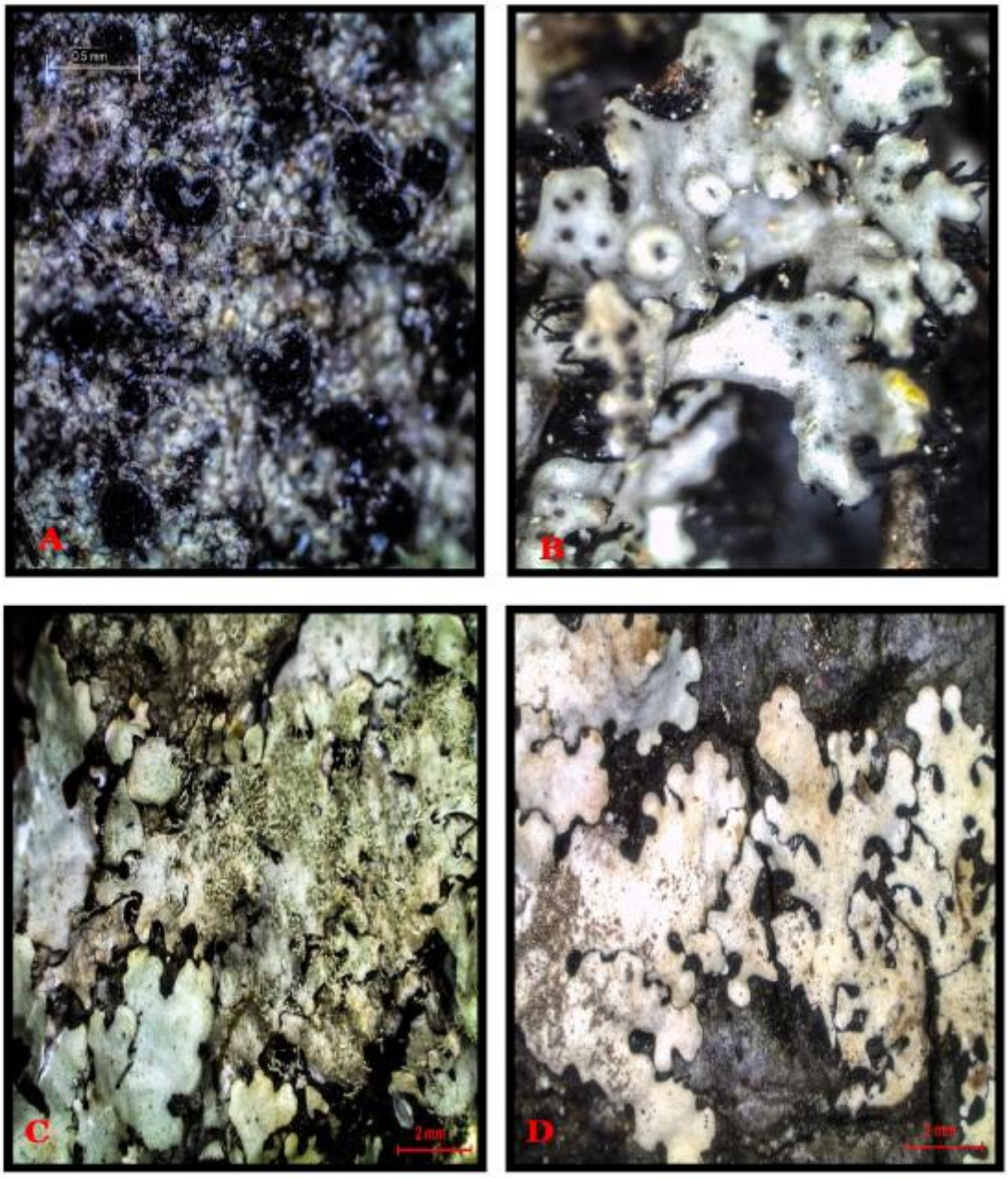
Mycotaxon 27: 282, 1986. *Permelia malaccensis* Nyl. in Nylander and Crombie, J. Bot.Linn. Soc. London 20: 52, 1883; Awasthi, Biol.mem. 1: 179, 1976. *Pseudopermelia malaccensis* (Nyl.) Hale, Phytologia 29: 190. 1974; Smithson. Contr. Bot. 31: 37, 1975.

Description : Thallus closely adnate to the substratum, 4.0 – 5.0cm across. Lobes contiguous centrally, separate at periphery, imbricate, sublinear, dichotomously branched, short, 0.5-2.0 mm wide, 100-200 µm thick; margins eciliate. Upper surface yellowish-green, flat to slightly convex, shiny, white-maculate at lobe apices, transversly cracked with age, isidiate. Lower surface pale brown, rhizinate up to margin. Rhizines dense simple, short, concolours with lower surface. Apothecia dense, numerous, sessile, 1.0-2.0 mm in diameter; disc plane to convex, dark brown; margin thin, minutely crenulate and inflexed; epithelium brown, 10-12 µm thick; hymenium 40-60 µm high. Asci clavate, 8 spored, 30-45 x 15 µm. Pycnidia not seen in the specimen examined.

Chemistry: Cortex K + yellow; medulla K-, C-, KC-, P+ orange-red. Usnic acid and protocetraric acid in TLC.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **23**), on bark,1650 mts alt. 20.09.2014, M. Chinlampianga, 14-031527 (LWG),

Plate: 31 (A - D)



A. Ramboldia subnexa (Stirt.) Kantvilas & Elix
B. Relicina sublanea (Kurok.) Hale
C. Relicina sydneyensis (Gyeln.) Hale
D. Relicinopsis malaccensis (Nyl.) Elix & Verdon

Stigmatochroma Marbach
(Caliciaceae)

Murlen National Park, Mizoram contributed 4 species of the genus *Stigmatochroma* to Indian lichen flora and they are reported as new to India.

125. ***Stigmatochroma adaucta*** (Malme) Marbach **[Plate: 32/A]**
Biblthca Lichenol. 74: 304, 2000.

Description : 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 inspersed 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.

Chemistry: Thallus K+ yellow turning into red crystals, C-, KC-, PD+ yellow; norstictic acid and atranorin present.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **23**), on bark, 1790 mts alt. 23.09.2014, M. Chinlampianga and A. R. Logesh, 14-031426 (LWG).

Comment: 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 on smooth bark trees.

126. ***Stigmatochroma gerontoides*** (Stirton) Marbach **[Plate: 32/B]**
Syn. *Lecidea gerontoides* Stirt. Trans. Glasgow Soc. Fld. Nat. 4 : 165, 1876; Ohio J. Sci. 67(5): 257-273; Zealand J. Bot. 46: 433-521.

Description : 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 spored; ascospores 1-septate, thin walled, 12-14 × 5-6 µm.

Chemistry : Thallus K+ yellow-red, C-, KC-, PD+; norstictic acid and xanthones present.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **23**), 1812 mts alt. 20.09.2014, M. Chinlampianga and A. R. Logesh, 14-031437 (LWG).

Comment: This species was earlier reported from Costa Rica and China. It is a **new record** for India found growing on the smooth barks of evergreenforests at an altitude of 1800 mts.

127. ***Stigmatochroma kryptoviolascens*** Marbach **[Plate: 32/C]**
Biblthca Lichenol. 74: 304, 2000.

Description : 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.

Chemistry: Thallus K+ red, C-, KC-, PD+; norstictic acid and atranorin present.

Specimen examined: Champhai district, Murlen National Park (East-Site No. **23**), on bark, 2092 mts alt. 23.09.2014, M. Chinlampianga and A. R. Logesh, 14-021035 (LWG).

Comment: 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 mts along with other physciaceae members.

128. ***Stigmatochroma metaleptoides*** (Nyl.) Marbach **[Plate: 32/D]**
Biblthca Lichenol. 74: 304, 2000.

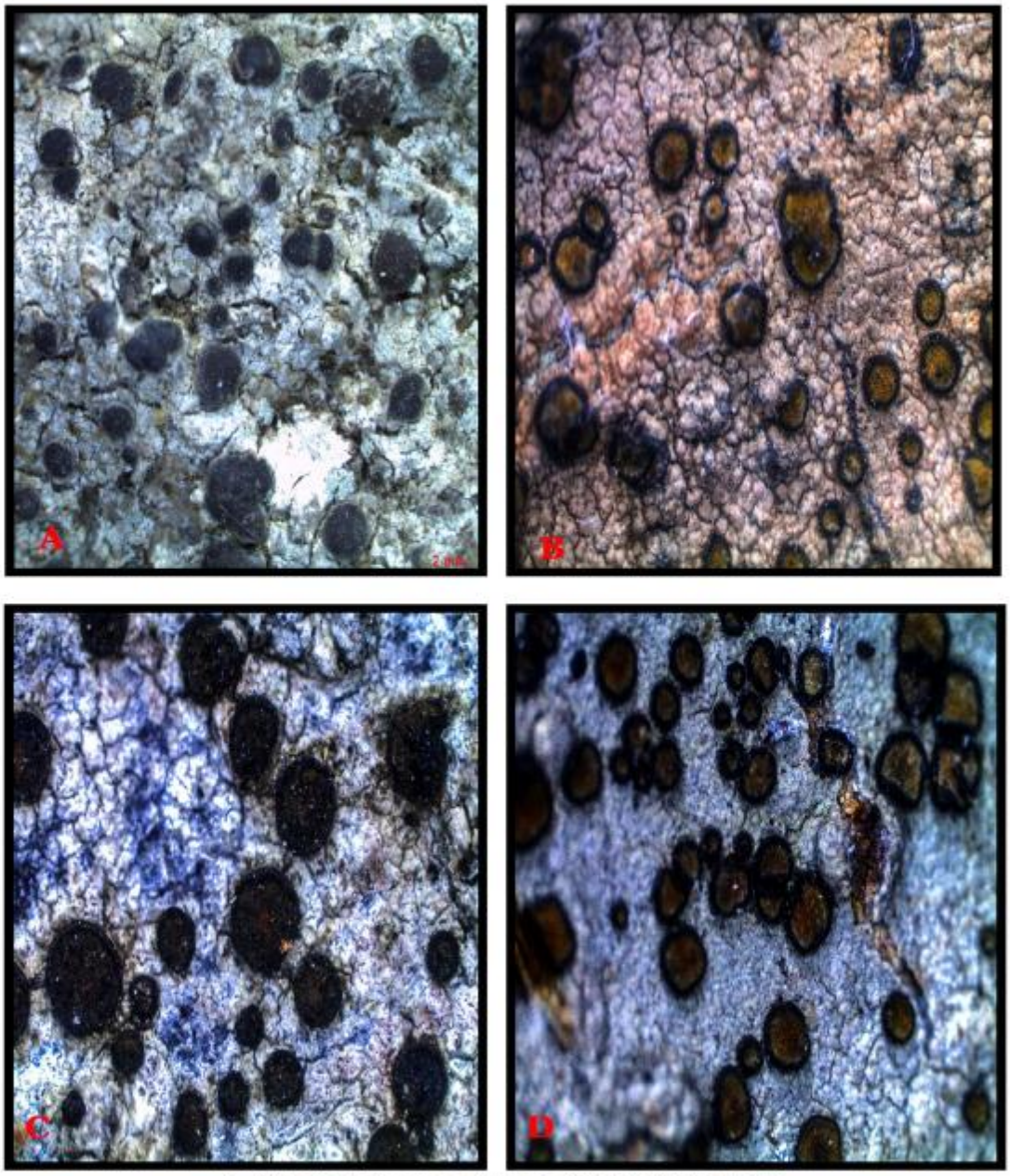
Description : Thallus crustose, corticolous, yellow, aereolate; apothecia round to irregular, 0.3-0.5 mm diam., disc pruinose (greenish yellow); epihymenium dark brown, 20-25 µm thick; hymenium hyaline, not inspersed, 60-80 µm thick; excipulum carbonized, dark brown, 60-70 µm thick; paraphyses simple to sparingly branched, not anastomosing; asci 8-spored; ascospores brown, 1-septate, thick walled, 14-18 × 6-7 µm.

Chemistry: Thallus K+ yellowred, C-, KC-, P+ red; norstictic acid present.

Specimen examined: Champhai district, Murlen National Park (East-Site No. **23**), on bark, N 23° 39' 11.2", E 93° 19' 56.2" & 2122 mts alt. 20.09.2014, A. R.Logesh & M. Chinlampianga, 14-021080 (LWG).

Comment: 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 mts.

Plate: 32 (A - D)



A. Stigmatochroma adaucta (Malme) Marbach
B. Stigmatochroma gerontoides (Stirton) Marbach
C. Stigmatochroma kryptoviolascens Marbach
D. Stigmatochroma metaleptoides (Nyl.) Marbach

Thecaria Fee,
(Graphidaceae)

Three species of the genus *Thecaria,* reported from India, the study area represent one species.

129. ***Thecaria austroindica*** (D.Awasthi & Upreti)V.Tewari & Upreti comb.Nova **[Plate: 33/A]**
Lopadium austroindica Awasthi and Upreti, Curr. Sci. 50(18): 822, 1981.

Description : Thallus corticolous, crustaceous, epiphloeodal, greyishish white to greenish white, smooth to cracked. Apothecia circular or oval rarely slightly elongate, present in clusyters, simple, unbranched, emergent, upto 1mm long; margin thin, concolorous with thallus; disc open wide, flat to concave, grayish black, pruinose. Exciple closed, totally carbonized, bowl shped, bsal exciple thiker than lateral sides, bsal outline slightly irregular or somewhat dentate; labia entire and slightly irregular towards outerside, divergent, covered with thalline veil. Hymenium hyaline, inspersed, 90-175µm high. Asi 2-8 spored; ascospores brown, muriform, oblong- ellipsoid, transverse 6-9 locular, longitudinally 1-3 locular, 25-36x10-15µm, I+ red brown.

Chemistry: K-, C-, KC-, Pd-; TLC not detectede.

Specimen examined: Champhai district, Murlen National Park (East – Site No. **23**), on rough bark, 1460 m alt. 23.09.2014, M. Chinlampianga and A.R. Logesh, 14-021046(LWG).

Trapelia Choisy
(Trapelariaceae)

The genus *Trapelia* is known by the occurrence of 12 species in the world. Out which 2 species are reported from India and only single record known from northern part of Murlen National Park, Mizoram.

130. ***Trapelia coarctata*** (Turner ex Sm.)M. Choisy **[Plate: 33/B]**
Bull. Soc. Sci. Nat. Maroc. 12:160, 1932; Hertel, Khumbu Himal 6(3): 334, 1977. *Lichen coarctatus* Turner ex Sm. in Sm. & Sowerby, Engl. Bot.: 8, tab. 534, 1799. *Lecidea coarctata* (Turner ex Sm.) Nyl., Acta Soc. Linn. Bordeaux 21: 358, 1856.

Description : Thallus thin, whitish, pale grey or pinkish rarely pale green, smooth or ± rugose,continuous or cracked, never distinctly effigurate at the edge, the areoles mostly contiguous or sometimes scattered; prothallus ± present, white. Apothecia 0.2-0.8mm diam., rose pink to red brown; thalline exciple thin, white, smooth to crenate, forming a halo-like rim atleast when young. Asci- ascospores 15-25 x 7-13µm.

Chemistry: Tallus K-, C^+ red, KC^+ red, Pd-; TLC: Gyropholic acid present.

Specimen examined: Champhai district, Murlen National Park (North- Site No. **25**), on rough bark, 1460 m alt. 12.02.2012, M. Chinlampianga,12-031529 (LWG).

Usnea Dill. *ex* Adans.
(Usneaceae)

Usnea is a large genus comprised of 650 species. Out of about 650 known from the world, 59 species were reported from India, Nepal and Srilanka (Awasthi, 2007), out of which 14 species are reported from Murlen National Park, Mizoram.

131. ***Usnea aciculifera*** Vain. **[Plate: 33/C]**
Bot.Mag.Tokyo. 35:45, 1992; Moty 38:322, 1936; G. Awasthi 1998: 363.

Description : Thallus corticolous, pendulous, to 13cm long; yellow-brown to blackish brown; branching dichotomous to subsympodial: branches convergent, 0.25-0.75 (-1) mm in diam., tapering; lateral spinules rarely present in apical region; surface annularly cracked, smooth to verrucose-isidiate; cortex palisade like; central axis solid, Apothecia absent.

Chemistry: Medulla K^+ yellow, P^+ deep yellow, Stictic and consticticacids present.

Specimen examined: Champhai district, Murlen National Park (South – Site No. **15**), on rough bark, 1460 m alt. 24.05.2013, M. Chinlampianga,13-019390 (LWG).

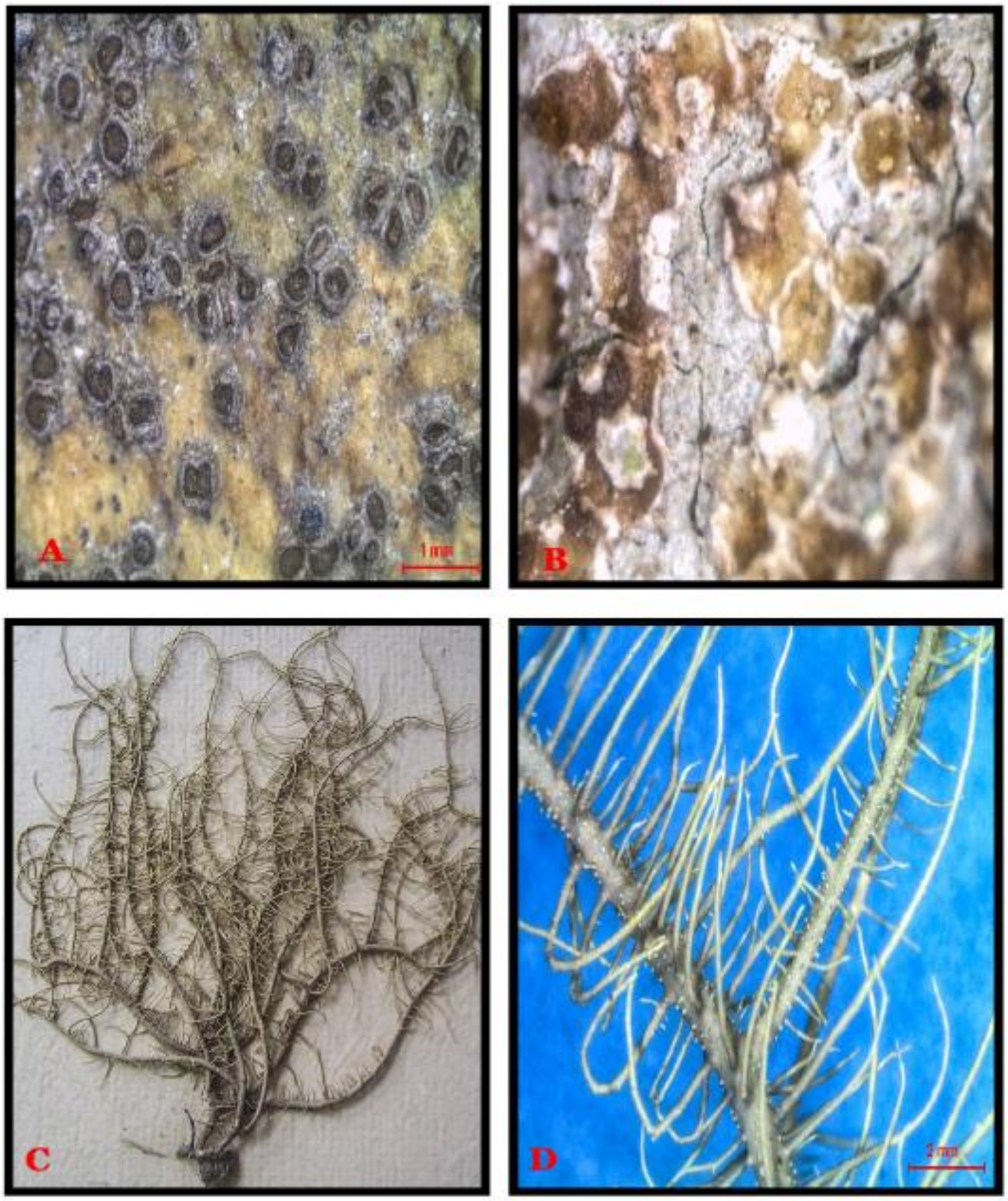
132. ***Usnea baileyi*** (Stirton) Zahlbr. **[Plate: 33/D]**
Denkschr. Akad. Wiss., Wien, Math.-naturw. CI. 83: 182, 1909; Motyka 38: 63, 1936. G Awasthi 1986: 346, Basionym: *Eumitria baileyi* Stirton, Scott. Natur. 6: 100, 1881. Synm.: *Usnea formosa* (Stirt.) Zahlbr.; *Usnea implicata* (Stirt.) Zahlbr.; and *Usnea insignis* Mot.,fide: Swinscow & Krog, Norw. J. Bot. 21: 170, 1974.

Description : Thallus usually corticolous, rarely saxicolous, fruticose, suberect to pendulous, to 15(-25) cm long, greenish grey to brown, dichotomously to subsympodially branched; main branches 1.5(-2) mm in diam., tapering; transversely cracked at intervals, pseudo-cyphellate and isidiate; isidia dense on cortex or along margin of pseudocyphellae; soredia absent; lateral branchlets sparse to dense; periaxial part of medulla yellowish red; central axis tubular (centrally hollow), 1-. Apothecia rare, to 5 mm in diam.; margins ciliate; ascospores 10 x 6 µm.

Chemistry: Medulla K^+ yellow then red, C-, KC-, PD- ; Norstictic and salazinic acids in TLC.

Specimens examined: Champhai district, Murlen National Park (East- Site No. **23**), on rough bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-031497, 031498, 031499, 031503, 031503, 03158, 031521; 15- 031629 (LWG).

Plate: 33 (A - D)



A. Thecaria austroindica (D. Awasthi & Upreti) V.Tewari & Upreti comb.Nova
B. Trapelia coarctata (Turner ex Sm.) M. Choisy
C. Usnea aciculifera Vain.
D. Usnea baileyi (Stirton)

133. ***Usnea bismolliuscula*** Zahlbr. **[Plate: 34/A]**

Cat. Lich. Univ. 6: 542, 1930; Asahina, J. Jap. Bot. 44: 33, 1969; G Awasthi 1986: 366. *Usnea molliuscula* Vainio, Bot. Mag. Tokyo 35: 45, 1921.

Description : Thallus fruticose, corticolous, erect to subpendent, to 16 cm long; straw yellow to yellowish to green when fresh and brownish in herbarium); branching dichotomous to sympodial; primary branches 1-2(-3) mm in diam. at base, rigid, articulate and inflated; lateral branch lets sparse or absent; surface smooth to foveolate, soralia-like extensive spots with minute soredia and whitish, filiform isidia; central axis solid, colourless, I-. Apothecia rare, laterial on laterial and terminal branches, upto 5.2 mm in diam., epihymenium 0-8µm thick spores 7.2 – 9.6 x 4.8-6.4 8µm long.

Chemistry: Medulla K+ yellow then red, P+ deep yellow to reddish. TLC: Usnic aid, norstictic acid, stictic and constictic acids and thamnolic acid present.

Specimens examined: Champhai district, Murlen National Park (South – Site No. **15**), on rough bark, 1460 m alt. 15.01.2015, M. Chinlampianga, 15-031620, 031631(LWG).

134. ***Usnea bornmuelleri*** J. Steiner **[Plate: 34/B]**

Verh. Zool. Bot. Ges. Wien 53: 227, 1903; Motyka 38: 623, 1936; G. Awasthi, 1986: 367; Swinscow & Krog 1988: 331.

Description : Thallus corticolous, shrubby, to 13 cm tall, grey green to olivaceous; branching subdichotomous to sympodial; branches spreading, articulate and inflated, to 2.5 mm in diam., attenuate, stiff; surface papillate and pseudocyphellate-isidiate; cortex double layered; central axis solid, colourless, 1-. Apothecia not known. Psoromic acid present.

Chemistry: - Medulla K-, C-, KC-, PD- ; psoromic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (East- Site No. **(21)**, on bark, 1760mts, alt.17.02.2014, M. Chinlampianga, 14-019190(LWG).

135. ***Usnea fragilis*** Stirt, **[Plate: 34/C]**

Scott. Naturalist (Perth) 6: 297, 1881; D.D. Awasthi, Beih. Nova Hedwigia 17: 129, 1965 & Comp. Macrolich. India, Nepal & Sri Lanka : 500, 2007.

Description : Thallus corticolous or saxicolous, fruticolous, bushy; erect to pendulous, to 17 cm long, greenish grey to brown; branching subdichotomous to sympodial; branches non-articulate and non-inflated; main branch to I:S (-2) mm in diam.; lateral branch lets sparse to dense; surface of branches annularly cracked and longitudinally fissured in basal part, apical region tuberculate,

pseudocyphellate-sorediate to pseudo-isidiate; outer part of medulla red pigmented; central axis solid, colourless. Apothecia not seen.

Chemistry: - Medulla K-, C-, KC-, PD- ; Barbatic acids present in TLC.

Specimen examined: Champhai district, Murlen National Park (North- Site No. **25**), on bark, 1460 m alt. 24.09.2014, M. Chinlampianga and A.R. Logesh, 14-021020 (LWG).

136. ***Usnea galbinifera*** Asahina **[Plate: 34/D]**

J. Jap. Bot. 38: 257, 1963; Asahina in Hara (ed.), Fl. Eastern Himal. Lichens: 602, 1966; G. Awasthi, J. Hattori Bot. Lab. 61: 372. 1986; D.D. Awasthi, Comp. Macrolich. India, Nepal & Sri Lanka : 501, 2007.

Description : Thallus corticolous, erect, 6-10 cm tall, pale reddish brown; branching dichotomous to subsympodial; main branches to 2 mm in diam., inflated, divergent, curved; lateral branchlets sparse to dense; surface of branches papillate and tuberculate-sorediate, and minutely isidiate; terminal part of branches sorediate; central axis solid, yellowish, Apothecia not seen.

Chemistry: - Medulla K^+ yellow-red, C-, KC-, PD+ orange- red ;galbinic and norstictic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (South -Site No. **15**), on bark, 1100 m alt. 24.02.2013, M. Chinlampianga, 13-019400 (LWG).

137. ***Usnea himantodes*** Stirton **[Plate: 35/A]**

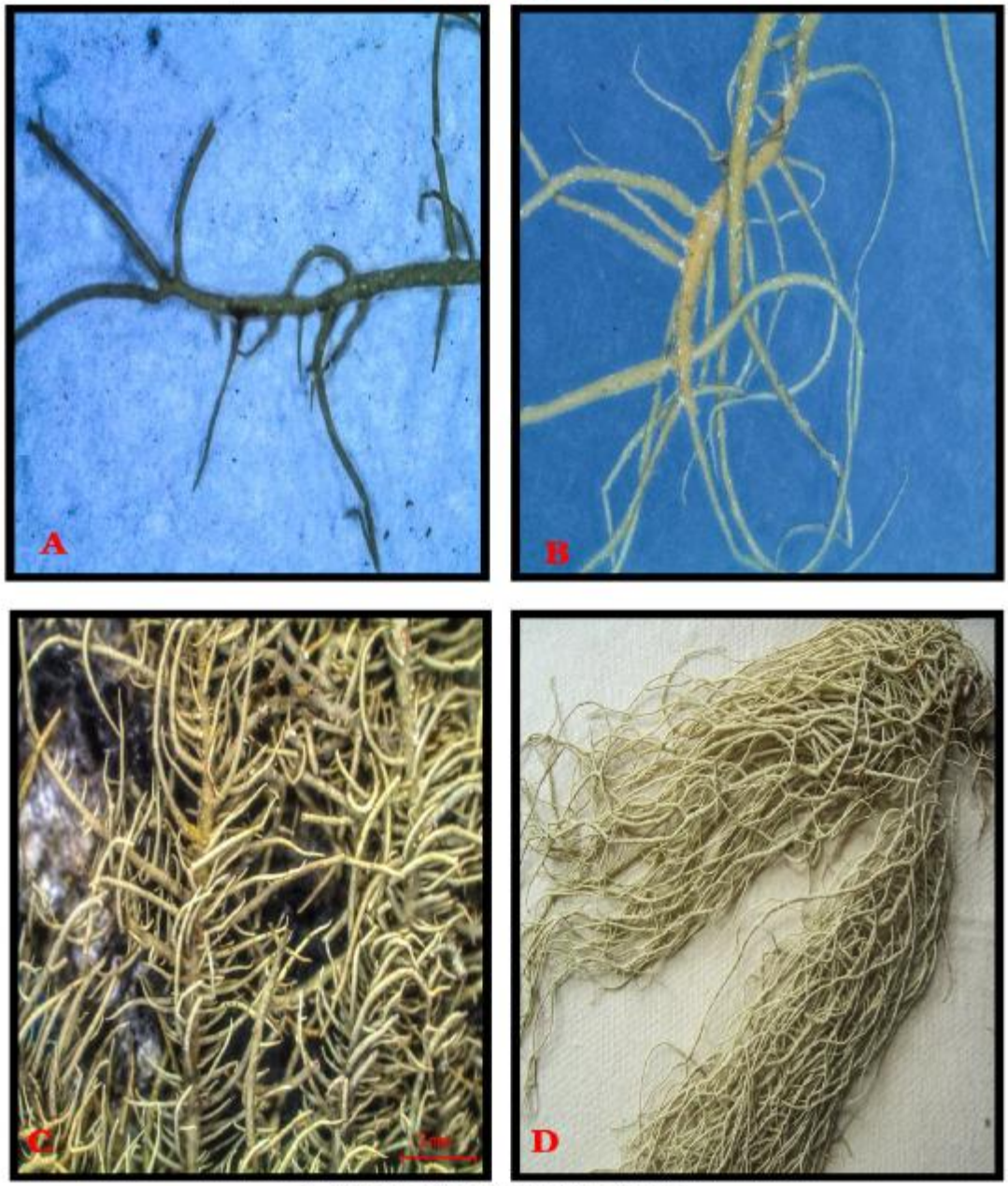
Scott.Natur.7: 75, 1883: Stevens. Lichenologist 22: 409-412, 1990. Synonym: *Usnea gigas* Motyka. Lich. Gen. *Usnea* Stud. Monogr. Pars Syst.: 400, 1936-38: G Awasthi 1986: 356.

Description : Thallus corticolous or saxicolous, pendulous, to 40 cm long, grey-green to blackish; main branches ftlamentose, to 1 mm in diam., angular to subangular in cross-section; surface trans-versely cracked, papillate, cortex persistent; lateral branch lets dense and perpendicular; pseudo-cyphellae and isidia sometimes present; soredia absent;, central axis irregularly dilacerate to excavate in the centre, inner part red pigmented. Apothecia absent.

Chemistry: Medulla K^+ yellow then red, C-, KC-, PD^+ orange; Stictic acid in TLC.

Specimens examined: Champhai district, Murlen National Park (East-Site No. **23**), on bark, 1460 m alt. 23.09.2014, M. Chinlampianga and A.R. Logesh,14-031519, 031502, 031511, 031512, 031513, 031495, 031500, 031501 (LWG).

Plate: 34 (A - D)



A. *Usnea bismolliuscula* Zahlbr.
B. *Usnea bornmuelleri* J. Steiner
C. *Usnea fragilis* Stirt.,
D. *Usnea galbinifera* Asahina

138. ***Usnea longissima*** Ach. **[Plate: 35/B]**

Lichenogr. Universalis: 626. 1810; D.D. Awasthi, Beih. Nova Hedwigia 17: 130, 1965 & Comp. Macrolich.India, Nepal & Sri Lanka: 504, 2007; G. Awasthi, J. Hattori Bot. Lab. 61: 357. 1986. *Usnea longissima* var. *himalayensis* Räsänen, Suom. Elain-ja Kasvit. Seuran Van. Tiedon. (Arch. Soc.Zool. Bot. Fenn. Vanamo) 6(2): 81, 1952.

Description: Thallus corticolous, fruticose, pendulous, filamentose branches to 60 cm long in herbarium, several meters long in nature, pale yellow, greyish green to light brownish; 0.5-1 mm in diam.; lateral branch lets dense, perpendicular, 2-5 cm long; surface of filamentose branches usually decorticated, rarely pulverulent to powdery, cortex of lateral branchlets persistent, cracked near base, with soredia or isidia; central axis solid, colourless, 1+ blue.

Apothecia rare, to 5 mm in diam., margin ciliate; ascospores 8 x 6 µm.

Chemistry:Medulla K-, C-, KC^+ yellowish, PD-; TLC: Barbatic, squamatic, diffractaic, evernic

Specimen examined: Champhai district, Murlen National Park (West-Site No. **24**), on bark, 1210mts alt. 24. 02.2013, M. Chinlampianga, 13-019399 (LWG).

139. ***Usnea orientalis*** Motyka. **[Plate: 35/C]**

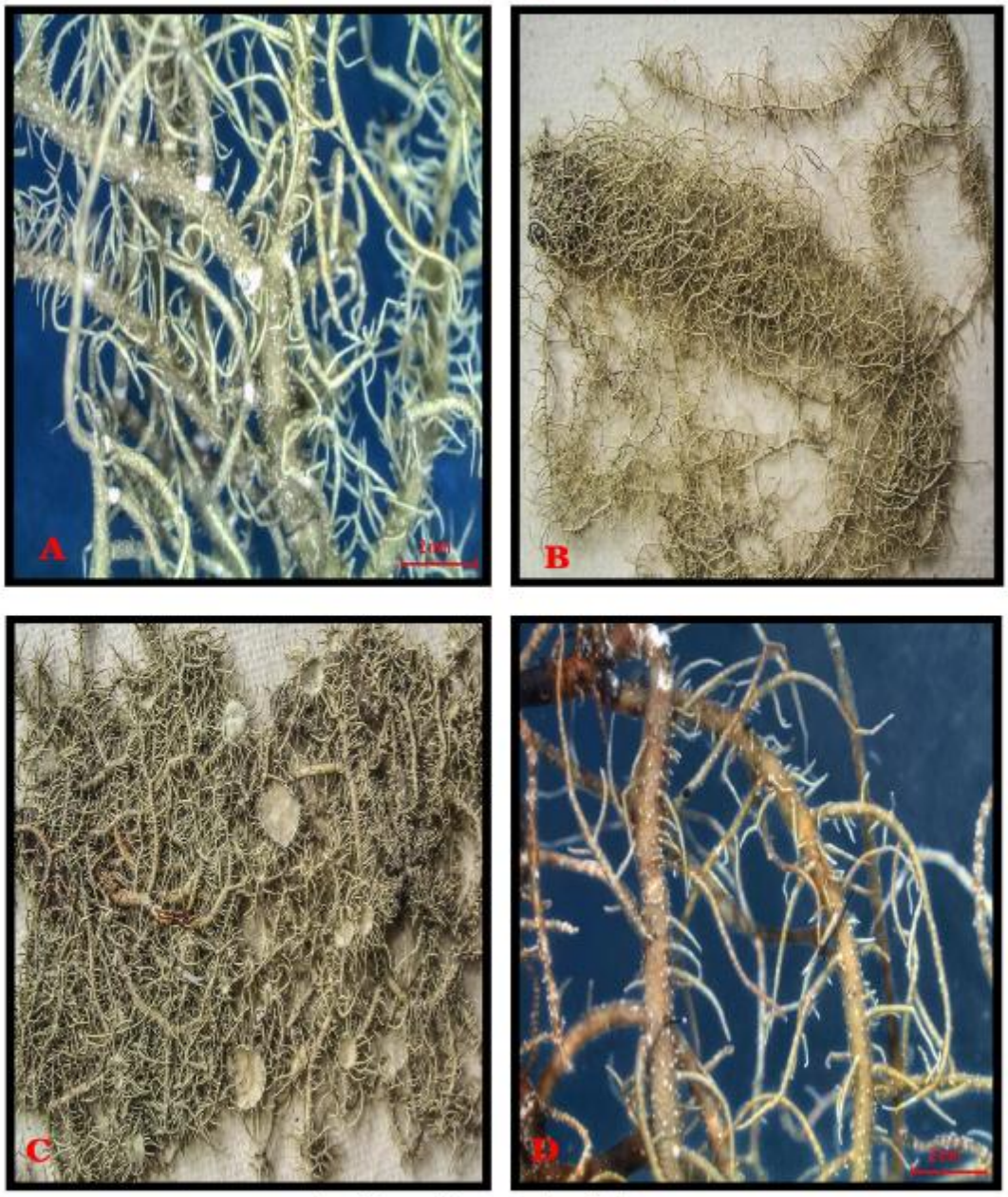
Lich. Gen. *Usnea* Monogr. 2(2): 547. 1937; D.D. Awasthi, Beih. Nova Hedwigia 17: 130. 1965 & Comp. Macrolich. India, Nepal & Sri Lanka : 509. 2007; G. Awasthi, J. Hattori Bot. Lab.61: 377, 1986.

Description : Thallus corticolous, fruticose, erect, to 6 cm tall, greenish grey, deep yellow to yellowish brown; primary branching dichotomous, subsequent branching sympodial; main branches to 2 mm in diam., somewhat irregularly inflated and annularly cracked; lateral branch lets dense, 2 to to mm long; surface of branches waxy, densely papillate; pseudocyphellae, isidia and soredia absent; cortex single layered; central axis solid, colourless to orange, I-. Apothecia initially lateral terminal, to to mm in diam.; margins densely ciliate; ascospores 10 x 8µm.

Chemistry: - Medulla K^+ yellow turning red, C-,KC-, PD^+ deep yellow; Salazinic acids present in TLC.

Specimens examined: Champhai district, Murlen National Park (West- Site No. **24**), on bark,1560 m alt. 26.09.2014, M. Chinlampianga and A.R. Logesh,14-031492, 031505, 031506, 031507, 031510, 031515, 021010; 13-019397 (LWG).

Plate: 35 (A - D)



A. *Usnea himantodes* Stirton
B. *Usnea longissima* Ach.
C. *Usnea orientalis* Motyka
D. *Usnea pangiana* Stirton

140. ***Usnea pangiana*** Stirton **[Plate: 35/D]**

Scott. Natur. 7: 77, 1883; Motyka 1936-38: 350; Stirt., Scott. Naturalist (Perth) 7: 77, 1883; D.D. Awasthi, Beih. Nova Hedwigia 17:130, 1965 & Comp. Macrolich. India, Nepal & Sri Lanka : 510, 2007; G. Awasthi, J. Hattori Bot. Lab. 61:378, 1986.

Description :Thallus corticolous, fruticose, pendulous, 7-15 cm long, rigid, yellowish brown to grey-brown; branching subdichotomous to sympodial; branches convergent; main branches to 2 mm in diam., non-articulate, non-inflated; lateral branch lets sparse to dense, 0.5-2 cm long; surface of branches annularly cracked, verrucose and isidiate-pseudocyphellate; cortex palisade like,rarely reddish pigmented, central axis solid, colourless. Apothecia not seen.

Chemistry: - Medulla K^+ yellow then red,, C-, KC-, PD^+ yellow; Barbatic, diffractaic and salazinic acids present. in TLC.

Specimens examined: Champhai district, Murlen National Park (South-Site No. **16**), on bark of *Schima wallichi*, 15. 01. 2015, M. Chinlampianga, 15-031632, 031491, 031496, 031514, 031518, 031522, 031502, 031511, 031512, 031513, 031519, 031491, 031496 (LWG).

141. ***Usnea pectinata*** Taylor **[Plate: 36/A]**

London J. Bot. 6: 191, 1847; D.D. Awasthi, Beih. Nova Hedwigia 17: 131, 1965; Comp. Macrolich. India, Nepal & Sri Lanka : 510, 2007; G. Awasthi, J. Hattori Bot. Lab. 61: 361, 1986.

Description : Thallus corticolous, fruticose, pendulous, filamentose branches to 30 cm long in herbarium, few meters long in nature, 0.5 mm in diam., pale yellow to yellowish grey; lateral branch lets dense, to 2.5 cm long; surface of filamentose branches decorticated or cortex cracked, areolate to pulverulent; cortex in lateral branch lets persistent, lacking isidia and soredia; central axis solid, colourless, Apothecia absent.

Chemistry: - Medulla K^+ yellow then red, C-, KC-, PD^+ deep yellow; Stictic acid complex present in TLC.

Specimens examined: Champhai district, Murlen National Park (West – Site No. **13**), on bark, 1160 m alt. 24.09.2014, M. Chinlampianga and A.R.Logesh, 14-031494, 031520 (LWG).

142. ***Usnea stigmatoides*** G. Awasthi **[Plate: 36/B]**

J. Hattori Bot. Lab. 61: 354, 1986; D.D.Awasthi, Comp.Macrolich.India,Nepal&Sri Lanka:518, 2007.

Description :Thallus corticolous, fruticose, procumbent to pendulous, rigid, to 20 cm long, repeatedly dichotomously branched; main branches to 2 mm in diam., gradually attenuating; lateral branch lets absent; surface of branches annularly cracked at intervals, pseudocyphellate; pseudocy-

phellae with or without isidia; isidia also directly on cortex; soredia absent; cortex palisadelike; central axis, colourless, solid. Apothecia absent.

Chemistry: - Medulla K^+ yellow-red, C-, KC-, PD^+ yellow; Stictic acid present in TLC.

Specimen examined: Champhai district, Murlen National Park (North- Site No. **25**), on bark, 1460 m alt. 23.09.2014, M. Chinlampianga and A.R. Logesh, 14-021019 (LWG).

143. ***Usnea undulata*** Stirton **[Plate: 36/C]**

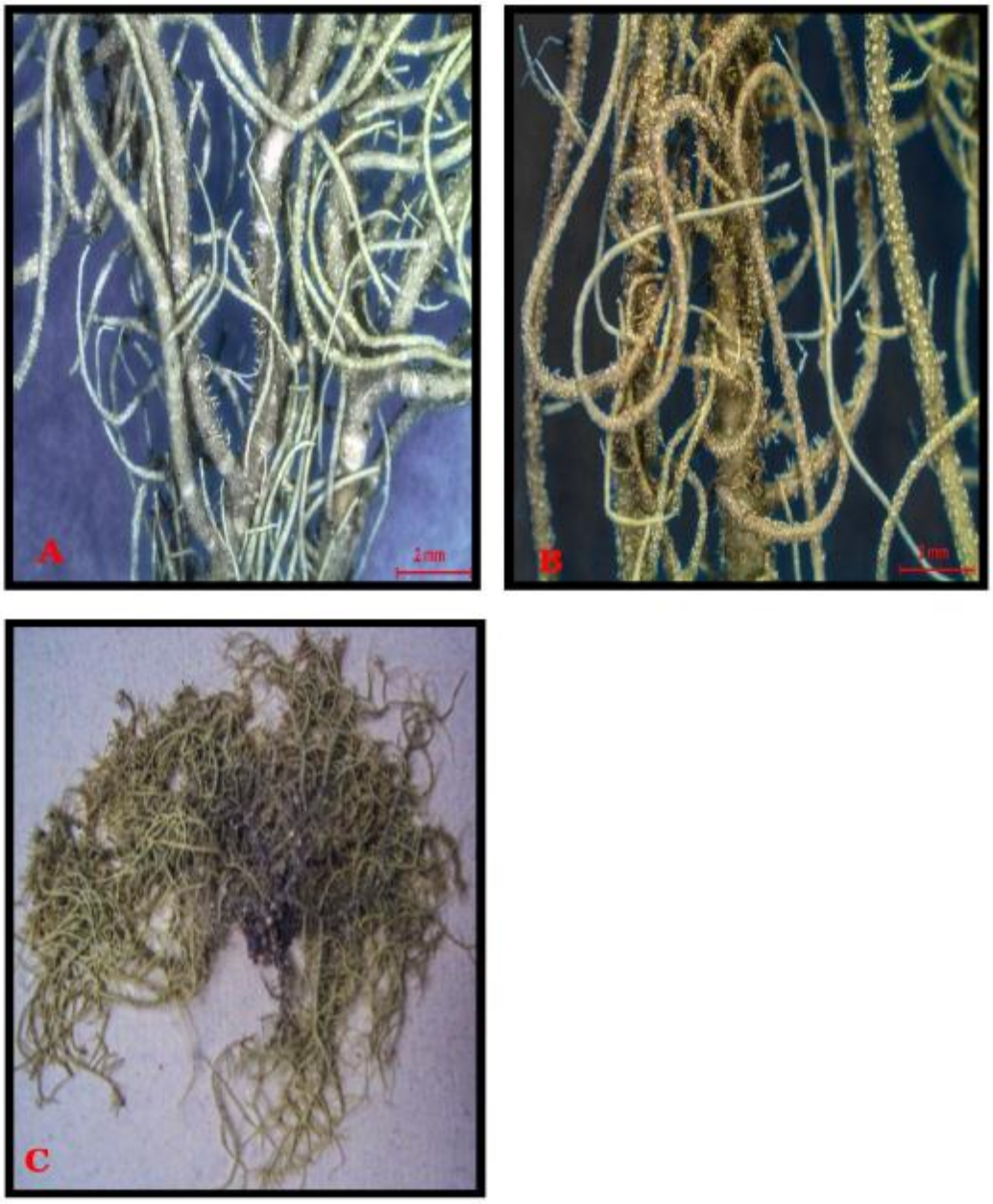
Scott. Naturalist (Perth) 6: 104, 1881; D.D. Awasthi, Beih. Nova Hedwigia 17: 32, 1965; Comp. Macrolich. India, Nepal & Sri Lanka : 520, 2007; G. Awasthi, J. Hattori. Bot. Lab. 61: 391, 1986.

Description : Thallus corticolous, fruticose, rarely saxicolous, erect shrubby, procumbent to pendulous, up to 15 (-25) cm long, paler at base, greyish brown to brown upwards; branching subsympodial to sympodial; main branches divergent, to 1 mm in diam., attenuate; lateral branch lets sparse to dense; surface of branches tuberculate-pseudocyphellate and isidiate; isidia also on cortex; soredia absent; central axis solid, colourless. Apothecia absent.

Chemistry: - Medulla K^+ yellow, C-, KC-, PD- ; TLC- Salazinic acid strain, galbinic, norstictic and salazinic acids strain, stictic acid complex strain, protocetraric acids strain and no lichen substance in medulla.

Specimens examined: Champhai district, Murlen National Park (West-Site No. **24**), on bark, 1300 m alt. 23.09.2014, M. Chinlampianga and A.R.Logesh, 14-031493, 031504, 031509, 031516; 13-019392 (LWG).

Plate: 36 (A - C)



A. Usnea pectinata Taylor
B. Usnea stigmatoides G. Awasthi
C. Usnea undulata Stirton

Photos during Laboratory Works (a-d)

a. Herbarium Pressing of Lichens Samples
b. Working under Jt. Supervisor (Dr. D.K. Upreti) in his office chamber, NBRI Lucknow
c. Segregation of samples collected
d. Specimen Examination through Microscope

Photo with Acknowledgeable Persons (a-d)

a. Interview with elders at Murlen Village
b. Interraction with elders at Murlen Village
c. With Dr. Logesh and Sandeep, during Laboratory work
d. With my Supervisor and Jt. Supervisor during Preliminary Field Survey at Reiek Tourist Resort, Mizoram

Photos during Field Visit (a-d)

a. Collection of Lichens from tree
b. Usnea Longissima collected from MNP
c. With a Forester MNP
d. With villager during field visit

4.2 Lichen diversity of Murlen National Park

All together about 1500 lichens samples were collected and recorded in the field note book during the course of the study from 25 collection sites within the study area. Furtunately, out of 361 documented lichens, 14 lichen species were reported as new record to Indian lichen flora (Table- 4.1). A detailed taxonomic description of 143 lichen species belongs to 28 families and 55 genera was mention. The pattern of distribution of species in four different localitios within the study area (i.e MNP-East, MNP-West, MNP- North and MNP-South) was assessed properly. It was recorded that three species (viz., *Heterodremia japonica, Parmotrema reticulatum, Parmotrema tinctorum*), 11 genera (viz., *Cladonia, Haematomma, Heterodermia Hypotrachyna, Lecanora, Parmotrema, Pertusaria, Phlyctis, Ramboldia, Relicina, Usnea*) and 9 families (viz., Arthoniaceae, Cladoniaceae, Lecanoraceae, Parmeliaceae, Pertusariaceae, Phlyctidaceae, Physciaceae, Ramalinaceae, Usneaceae) of lichens were commonly occurs in the four locations (Fig. 4.1). The distribution of numbers of species, genera and families in the four different locations are summarized in Fig- 4.2 & Table 4.2. The pattern of occurrence of lichen family and genera at four locations are recorded in Table- 4.3-4.4. Further, locationwise list of lichen species along with the LWG number are also summerized (Table 4.5-4.8).

Out of 14 lichens species recorded as new to India, 11 species were collected from eastern part of Murlen National Park, 02 from western part, and 01 species from northern part of MNP. Besides this, MNP-East location shows maximum diversity with respect to species, genera, family and maximum number of lichen specimen with LWG number (Fig. 4.3). The different types of growth form existing and number of the respective growth form occurence in the eastern part of the park are recorded in Table 4.5; and Fig- 4.3.

The lichen diversity of western part of MNP represents 02 new species, 33 species from 20 genera under 23 families. 63 numbers of lichen specimens with LWG number (Table 4.6; and Fig. 4.4). Different types of growh forms of lichens (viz., crustose-14, foliose-11, fruticose-6; squamulose-2 and leprose -1) were reported from the western part of MNP (Fig. 4.4C). However, one new lichen species was recorded from northern part of Murlen National Park. The lichen diversity of northern and southern part of the study area was shown in (Table 4.7 & 4.8; Fig-4.5 & 4.6). The northern part exhibit the occurance of three growth forms (i.e, crustose-9, foliose-10 and fruticose-5) (Fig. 4.5C).

The different types of growth form existing and number of the respective growth form occurence in the eastern part of the park are recorded in Table 4.5; and Fig- 4.3.

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The percentage of substrata and their habitat of lichens in the study were noted properly. 66·5% of the species, 26·7% of the genera and 4· 4% of the families were lignicolous (on wood), 15·3% of the species, 13·3% of the genera and 15·4% of the families were saxicolous (on rocks), while none of the genera and families but 1·2% of the species were terricolous. 38·8% of the families, 12·7% of the genera and 27% of the species appeared to be generalists, occurring in all three substrata. The rest of the taxa shared two of the three microhabitats in the study area.

There was a tendency towards niche separation in terms of habitat specialization with the process of diversification of species, as reflected in relatively higher proportions of generalists at higher levels of taxonomic ranks. *Heterodermia japonica* (Sato) Swinsc. & Korg. *Parmotrema reticulatum* (Taylor) Choisy and *Parmotrema tinctorum* (Nyl.) Hale were broad-niched generalist species occurring frequently in all the localities spreading across wide elevation ranges. *Coccocarpia palmicola* (Spreng.) Arvidss. & D.J.Halloway, *Lopadium leucoxanthum* (Spreng.) Zahlbr., *Lecidea granifera* (Ach.) Vain., *Mycobilimbia hunana* (Zahlbr.) D.D.Awasthi, *Chiodecton leptosporum* Müll. Arg., *Myriotrema microporum* (Mont.) Hale and *Trapelia coarctata* (Sm.) M.Choisy were encountered only once during the study period and hence can be considered as rare members of the community.

Table-4.1: List of lichen species reported as *new record* to Indian lichen flora from the study area MNP

Sl. No	Name of species	Family	Place of collection in MNP	LWG Number
1	*Buellia aeruginascens* (Nyl.) Zahlbr.	Physiaceae	East – Site No. **1**	14-021055
2	*Chaenotheca chrysocephala* (Turner ex Ach.)	Coniocybaceae	East – Site No. **8**	14-019194
3	*Diorygma reniforme* (Fee) Kalb., Staiger & Elix	Graphidceae	West – Site No. **17**	14-021015
4	*Gassicurtia acidobaeomyceta* Marbach,,	Physiaceae	East – Site No. **19**	14-031428
5	*Graphis granulosa* (Mu¨ ll. Arg.) Lucking	Graphidaceae	East – Site No. **18**	14-031452
6	*Hafellia demutans* (Zalhbr.) Puswald	Physiaceae	East – Site No. **1**	14-021068
7	*Phyllopsora soralifera* Timdal	Biatoraceae	East- Site No. **22**	14-031436
8	*Ramboldia sorediata* Kalb	Lecanoraceae	North-Site No. **25**	14-021030
9	*Ramboldia subnexa* (Stirt.) Kantvilas and Elix	Lecanoraceae	West- Site No. **13**	14-021032
10	*Relicina sublanea* (Kurok.) Hale	Parmeliaceae	East- Site No. **23**	14-031478
11	*Stigmatochroma adaucta* (Malme) Marbach	Caliciaceae	East- Site No. **23**	14-031426
12	*Stigmatochroma gerontoides* (Stirt.) Marbach	Caliciaceae	East- Site No. **23**	14-031437
13	*Stigmatochroma kryptoviolascens* Marbach	Caliciaceae	East-Site No. **23**	14-021035
14	*Stigmatochroma metaleptodes* (Nyl.) Marbach	Caliciaceae	East-Site No. **23**	14-021080

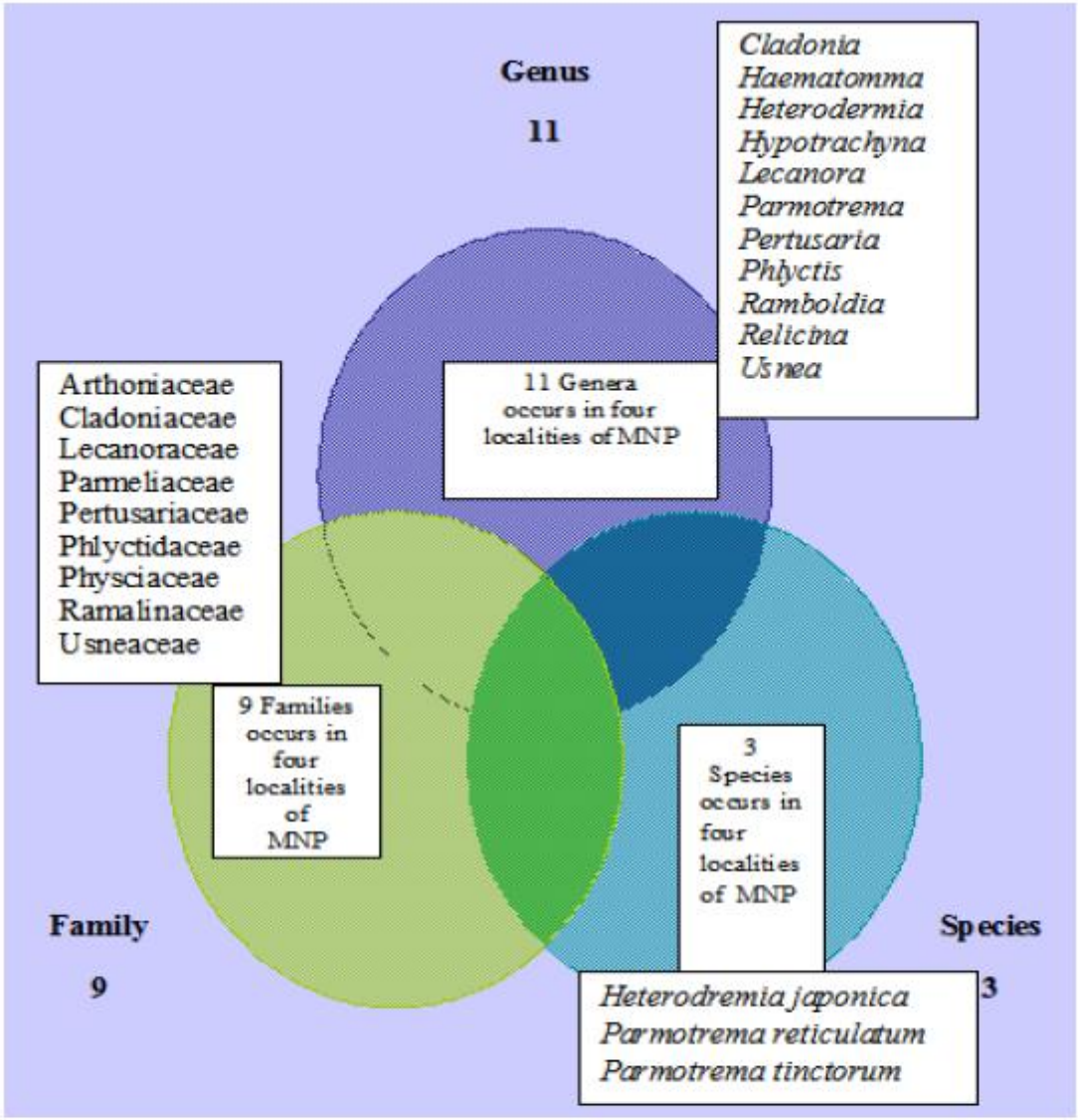

Fig- 4.1: Numbers of family, genera and species of lichen commonly occurs in four major localities (east, west, north and south) of Murlen National Park

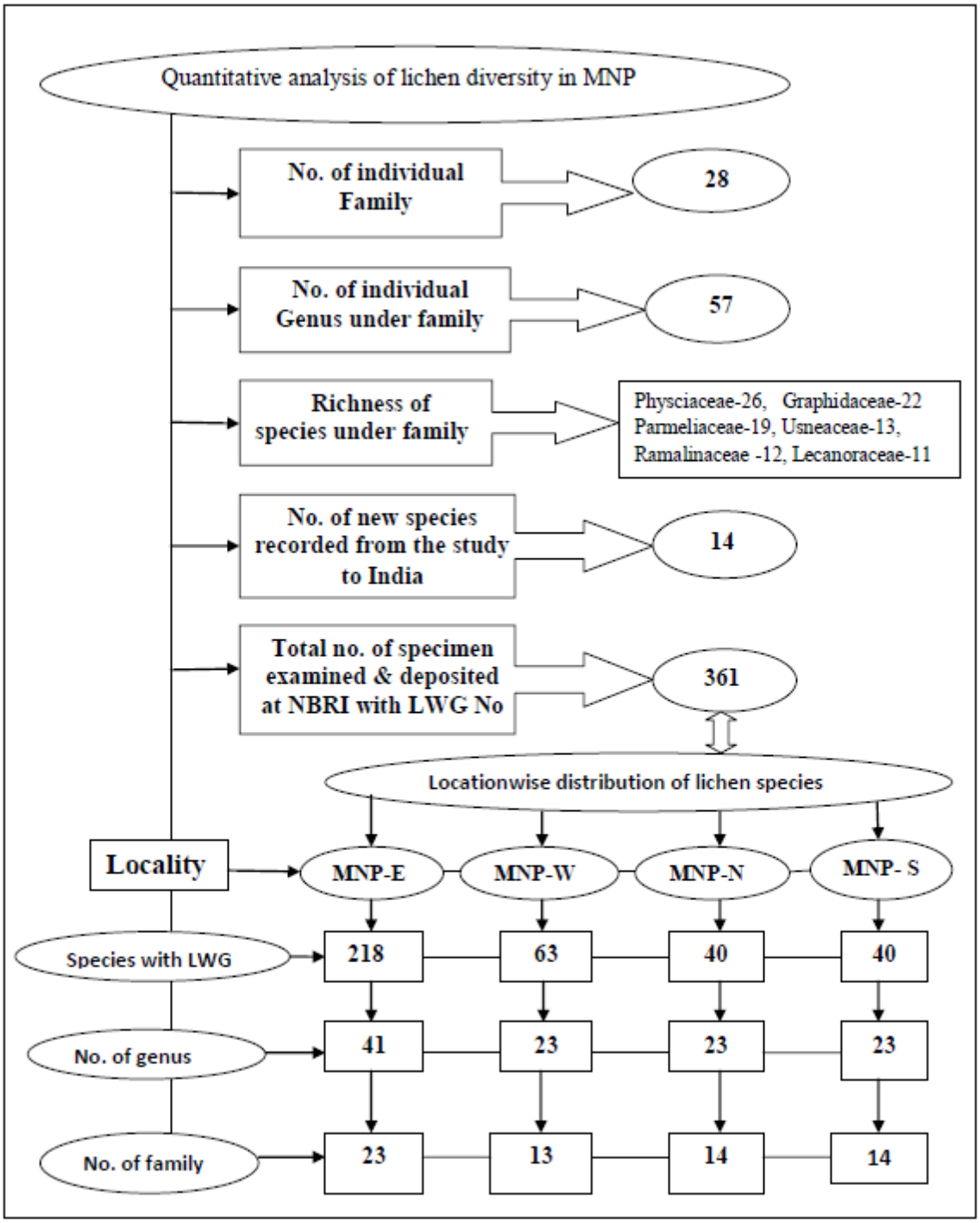

Fig.- 4.2 : Numerical presentation of diversity of lichens from the study area

Table- 4.2: Number of family, genus and species systematically identified from the study area

Sl. No	Family	Nos. of Genus	Species	Nos. of species
1	Arthoniaceae	**2**	*Arthothelium albesces* Patwa&Malch *Arthothelium verruculosum* Patwa&Malch *Cryptothecia lunulata* (Zahlbr.) Makh. &Patw	**3**
2	Cladoniaceae	**1**	*Cladonia coniocraea* (Flörke) Spreng. *Cladonia fruticulosa* Kremp.	**2**
3	Coccocarpiaceae	**1**	*Coccocarpia palmicola* (Spreng.) Arvidss. & D.J.Halloway	**1**
4	Collemataceae	**2**	*Collema subconveniens* Nyl. *Leptogium askotense* D.D.Awasthi *Leptogium denticulatum* Nyl. *Leptogium ulvaceum* (Pers.) Vain.	**4**
5	Coniocybaceae	**1**	*Chaenotheca chrysocephala* (Turner ex. Ach.) Thr.	**1**
6	Ectolechiaceae	**1**	*Lopadium leucoxanthum* (Spreng.) Zahlbr.	**1**
7	Graphidaceae	**9**	*Diorygma hieroglyphicum* (Pers.) Staiger& Kalb. *Diorygma junghuhnii* (Mont. & Bosch) Kalb., Staiger & Elix *Diorygma renifrome* (Fée) Kalb., Staiger&Elix *Fissurina dumastii* Fée *Glyphis cicatricosa* Ach. *Glyphis duriuscula* Vain *Graphis arecae* Vain. *Graphis assimilis* Nyl. *Graphis caesiella* Vain *Graphis duplicate* Ach. *Graphis granulosa* (Müll. Arg.) Luecking *Graphis insulana* (Muell. Arg.) Luecking *Graphis lineola* Ach. *Graphis proserpens* Vain. *Graphis scripta* (L.) Ach. *Haematomma puniceum* (Sm. ex Ach.) A. Massal. *Hemithecium aphanes* (Mont. & Bosch.) M.Nakan & Kashiw. *Hemithecium divaricoides* (Rasanen) V. Tiwari &Upreti *Hemithecium pyrrhochroa* (Mont. & Bosch.) V.Tewari & Upreti *Phaeographis dendroides* (Leight.) Müll. Arg.	**22**

			Sarcographa labyrinthica (Ach.) Müll. Arg. *Thecaria austroindica* (D.D.Awasthi & Upreti) K.P.Singh & G.P.Singh	
8	Haematommataceae	**1**	*Haematomma puniceum* (Sm. ex Ach.) Massal. *Haematommawatii* (Stirt.) Zahlbr.	**2**
9	Lecanoraceae	**2**	*Lecanora achroa* Nyl *Lecanora alba* Lumbsch *Lecanora chlarotera* Nyl. *Lecanora coronulans* Nyl. *Lecanora concilianda* Vainio *Lecanora fimbriatula* Stirton *Lecanora helva* Stizenb. *Ramboldia manipurensis* (K.Singh) Kalb & al *Ramboldia russula* (Ach.) Kalb & al *Ramboldia sorediata* Kalb. *Ramboldia subnexa* (Stirt.) Kantvilas & Elix	**11**
10	Lecideaceae	**1**	*Lecidea granifera* (Ach.) Vain.	**1**
11	Lobariaceae	**1**	*Lobaria retigera* (Bory) Trevis	**1**
12	Pannariaceae	**2**	*Pannaria emodi* P.M.Jørg *Parmeliellapapillata*P.M.Jørg	**2**
13	Parmeliaceae	7	*Everniastrum cirrhatum* (Fr.) Hale ex Sipman *Everniastrum nepalense* (Taylor) Hale ex. Sipman *Hypotrachyna adducta* (Nyl.) Hale *Hypotrachyna awasthi* Hale &Patw. *Hypotrachyna crenata* (Kurok.) Hale *Hypotrachyna imbricatula* (Zahlbr.) Hale, Smithson *Hypotrachyna sublaevigata* (Nyl.) Hale *Myelochroa perisidians* (Nyl.) Elix& Hale *Myelochroa xantholepis* (Mont. & Bosch) Elix&Hale *Parmotrema hababianum* (Gyeln.) Hale *Parmotrema reticulatum* (Taylor) M.Choisy *Parmotrema saccatilobum* (Taylor) Hale *Parmotrema stuppeum* (Taylor) Hale *Parmotrema tsavoense* (Krog. &Swinsc.) Krog.& Swins *Parmotrema tinctorum* (Despr. ex Nyl.) Hale *Punctelia rudecta* (Ach) Korg. *Relicina sublanea* (Kurok.) Hale *Relicina sydneyensis* (Gyeln.) Hale *Relicinopsis malaccensis* (Nyl.) Elix &Verdon	**19**

14	Pertusariaceae	1	*Pertusaria albescenes* (Huds.) M.Choisy & Werner *Pertusaria amara* Nyl. *Pertusaria leucosorodes* Nyl. *Pertusaria multipunctata* (Turner) Nyl. *Pertusaria pustulata* (Ach.) Duby *Pertusaria quassiae* (Fée) Nyl.	6
15	Phlyctidaceae	1	*Phlyctis karnatakana* S.Joshi & Upreti *Phlyctis polyphora* Stirton	2
16	Physciaceae	8	*Amandinea aplacodiomorpha* (Vainio) Marbach *Buellia aeruginascens* (Nyl.) Zalhbr. *Buellia morehensis* K.Singh&S.R.Singh *Dirinaria aegialita* (Afz. In Ach.) Moore *Dirinariaconfluens* (Fr.) D.D.Awasthi *Dirinariapapillulifera* (Nyl.) D.D.Awasthi *Gassicurtia acidobaeomyceta* Marbach *Hafellia curatellae* (Malme) Marbach *Hafellia demutans* (Stirton) Puswald *Heterodermia albidiflava* (Kurok.) D.D. Awasthi *Heterodermia boryii* (Fée) Kr.P.Singh&S.R.Singh *Heterodermia comosa* (Eschw.) Follmann&Redón *Heterodermia diademata* (Taylor) D.D.Awasthi *Heterodermia flabellata* (Fée) D.D.Awasthi *Heterodermia hypochraea* (Vain.) Swinsc. &Krog *Heterodermia isidiophora* (Nyl.) D.D.Awasthi *Heterodermia japonica* (M.Satô) Sw. &Krog *Heterodermia obscurata* (Nyl.) Trevis *Heterodermia podocarpa* (Bél.) D.D.Awasthi *Heterodermia speciosa* (Wulf.) Trevis *Heterodermia togashi* (Kurok.) D.D. Awasthi *Physcia aipolia* (Ehrh. ex. Humb.) Fürnr. *Physcia dilatata* Nyl *Physcia integrate* Nyl. *Physcia stellaris* (L.) Nyl. *Pyxine cocoes* (Sw.) Nyl. *Pyxine subcinerea* Stirt.	27
17	Caliciaceae	1	*Stigmatochroma adaucta* (Malme) Marbach *Stigmatochroma gerontoides* (Stirton) Marbach *Stigmatochroma kryptoviolascens* Marbach *Stigmatochroma metaleptoides* (Nyl.) Marbach	4

18	Porinaceae	1	*Porina americana* Fée	1
19	Porpidiaceae	1	*Mycobilimbia hunana* (Zahlbr.) D.D.Awasthi	1
20	Pyrenulaceae	2	*Anthracothecium macrosporum* (Hepp.) Müll. Arg. *Pyrenula zeylanica* Upreti& A.Singh	2
21	Ramalinaceae	4	*Bacidia fusconigrescens* (Nyl.) Zalhbr. *Bacidia imundata* (Fr.) Korb. *Bacidia laurocerasi* (Delise ex Duby) Vain. *Bacidia medialis* (Tuck. ex Nyl.) Zahlbr. *Phyllopsora corallina* (Eschw.) Müll. Arg. *Phyllopsora soralifera* Timdal *Ramalina conduplicans* Vain. *Ramalina hossei* Vain. *Ramalina sinensis* Jatta *Phyllopsora albicans* Müll. Arg. *Phyllopsora buettneri* (Mull. Arg.)Zahlbr.	11
22	Roccellaceae	1	*Chiodecton leptosporum* Müll. Arg.	1
23	Stereocualaceae	1	*Lepraria lobificans* Nyl. *Lepraria incana* (L.) Ach. *Lepraria sp.*	3
24	Teloschistaceae	1	*Caloplaca amarkantakana*Y.Joshi&Upreti *Caloplaca cerinelloides* (Erichs.) Poelt	2
25	Thelotremataceae	1	*Myriotrema microporum* (Mont.) Hale	1
26	Trapeliaceae	1	*Trapelia coarctata* (Sm.) M.Choisy	1
27	Usneaceae	1	*Usneaa ciculifera* Vain. *Usnea baileyi* (Stirton) Zahlbr. *Usnea bismolliuscula* Zablbr. *Usnea bornmuelleri* J. Steiner *Usnea fragilis* Stirt. *Usnea galbinifera* Asahina *Usnea himantodes* Stirton *Usnea longissima* Ach. *Usnea orientalis* Mot. *Usnea pangiana* Stirton *Usnea pectinata* Taylor *Usnea stigmatoides* G. Awasthi *Usnea undulata* Stirton	13
28	Verrucariaceae	1	*Normandina pulchella* (Borrer) Nyl.	1

Table- 4.3: Pattern of occurance of lichen's family in different localities at MNP

Sl. No	Family	Occurance of lichens in different localities in MNP			
1	Arthoniaceae	MNP-E	MNP-W	MNP-N	MNP-S
2	Caliciaceae	MNP-E			
3	Cladoniaceae	MNP-E	MNP-W	MNP-N	MNP-S
4	Coccocarpiaceae	MNP-E		MNP-N	
5	Collemataceae	MNP-E		MNP-N	MNP-S
6	Coniocybaceae		MNP-W		
7	Ectolechiaceae		MNP-W	MNP-N	
8	Graphidaceae	MNP-E	MNP-W		MNP-S
9	Haematommataceae	MNP-E	MNP-W	MNP-N	
10	Lecanoraceae	MNP-E	MNP-W	MNP-N	MNP-S
11	Lecideaceae	MNP-E			
12	Lobariaceae	MNP-E			
13	Pannariaceae	MNP-E			
14	Parmeliaceae	MNP-E	MNP-W	MNP-N	MNP-S
15	Pertusariaceae	MNP-E	MNP-W	MNP-N	MNP-S
16	Phlyctidaceae	MNP-E	MNP-W	MNP-N	MNP-S
17	Physciaceae	MNP-E	MNP-W	MNP-N	MNP-S
18	Porinaceae	MNP-E			
19	Porpidiaceae				MNP-S
20	Pyrenulaceae	MNP-E			
21	Ramalinaceae	MNP-E	MNP-W	MNP-N	MNP-S
22	Rocellaceae	MNP-E			MNP-S
23	Stereoculaceae	MNP-E	MNP-W		
24	Teloschistaceae	MNP-E			
25	Thelotremataceae	MNP-E			
26	Trapeliaceae			MNP-N	
27	Verrucariaceae	MNP-E			MNP-S
28	Usneaceae	MNP-E	MNP-W	MNP-N	MNP-S

Table 4.4: Pattern of occurrence of lichen genera in different localities of Murlen National Park

Sl. No	Genus	Occurance of different genera of lichens in each localities within Murlen National Park			
1	Amandinea	MNP-E			
2	*Anthracothecium*	MNP-E			
3	*Arthothelium*	MNP-E			MNP-S
4	*Bacidia*	MNP-E			MNP-S
5	*Buellia*	MNP-E			
6	*Caloplaca*	MNP-E			
7	*Chaenotheca*		MNP-W		
8	*Chapsa*	MNP-E			
9	*Chiodecton*	MNP-E			
10	*Cladonia*	MNP-E	MNP-W	MNP-N	MNP-S
11	*Coccocarpia*	MNP-E		MNP-N	
12	*Collema*	MNP-E			
13	*Cryptothecia*		MNP-W	MNP-N	
14	*Diorygma*	MNP-E	MNP-W		MNP-S
15	*Dirinaria*	MNP-E	MNP-W	MNP-N	
16	*Everniastrum*	MNP-E	MNP-W	MNP-N	
17	*Fissurina*	MNP-E			
18	*Gassicurtia*	MNP-E			
19	*Glyphis*	MNP-E			MNP-S
20	*Graphis*	MNP-E			MNP-S
21	*Haematomma*	MNP-E	MNP-W	MNP-N	MNP-S
22	*Hafellia*	MNP-E			
23	*Hemithecium*	MNP-E	MNP-W		MNP-S
24	*Heterodermia*	MNP-E	MNP-W	MNP-N	MNP-S
25	*Hypotrachyna*	MNP-E	MNP-W	MNP-N	MNP-S
26	*Lecanora*	MNP-E	MNP-W	MNP-N	MNP-S
27	*Lecidea*	MNP-E			
28	*Lepraria*		MNP-W		MNP-S

29	*Leptogium*	MNP-E		MNP-N	MNP-S
30	*Lobaria*	MNP-E			
31	*Lopadium*		MNP-W	MNP-N	
32	*Mycobilimbia*				MNP-S
33	*Myelochroa*	MNP-E	MNP-W	MNP-N	
34	*Myriotrema*	MNP-E			
35	*Normandina*	MNP-E			MNP-S
36	*Pannaria*	MNP-E			
37	*Parmeliella*	MNP-E			
38	*Parmotrema*	MNP-E	MNP-W	MNP-N	MNP-S
39	*Pertusaria*	MNP-E	MNP-W	MNP-N	MNP-S
40	*Phaeographis*	MNP-E			
41	*Phlyctis*	MNP-E	MNP-W	MNP-N	MNP-S
42	*Phyllopsora*	MNP-E	MNP-W	MNP-N	
43	*Physcia*	MNP-E			
44	*Porina*	MNP-E			
45	*Punctelia*				MNP-S
46	*Pyrenula*	MNP-E			
47	Pyxine	MNP-E	MNP-W		MNP-S
48	*Ramalina*	MNP-E	MNP-W	MNP-N	
49	*Ramboldia*	MNP-E	MNP-W	MNP-N	MNP-S
50	*Relicina*	MNP-E	MNP-W	MNP-N	MNP-S
51	*Relicinopsis*	MNP-E			
52	*Stigmatochroma*	MNP-E			
53	*Thecaria*	MNP-E			
54	*Trapelia*			MNP-N	
55	Usnea	MNP-E	MNP-W	MNP-N	MNP-S

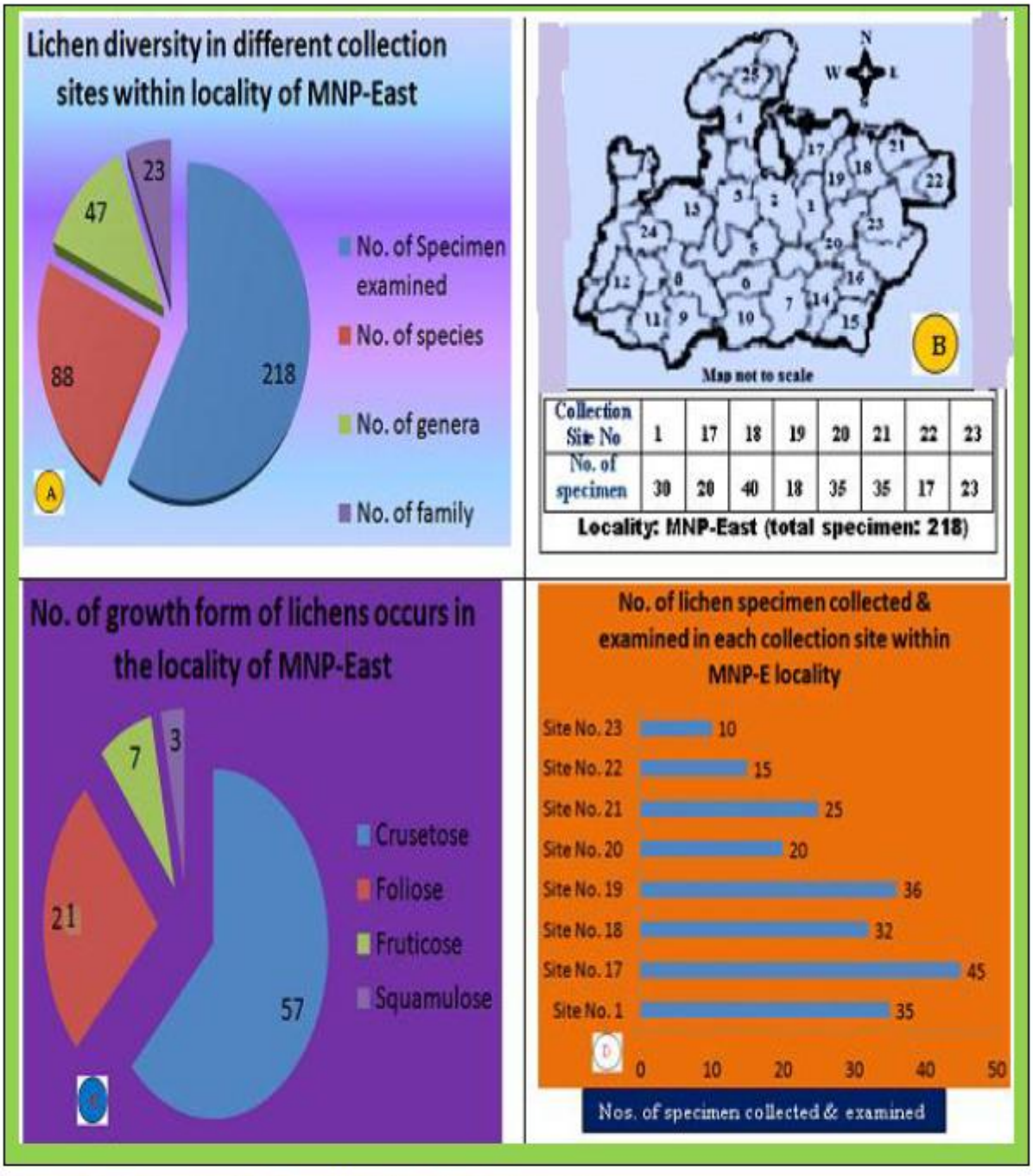

Fig- 4.3(A-D): Diversity of lichens in MNP-East locality of the study area
A- Pie-chart showing nos. of lichen's family, genus, species and specimen with LWG Acc. No.
B- Sketch map of MNP showing nos. of lichens collected from each collection site
C- Pie-chart showing different growth form of lichens
D- Bar-graph showing nos. of lichen specimens collected and systematically examined

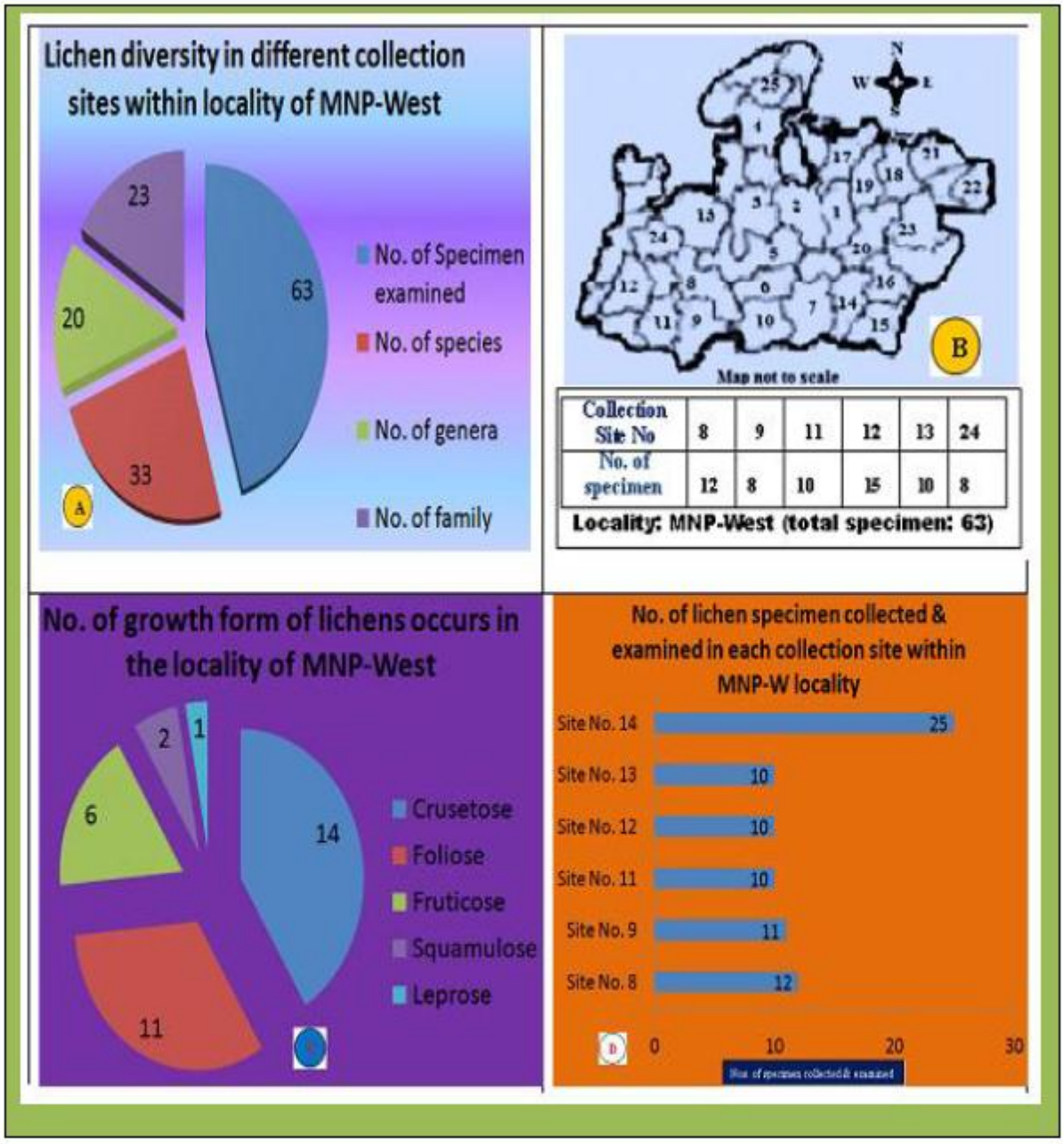

Fig- 4.4 (A-D): Diversity of lichens in MNP-West locality of the study area

A- Pie-chart showing nos. of lichen's family, genus, species and specimen with LWG Acc. No

B- Sketch map of MNP showing nos. of lichens collected from each collection site

C- Pie-chart showing different growth form of lichens

D- Bar-graph showing nos. of lichen specimens collected and systematically examined

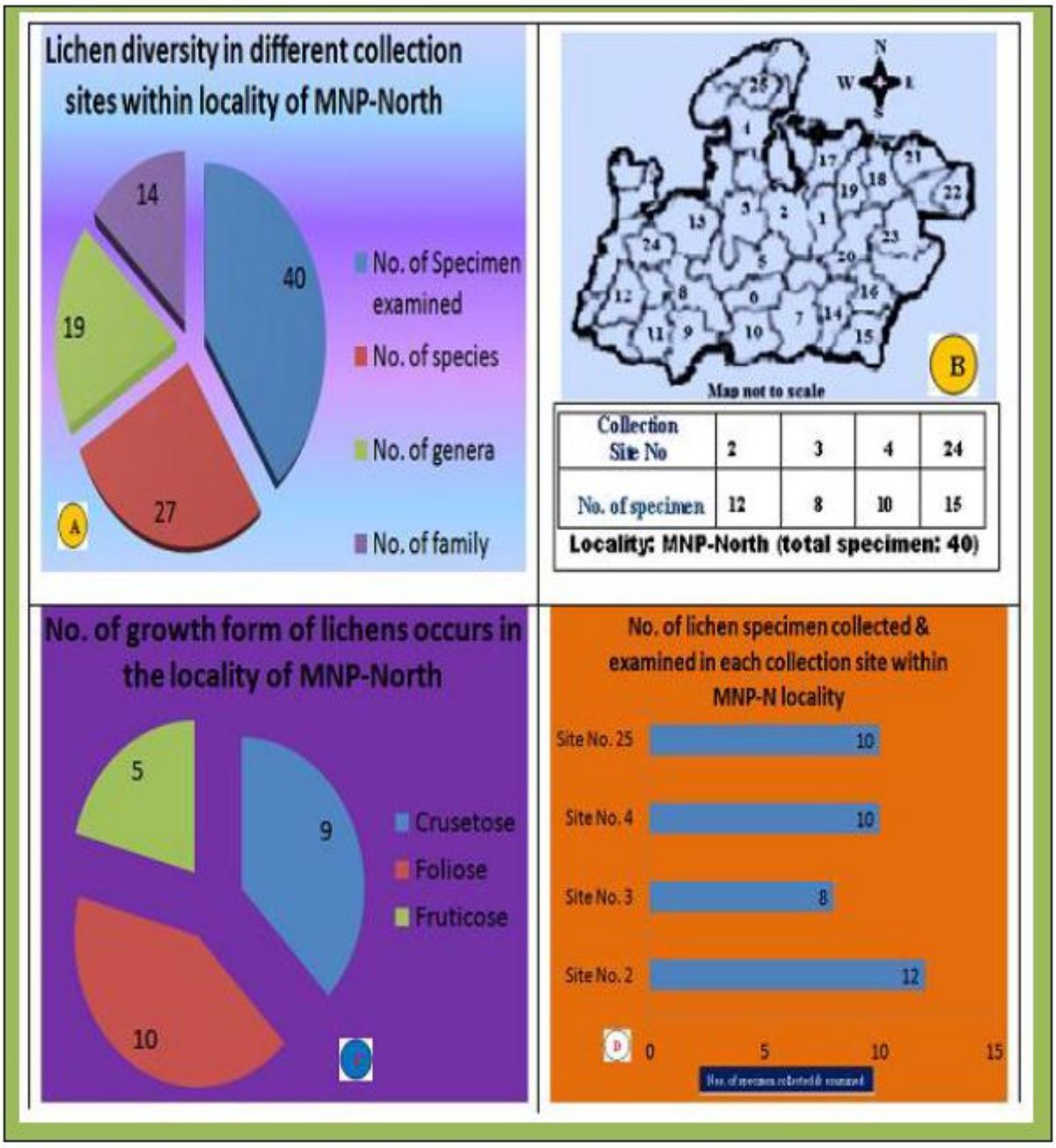

Fig- 4.5 (A-D): Diversity of lichens in MNP-North locality of the study area

A- Pie-chart showing nos. of lichen's family, genus, species and specimen with LWG Acc. No

B- Sketch map of MNP showing nos. of lichens collected from each collection site

C- Pie-chart showing different growth form of lichens

D- Bar-graph showing nos. of lichen specimens collected and systematically examined

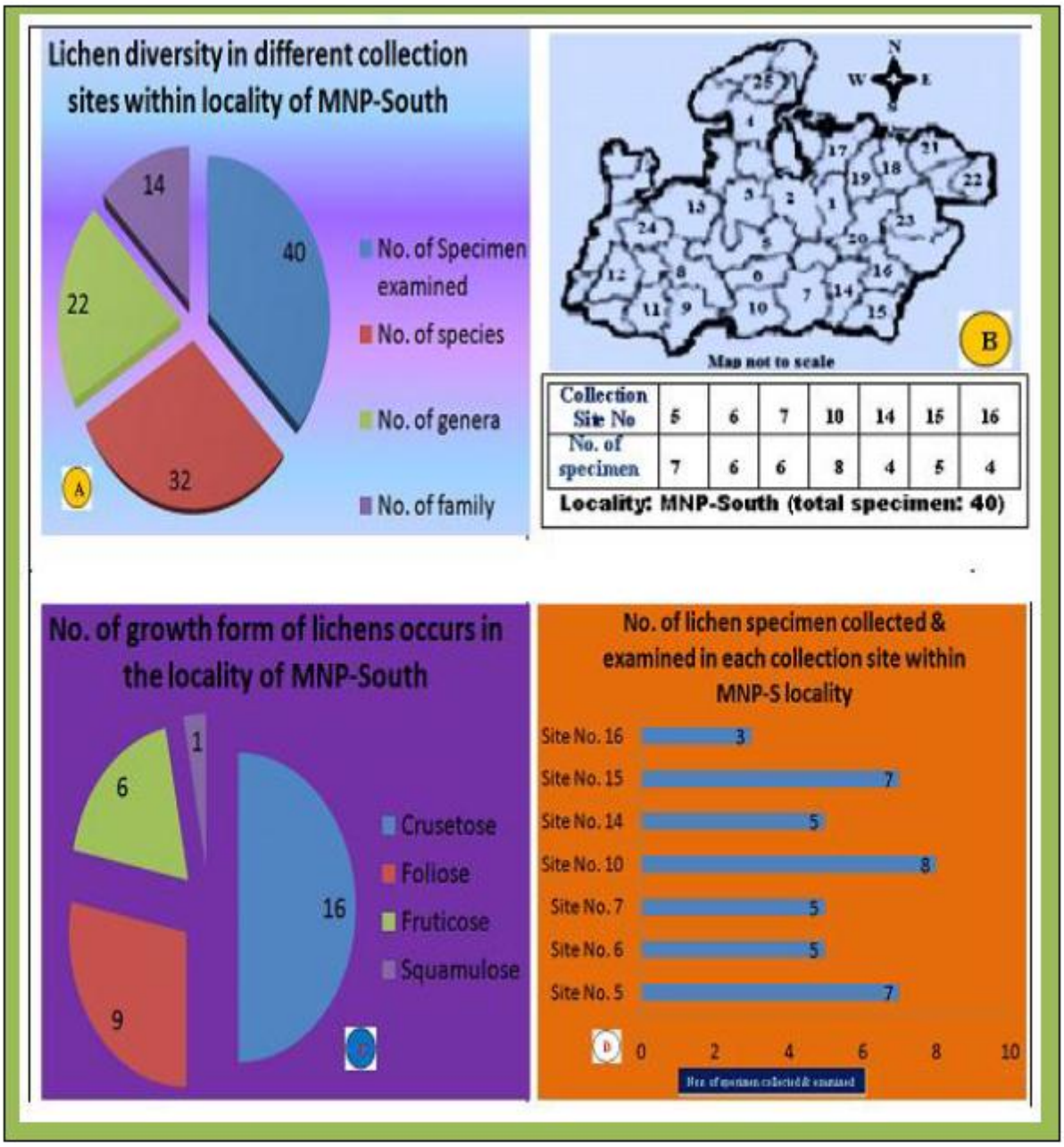

Fig- 4.6 (A-D): Diversity of lichens in MNP-South locality of the study area
- A- Pie-chart showing nos. of lichen's family, genus, species and specimen with LWG Acc. No
- B- Sketch map of MNP showing nos. of lichens collected from each collection site
- C- Pie-chart showing different growth form of lichens
- D- Bar-graph showing nos. of lichen specimens collected and systematically examined

Table-4.5: List of documented lichens specimens collected from Eastern part of Murlen National Park, Mizoram

Family	Species (Alphabetical order)	Growth form	LWG No
Pyrenulaceae	*Amandinea placodiomorpha* (Vainio) Marbach	Crustose	14-031407
	Anthracothecium macrosporum (Hepp.) Müll. Arg.	Crustose	14-021054
	Anthracothecium macrosporum (Hepp.) Müll. Arg.	Crustose	14-021060
	Anthracothecium macrosporum (Hepp.) Müll. Arg.	Crustose	14-021064
	Anthracothecium macrosporum (Hepp.) Müll. Arg.	Crustose	14-021067
Arthoniaceae	*Arthothelium albesces* Patwa & Malch	Crustose	15-031612
	Arthothelium verruculosum Patwa & Malch	Crustose	15-031617
Ramalinaceae	*Bacidia fusconigrescens* (Nyl.) Zalhbr.	Crustose	14-021091
	Bacidia laurocerasi (Delise ex Duby) Vain.	Crustose	14-021090
	Bacidia medialis (Tuck. in Nyl.) Zahlbr.	Crustose	12-019385
Physciaceae	*Buellia aeruginascens* (Nyl.) Zalhbr.	Crustose	14-021055
	*Buellia morehensis*K.Singh & S.R.Singh	Crustose	14-021042
Teloschistaceae	*Caloplaca amarkantakana* Y.Joshi & Upreti	Crustose	14-031418
	Caloplaca amarkantakana Y.Joshi & Upreti	Crustose	14-031423
	Caloplaca cerinelloides (Erichs.) Poelt	Crustose	14-031414
Roccellaceae	*Chiodecton leptosporum* Müll. Arg.	Crustose	14-021056
Cladoniaceae	*Cladonia fruticulosa* Kremp.	Fruticose	14-031446
Coccocarpaceae	*Coccocarpia palmicola* (Spreng.) Arvidss. & D.J.Halloway	Foliose	14-021071
	Coccocarpia palmicola (Spreng.) Arvidss. & D. J. Halloway	Foliose	14-031403
Collemataceae	*Collema subconveniens* Nyl.	Foliose	14-031405
Graphidaceae	*Chapsa alborosella* (Nyl.) A. Frisch	Crustose	14-031438
	Diorygma hieroglyphicum (Pers.) Staiger & Kalb.	Crustose	14-031432

	Diorygma junghuhnii (Mont. & Bosch) Kalb., Staiger & Elix	Crustose	14-031431
	Diorygma junghuhnii (Mont. & Bosch) Kalb., Staiger & Elix	Crustose	14-031433
Physciaceae	*Dirinaria aegialita* (Afz. In Ach.) Moore	Foliose	14-021038
	Dirinaria aegialita (Afz. In Ach.) Moore	Foliose	14-021088
	Dirinaria aegialita (Afz. In Ach.) Moore	Foliose	14-021089
	Dirinaria papillulifera (Nyl.) D.D.Awasthi	Foliose	14-021039
Parmeliaceae	*Everniastrum cirrhatum* (Fr.) Hale ex Sipman	Foliose	14-031427
	Everniastrum cirrhatum (Fr.) Hale ex Sipman	Foliose	14-031471
	Hypotrachyna awasthi Hale & Patw.	Foliose	14-021075
	Hypotrachyna crenata (Kurok.) Hale	Foliose	14-021072
Graphidaceae	*Fissurina dumastii* Fée	Crustose	14-031440
	Glyphis cicatricosa Ach.	Crustose	14-021041
	Glyphis cicatricosa Ach.	Crustose	14-031447
	Glyphis cicatricosa Ach.	Crustose	14-031449
	Graphis arecae Vain.	Crustose	14-031435
	Graphis assimilis Nyl.	Crustose	14-031464
	Graphis assimilis Nyl.	Crustose	14-031466
	Graphis caesiella Vain	Crustose	14-031456
	Graphis caesiella Vain	Crustose	14-031459
	Graphis caesiella Vain	Crustose	14-031462
	Graphis assimilis Nyl.	Crustose	14-031464
	Graphis assimilis Nyl.	Crustose	14-031466
	Graphis caesiella Vain	Crustose	14-031456
	Graphis caesiella Vain	Crustose	14-031459
	Graphis caesiella Vain	Crustose	14-031462

	Graphis granulosa (Müll. Arg.) Luecking	Crustose	14-031452
	Graphis insulana (Muell. Arg.) Luecking	Crustose	14-021036
	Graphis insulana (Muell. Arg.) Luecking	Crustose	14-031454
	Graphis lineola Ach.	Crustose	14-031429
	Graphis proserpens Vain.	Crustose	14-021063
	Graphis proserpens Vain.	Crustose	14-031453
	Graphis proserpens Vain.	Crustose	14-031455
	Graphis proserpens Vain.	Crustose	14-031457
	Hemithecium aphanes (Mont. & Bosch.) M.Nakan & Kashiw.	Crustose	14-021037
	Hemithecium aphanes (Mont. & Bosch.) M.Nakan & Kashiw.	Crustose	14-021062
	Hemithecium aphanes (Mont. & Bosch.) M.Nakan & Kashiw.	Crustose	14-031430
	Hemithecium aphanes (Mont. & Bosch.) M.Nakan & Kashiw.	Crustose	14-031450
	Hemithecium aphanes (Mont. & Bosch.) M.Nakan & Kashiw.	Crustose	14-031451
	Hemithecium aphanes (Mont. & Bosch.) M.Nakan & Kashiw.	Crustose	14-031463
	Graphis proserpens Vain.	Crustose	14-031458
	Graphis proserpens Vain.	Crustose	14-031460
	Graphis proserpens Vain.	Crustose	14-031465
	Graphis scripta (L.) Ach.	Crustose	14-031461
Haematommataceae	*Haematomma puniceum* (Sm. ex Ach.) Massal.	Crustose	14-021043
	Haematomma puniceum (Sm. ex Ach.) Massal.	Crustose	14-021066
	Haematomma puniceum (Sm. ex Ach.) Massal.	Crustose	14-031406

	Haematomma puniceum (Sm. ex Ach.) Massal.	Crustose	14-031479
	Haematomma watii (Stirt.) Zahlbr.	Crustose	14-031401
Physciaceae	*Gassicurtia acidobaeomyceta* Marbach	Crustose	14-031428
	Hafellia curatellae (Malme) Marbach	Crustose	14-031408
	Hafellia demutans (Stirton) Puswald	Crustose	14-021068
	Heterodermia albidiflava (Kurok.) D.D. Awasthi	Foliose	14-019143
	Heterodermia boryii (Fée) Kr.P.Singh & S.R.Singh	Foliose	14-021074
	Heterodermia boryii (Fée) Kr.P.Singh & S.R.Singh	Foliose	14-031442
	Heterodermia boryii (Fée) Kr.P.Singh & S.R.Singh	Foliose	14-031443
	Heterodermia diademata (Taylor) D.D.Awasthi	Foliose	14-021069
	Heterodermia diademata (Taylor) D.D.Awasthi	Foliose	14-021094
	Heterodermia flabellata (Fée) D.D.Awasthi	Foliose	14-031424
	Heterodermia hypochraea (Vain.) Swinsc.& Krog	Foliose	14-021092
	Heterodermia isidiophora (Nyl.) D.D.Awasthi	Foliose	14-021052
	Heterodermia isidiophora (Nyl.) D.D.Awasthi	Foliose	14-021073
	Heterodermia japonica (M.Satô) Sw. & Krog	Foliose	14-021077
	Heterodermia obscurata (Nyl.) Trevis	Foliose	14-021095
	Heterodermia speciosa (Wulf.) Trevis	Foliose	14-021076
Lecanoraceae	*Lecanora achroa* Nyl	Crustose	14-031482
	Lecanora alba Lumbsch	Crustose	14-031483
	Lecanora alba Lumbsch	Crustose	14-031487
	Lecanora coronulans Nyl.	Crustose	14-021059
	Lecanora coronulans Nyl.	Crustose	14-031488

	Lecanora coronulans Nyl.	Crustose	14-031489
	Lecanora coronulans Nyl.	Crustose	14-031490
	Lecanora fimbriatula Stirton	Crustose	14-031484
	Lecanora fimbriatula Stirton	Crustose	14-031485
	Lecanora helva Stizenb.	Crustose	14-031486
Lecideaceae	*Lecidea granifera* (Ach.) Vain.	Crustose	14-021040
	Lecidea granifera (Ach.) Vain.	Crustose	14-021049
	Lecidea granifera (Ach.) Vain.	Crustose	14-021051
	Lecidea granifera (Ach.) Vain.	Crustose	14-021053
	Lecidea granifera (Ach.) Vain.	Crustose	14-021079
	Lecidea granifera (Ach.) Vain.	Crustose	14-031409
Collemataceae	*Leptogium askotense* D.D.Awasthi	Crustose	14-021078
	Leptogium denticulatum Nyl.	Crustose	14-021073
	Leptogium ulvaceum (Pers.) Vain.	Crustose	14-021053
Lobariaceae	*Lobaria retigera* (Bory) Trevis	Foliose	14-031404
Thelotremataceae	*Myriotrema microporum* (Mont.) Hale	Crustose	14-031477
Verrucariaceae	*Normandina pulchella* (Borrer) Nyl	Squamulose	14-031476
Pannariaceae	*Pannaria emodi* P.M.Jørg	Foliose	14-021070
	Pannaria emodi P.M.Jørg	Foliose	14-031410
	Parmeliella papillata P.M.Jørg	Foliose	14-031439
Parmeliaceae	*Myelochroa xantholepis* (Mont. & Bosch) Elix & Hale	Foliose	14-031402
	Myelochroa xantholepis (Mont. & Bosch) Elix & Hale	Foliose	14-031434
	Parmotrema hababianum (Gyeln.) Hale	Foliose	14-031425
	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-021050

	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-031413
	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-031469
	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-031481
	Parmotrema saccatilobum (Taylor) Hale	Foliose	14-031480
	Parmotrema tsavoense (Krog. & Swinsc.) Krog. & Swins	Foliose	14-031528
Physciaceae	*Heterodermia boryii* (Fée) Kr.P.Singh & S.R.Singh	Foliose	14-031443
	Heterodermia *diademata* (Taylor) D.D.Awasthi	Foliose	14-021069
	Heterodermia diademata (Taylor) D.D.Awasthi	Foliose	14-021094
	Heterodermia flabellata (Fée) D.D.Awasthi	Foliose	14-031424
	Heterodermia hypochraea (Vain.) Swinsc. & Krog	Foliose	14-021092
	Heterodermia isidiophora (Nyl.) D.D.Awasthi	Foliose	14-021052
	Heterodermia isidiophora (Nyl.) D.D.Awasthi	Foliose	14-021073
	Heterodermia japonica (M.Satô) Sw. & Krog	Foliose	14-021077
	Heterodermia obscurata (Nyl.) Trevis	Foliose	14-021095
	Heterodermia speciosa (Wulf.) Trevis	Foliose	14-021076
Parmeliaceae	*Hypotrachyna awasthi* Hale & Patw.	Foliose	14-021075
	Hypotrachyna crenata (Kurok.) Hale	Foliose	14-021072
Lecanoraceae	*Lecanora achroa* Nyl	Crustose	14-031482
	Lecanora alba Lumbsch	Crustose	14-031483
	Lecanora alba Lumbsch	Crustose	14-031487
	Lecanora coronulans Nyl.	Crustose	14-021059
	Lecanora coronulans Nyl.	Crustose	14-031488
	Lecanora coronulans Nyl.	Crustose	14-031489
	Lecanora coronulans Nyl.	Crustose	14-031490
	Lecanora fimbriatula Stirton	Crustose	14-031484
	Lecanora fimbriatula Stirton	Crustose	14-031485
	Lecanora helva Stizenb.	Crustose	14-031486

Lecideaceae	*Lecidea granifera* (Ach.) Vain.	Crustose	14-021040
	Lecidea granifera (Ach.) Vain.	Crustose	14-021049
	Lecidea granifera (Ach.) Vain.	Crustose	14-021051
	Lecidea granifera (Ach.) Vain.	Crustose	14-021053
	Lecidea granifera (Ach.) Vain.	Crustose	14-021079
	Lecidea granifera (Ach.) Vain.	Crustose	14-031409
	Lecidea granifera (Ach.) Vain.	Crustose	14-021051
Collemataceae	*Leptogium askotense* D.D.Awasthi	Crustose	14-021078
Lobariaceae	*Lobaria retigera* (Bory) Trevis	Foliose	14-031404
Thelotremataceae	*Myriotrema microporum* (Mont.) Hale	Crustose	14-031477
Verrucariaceae	*Normandina pulchella* (Borrer) Nyl	Squamulose	14-031476
Pannariaceae	*Pannaria emodi* P.M.Jørg	Foliose	14-021070
	Pannaria emodi P.M.Jørg	Foliose	14-031410
	Parmeliella papillata P.M.Jørg	Foliose	14-031439
Parmeliaceae	*Parmotrema hababianum* (Gyeln.) Hale	Foliose	14-031425
	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-021050
	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-031413
	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-031469
	Parmotrema reticulatum (Taylor) M.Choisy	Foliose	14-031481
	Parmotrema saccatilobum (Taylor) Hale	Foliose	14-031480
	Parmotrema tinctorum (Despr. ex Nyl.) Hale	Foliose	14-021048
	Parmotrema tinctorum (Despr. ex Nyl.) Hale	Foliose	14-031412
	Myelochroa xantholepis (Mont. & Bosch) Elix & Hale	Foliose	14-031402
	Myelochroa xantholepis (Mont. & Bosch) Elix & Hale	Foliose	14-031434

Pertusariaceae	*Pertusaria albescenes* (Huds.) M.Choisy & Werner	Crustose	14-021083
	Pertusaria albescenes (Huds.) M.Choisy & Werner	Crustose	14-031420
	Pertusaria amara Nyl.	Crustose	14-031416
	Pertusaria leucosorodes Nyl.	Crustose	14-021084
	Pertusaria leucosorodes Nyl.	Crustose	14-021087
	Pertusaria leucosorodes Nyl.	Crustose	14-031422
	Pertusaria multipunctata (Turner) Nyl.	Crustose	14-031415
	Pertusaria multipunctata (Turner) Nyl.	Crustose	14-031419
	Pertusaria pustulata (Ach.) Duby	Crustose	14-021082
	Pertusaria pustulata (Ach.) Duby	Crustose	14-021082
	Pertusaria pustulata (Ach.) Duby	Crustose	14-021085
	Pertusaria pustulata (Ach.) Duby	Crustose	14-031417
	Pertusaria pustulata (Ach.) Duby	Crustose	14-031421
	Pertusaria quassiae (Fée) Nyl.	Crustose	14-021086
Graphidaceae	*Phaeographis dendroides* (Leight.) Müll. Arg.	Crustose	14-031526
Phlyctidaceae	*Phlyctis karnatakana* S.Joshi & Upreti	Crustose	14-031445
Physciaceae	*Physcia aipolia* (Ehrh. ex. Humb.) Fürnr.	Foliose	14-021058
	Physcia dilatata Nyl	Foliose	14-031472
	Physcia integrata Nyl.	Foliose	14-021098
	Physcia stellaris (L.) Nyl.	Foliose	14-021099
	Physcia stellaris (L.) Nyl.	Foliose	14-031473
Porinaceae	*Porina americana* Fée	Crustose	14-031411
	Porina subcutanea Ach.	Crustose	14-021047
	Porina subcutanea Ach.	Crustose	14-021057
Physciaceae	*Pyxine subcinerea* Stirt.	Foliose	14-021096

Pyrenulaceae	*Pyrenula complanata (Mont.) Trevis*	Crustose	14-019146
	Pyrenula zeylanica Upreti & A.Singh	Crustose	14-021044
Ramalinaceae	*Ramalina conduplicans* Vain.	Fruticose	14-021093
	Ramalina conduplicans Vain.	Fruticose	14-031467
	Ramalina conduplicans Vain.	Fruticose	14-031468
	Ramalina conduplicans Vain.	Fruticose	14-031470
	Ramalina hossei Vain.	Fruticose	14-031444
	Ramalina sinensis Jatta	Fruticose	14-031441
	Phyllopsora corallina (Eschw.) Müll. Arg.	Squamulose	14-021065
	Phyllopsora soralifera Timdal	Squamulose	14-031436
Lecanoraceae	*Ramboldia manipurensis* (K.Singh) Kalb & al	Crustose	14-021045
	Ramboldia manipurensis (K.Singh) Kalb & al	Crustose	14-021081
	Ramboldia manipurensis (K.Singh) Kalb & al	Crustose	14-021097
	Ramboldia manipurensis (K.Singh) Kalb & al	Crustose	14-031474
	Ramboldia manipurensis (K.Singh) Kalb & al	Crustose	14-031475
Parmeliaceae	*Relicina sublanea* (Kurok.) Hale	Foliose	14-031478
	Relicinopsis malaccensis (Nyl.) Elix & Verdon	Foliose	14-031527
Caliciaceae	*Stigmatochroma adaucta* (Malme) Marbach	Crustose	14-031426
	Stigmatochroma gerontoides (Stirton) Marbach	Crustose	14-031437
	Stigmatochroma kryptoviolascens Marbach	Crustose	14-021035
	Stigmatochroma metaleptoides (Nyl.) Marbach	Crustose	14-021080
Graphidaceae	*Thecaria austroindica* (D.D.Awasthi & Upreti) K.P.Singh & G.P.Singh	Crustose	14-021046
	Thecaria austroindica (D.D.Awasthi & Upreti) K.P.Singh & G.P.Singh	Crustose	14-021061
	Sarcographa labyrinthica (Ach.) Müll. Arg.	Crustose	14-031448

Usneaceae	*Usnea baileyi* (Stirton) Zahlbr.	Fruticose	14-031497
	Usnea baileyi (Stirton) Zahlbr.	Fruticose	14-031498
	Usnea baileyi (Stirton) Zahlbr.	Fruticose	14-031499
	Usnea baileyi (Stirton) Zahlbr.	Fruticose	14-031503
	Usnea baileyi (Stirton) Zahlbr.	Fruticose	14-031508
	Usnea baileyi (Stirton) Zahlbr.	Fruticose	14-031517
	Usnea baileyi (Stirton) Zahlbr.	Fruticose	14-031521
	*Usnea bornmuelleri*J. Steiner	Fruticose	14-019144
	Usnea himantodes Stirton	Fruticose	14-031495
	Usnea himantodes Stirton	Fruticose	14-031500
	Usnea himantodes Stirton	Fruticose	14-031501

Table-4.6: List of documented lichens specimens collected from Western part of Murlen National Park, Mizoram

Family	Species	Growth form	LWG No
Coniocybaceae	*Chaenotheca chrysocephala* (Turner ex. Ach.) Th.Fr	Crustose	14-019194
Cladoniaceae	*Cladonia coniocraea* (Flörke) Spreng.	Fruticose	14-019178
Arthoniaceae	*Cryptothecia lumulata* (Zahlbr.) Makh. & Patw	Crustose	14-019193
Graphidaceae	*Diorygma heiroglyphicum* (Pers.) Staiger & Kalb	Crustose	14-021017
	Diorygma renifrome (Fée) Kalb., Staiger & Elix	Crustose	14-021015
Physciaceae	*Dirinaria confluens* (Fr.) D.D.Awasthi	Foliose	14-019177
Parmeliaceae	*Everniastrum nepalense* (Taylor) Hale ex. Sipman	Foliose	14-019182
Haematommaceae	*Haematomma puniceum* (Sw.) A.Massal.	Crustose	14-019162
Physciaceae	*Hemithecium pyrrhochroa* (Mont. & Bosch.) V.Tewari & Upreti	Crustose	14-021026
	Heterodermia comosa (Eschw.) Follmann & Redon	Foliose	14-019183
	Heterodermia japonica (Sato) Swinsc. & Krog	Foliose	14-019179
	Heterodermia comosa (Eschw.) Follmann & Redon	Foliose	14-019183
	Heterodermia togashi (Kurok.) D.D. Awasthi	Foliose	14-019170

Parmeliaceae	*Hypotrachyna awasthii* Hale & Patw.	Foliose	14-019195
	Hypotrachyna adducta (Nyl.) Hale	Foliose	14-019160
	Hypotrachyna awasthii Hale & Patw.	Foliose	14-019159
Lecanoraceae	*Lecanora achroa* Nyl.	Crustose	14-021022
	Lecanora alba Lumbsch	Crustose	14-021009
	Lecanora chlarotera Nyl.	Crustose	14-021013
	Lecanora concilianda Vainio	Crustose	14-021011
Stereocaulaceae	*Lepraria lobificans* Nyl.	Leprose	14-021031
Ectolechiaceae	*Lopadium leucoxanthum* (Spreng.) Zahlbr.	Crustose	14-019184
Parmeliaceae	*Myelochroa perisidians* (Nyl.) Elix & Hale	Foliose	14-019158
	Myelochroa xantholepis (Mont. & Bosch.) Elix & Hale	Foliose	14-019192
Parmeliaceae	*Parmotrema tinctorum* (Nyl.) Hale	Foliose	14-019155
	Parmotrema reticulatum (Taylor) Choisy	Foliose	14-019196
	Parmotrema reticulatum (Taylor) Choisy	Foliose	14-019172
	Parmotrema stuppeum (Taylor) Hale	Foliose	14-021029
Pertusariaceae	*Pertusaria quassiae* Fee	Crustose	14-021021
Phlyctidaceae	*Phlyctis polyphora* Stirton	Crustose	14-019191
	Phyllopsora albicans Müll. Arg.	Squamulose	14-021007
	Phyllopsora buettneri (Mull. Arg.) Zahlbr.	Squamulose	14-019165
	Pyxine subcinerea Stirt.	Crustose	14-021096
	Ramboldia subnexa (Stirt.) Kantvilas & Elix	Crustose	14-021032
Ramalinaceae	*Ramalina conduplicans* Vain.	Fruticose	14-019166
Parmeliaceae	*Relicina sydneyensis* (Gyeln.) Hale	Foliose	14-021003
	Relicina sydneyensis (Gyeln.) Hale	Foliose	14-021003
Usneaceae	*Usnea himantodes* Stirton	Fruticose	14-031502
	Usnea himantodes Stirton	Fruticose	14-031511
	Usnea himantodes Stirton	Fruticose	14-031512
	Usnea himantodes Stirton	Fruticose	14-031513
	Usnea himantodes Stirton	Fruticose	14-031519
	Usnea longissima Ach.	Fruticose	13-019399
	Usnea orientalis Mot.	Fruticose	14-031492

	Usnea orientalis Motyka	Fruticose	14-021010
	Usnea orientalis Mot.	Fruticose	14-031505
	Usnea orientalis Mot.	Fruticose	14-031506
	Usnea orientalis Mot.	Fruticose	14-031507
	Usnea orientalis Mot.	Fruticose	14-031510
	Usnea orientalis Mot.	Fruticose	14-031515
	Usnea pangiana Stirton	Fruticose	14-031491
	Usnea pangiana Stirton	Fruticose	14-031496
	Usnea pangiana Stirton	Fruticose	14-031514
	Usnea pangiana Stirton	Fruticose	14-031518
	Usnea pangiana Stirton	Fruticose	14-031522
	Usnea pectinata Taylor	Fruticose	14-031494
	Usnea pectinata Taylor	Fruticose	14-031520
	Usnea Sp.	Fruticose	14-031523
	Usnea Sp.	Fruticose	14-031524
	Usnea Sp.	Fruticose	14-031525
	Usnea undulata Stirton	Fruticose	14-031493
	Usnea undulata Stirton	Fruticose	14-031504
	Usnea undulata Stirton	Fruticose	14-031509
	Usnea undulata Stirton	Fruticose	14-031516

Table-4.7: List of documented lichens specimens collected from Northern part of Murlen National Park, Mizoram

Family	Species	Growth form	LWG No
Cladoniaceae	*Cladonia coniocraea* (Flörke) Spreng.	Fruticose	14-019178
	Coccocarpia palmicola (Spreng.) Arvids. & D.J.Galloway	Foliose	14-019168
Coccocarpiaceae	*Coccocarpia palmicola* (Spreng.) Arvids. & D.J.Galloway	Foliose	14-019174
	Cryptothecia lumulata (Zahlbr.) Makh. & Patw	Crustose	14-019193
	*Cryptothecia verruculifera*J.Ram, G.P.Sinha, Kr.P.Singh,	Crustose	14-021004
Arthoniaceae	*Cryptothecia verruculifera*J.Ram, G.P.Sinha, Kr.P.Singh,	Crustose	14-021004
Physiaceae	*Dirinaria confluens* (Fr.) D.D.Awasthi	Foliose	14-019177
Parmeliaceae	*Everniastrum nepalense* (Taylor) Hale ex. Sipman	Foliose	14-019182
Haematommataceae	*Haematomma puniceum* (Sm. Ex. Ach.) Massl.	Crustose	14-019162
	Heterodermia comosa (Eschw.) Follmann & Redon	Foliose	14-019183
Physciaceae	*Heterodermia comosa* (Eschw.) Follmann & Redon	Foliose	14-019171
	Heterodermia diademata (Taylor) D.D.Awasthi	Foliose	14-019169
	Heterodermia japonica (Sato) Swinsc. & Krog	Foliose	14-019179
	Heterodermia togashi (Kurok.) D.D. Awasthi	Foliose	14-019170
	Hypotrachyna awasthii Hale & Patw.	Foliose	14-019159
	Hypotrachyna adducta (Nyl.) Hale	Foliose	14-019160
	Hypotrachyna adducta (Nyl.) Hale	Foliose	14-019163
	Hypotrachyna adducta (Nyl.) Hale	Foliose	14-019181
	Hypotrachyna rhabdiformis (Kurok.) Hale	Foliose	14-019164
Collemataceae	*Leptogium askotense* Awasthi	Foliose	14-019180
	Lopadium ionexcipulum Patwa. Makhija	Crustose	14-019152
Ectolechiaceae	*Lopadium leucoxanthum* (Spreng.) Zahlbr.	Crustose	14-019184

Parmeliaceae	*Myelochroa perisidians* (Nyl.) Elix & Hale	Foliose	14-019158
	Myelochroa xantholepis (Mont. & Bosch.) Elix & Hale	Foliose	14-019192
Parmotremaceae	*Parmotrema reticulatum* (Taylor) Choisy	Foliose	14-019154
	Parmotrema tinctorum (Nyl.) Hale	Foliose	14-019155
	Parmotrema reticulatum (Taylor) Choisy	Foliose	14-019172
	Parmotrema tinctorum (Nyl.) Hale	Foliose	14-019173
Pertusariaceae	*Pertusaria leucosoroides* Nyl.	Crustose	14-019153
Phlyctidaceae	*Phlyctis karnatakana* S.Joshi & Upreti	Crustose	14-019157
	Phlyctis polyphora Stirton	Crustose	14-019191
	Phyllopsora sp.	Crustose	14-019165
Ramalinaceae	*Ramalina conduplicans* Vain.	Fruticose	14-019166
	Relicina sydneyensis (Gyeln.) Hale	Foliose	14-019175
Lecanoraceae	*Ramboldia manipurensis* (K.P.Singh) Kalb. & al	Crustose	14-019156
	Ramboldia manipurensis (K.P.Singh) Kalb. & al	Crustose	14-019161
	Ramboldia sorediata Kalb.	Crustose	14-021030
Trapeliaceae	*Trapelia coarctata* (Sm.) M.Choisy	Crustose	12-031529
Usneaceae	*Usnea fragilis* Stirt.	Fruticose	14-021020
	Usnea stigmatoides G. Awasthi	Fruticose	14-021019

Table- 4.8: List of documented lichens specimens from Southern part of Murlen National Park, Mizoram

Family	Species	Growth form	LWG No
Arthoniaceae	*Arthothelium verruculosum* Patwa & Malch	Crustose	15-031614
Ramalinaceae	*Bacidia medialis* (Tuck. ex Nyl.) Zahlbr.	Crustose	12-019385
	Bacidia inundata (Fr.) Korb.	Crustose	15-031619
Cladoniaceae	*Cladonia fruticulosa* Kremp.	Fruticose	15-031623
Graphidaceae	*Dioryma junghuchnii* (Mont & Bosch.) Kalb, Straiger & Elix	Crustose	15-031626
	Dioryma hieroglyphicum (Pers.) Straiger &Kalb.	Crustose	15-031603
	Glyphis duriuscula Vain	Crustose	15-031610
	Graphis duplicata	Crustose	15-031604
Haematommataceae	*Haematomma puniceum*	Crustose	15-031611
Graphidaceae	*Hemithecium divaricoides (*Rasanen) V. Tiwari & Upreti	Crustose	15-031607
	Hemithecium pyrrhochroa (Mont. et vd. Bosch) V. Tiwari & Upreti	Crustose	15-031605
Physciaceae	*Heterodermia diametata* (Taylor) D.D. Awasthi	Foliose	15-031633
	Heterodermia dactyliza (Nyl.) Swinsc. & Krog	Foliose	12-019376
	Heterodermia japonica (Sato) Swinsc & Korg	Foliose	15-031622
	Heterodermia japonica (Sato) Swinsc & Korg	Foliose	15-031634
	Heterodermia podocarpa (Bél.) D.D.Awasthi	Foliose	12-019388
Parmeliaceae	*Hypotrachyna imbricatula* (Zahlbr.) Hale, Smithson	Foliose	12-019394
	Hypotrachyna sublaevigata (Nyl.) Hale	Foliose	12-019384
Lecanoraceae	*Lecanora helva* Stigzerb	Crustose	15-031628
Collemataceae	*Leptogium ulvaceum* (Pers.) Vain	Leprose	15-031613
Stereocualaceae	*Lepraria incana* (L.) Ach.	Leprose	12-019395
	Lepraria sp.	Leprose	15-031618

Porpidiaceae	*Mycobilimbia hunana* (Zahlbr.) D.D.Awasthi	Crustose	12-019387
Verrucariaceae	*Normandina pulchella* (Borrer) Nyl.	Crustose	15-031609
Parmeliaceae	*Parmotrema reticulatum* (Taylor) Choisy	Crustose	15-031608
	Parmotrema reticulatum (Taylor) Choisy	Crustose	15-031621
	Parmotrema tinctorum (Nyl). Hale	Crustose	15-031625
Pertusariaceae	*Pertusaria leucosoroides* Nyl.	Crustose	15-031606
Phlyctidaceae	*Phlyctis kalnatakana* S. Joshi & Upreti	Crustose	15-031601
Parmeliaceae	*Punctelia rudecta* (Ach) Korg.	Crustose	15-031630
Lecanoraceae	*Ramboldia russula* (Ach.) Kalb & al	Crustose	13-019380
Physciaceae	*Pyxine cocoes* (Sw.) Nyl.	Crustose	15-031624
	Pyxine cocoes (Sw.) Nyl.	Crustose	15-031627
	Relicina sublanea (Kurok) Hale	Crustose	15-031616
Usneaceae	*Usnea aciculifera* Vain.	Fruticose	13-019390
	Usnea baileyi	Fruticose	15-031629
	Usnea bismolliuscula Zablbr.	Fruticose	15-031620
	Usnea bismolliuscula Zablbr.	Fruticose	15-031631
	Usnea galbinifera Asahina	Fruticose	13-019400
	Usnea pangiana	Fruticose	15-031632

4.3 *In vitro* antimicrobial investigations

The observations recorded in table 4.9 to 4.11 as well as fig 4.7 to 4.18 reveals that the percentage of spore germination inhibition (SGI %) with **aqueous extract** of *Parmotrema reticulatum* against *Aspergillus flavus,* was ranges from 9.33 – 100.00, against *Colletotrichum capsici* 7.80 – 100.00, and against *Fusarium oxysporum* ranges from 9.20 – 100.00 at the concentration of 0.1 - 50µl/ml, respectively; while with **acetone extract**- it was ranges from 17.65 – 100. 00 against *A. flavus*, 12.03-100.00 aginst *C. capsici* and 16.25 -100.00 against *F. oxysporum* but in case of **methanol extract,** the SGI (%) was recorded as 7.50-100.00 against *A. flavus*, 15.16-100.00 against *C. capsici* and 15.75-100.00 against *F. oxysporum* at the same concentrations respectively.

Similarly, as per the observations recorded in table 4.12 to 4.14 as well as fig 4.19 to 4.30 reveals that the percentage of spore germination inhibition (SGI %) with **aqueous extract** of *Everniastrum cirrhatum* against *Aspergillus flavus,* was ranges from 9.53 – 100.00, against *Colletotrichum capsici* 8.80 – 100.00, and against *Fusarium oxysporum* ranges from 11.20 – 100.00 at the concentration of 0.1 - 50µl/ml, respectively; while with **acetone extract**- it was ranges from 7.65 – 100. 00 against *A. flavus*, 13.03-100.00 aginst *C. capsici* and 19.25 -100.00 against *F. oxysporum* but in case of **methanol extract,** the SGI (%) was recorded as 11.50-100.00 against *A. flavus*, 13.16-100.00 aginst *C. capsici* and 16.75-100.00 against *F. oxysporum* at the same concentrations respectively.

However, as per the observations recorded in table 4.15 to 4.17 as well as fig 4.31 to 4.42 reveals that the percentage of spore germination inhibition (SGI %) with **aqueous extract** of *Usnea longissima* against *Aspergillus flavus,* was ranges from 7.34 – 100.00, against *Colletotrichum capsici* 5.80 – 100.00, and against *Fusarium oxysporum* ranges from 10.20 – 100.00 at the concentration of 0.1 - 50µl/ml, respectively; while with **acetone extract**- it was ranges from 4.00 – 100. 00 against *A. flavus*, 6.00 -100.00 aginst *C. capsici* and 6.40 -100.00 against *F. oxysporum* but in case of **methanol extract,** the SGI (%) was recorded as 12.50-100.00 against *A. flavus*, 12.10-100.00 aginst *C. capsici* and 13.75-100.00 against *F. oxysporum* at the same concentrations respectively.

Range of spectrum of *Eversniastrum cirrhatum* with aqueous and acetone against *Aspergillus flavus* and *Colletotrichum capsici* showed static at the concentration of 50µl/ml, while with methanol extract in the same test fungi showed cidal at the same concentration. The range of spectrum of *Everniastrum cirrhatum* in aqueous extract against *Aspergillus flavus* showed static and acetone and

methanol extract against the same test fungi at the respective concentration showed cidal activity. The range of spectrum of *Parmotrema reticulatum* in aqueous and acetone extract against *Aspergillus flavus* showed static and methanol extract against the same test fungi, at the respective concentration, showed cidal activity.

The range of spectrum of all the extracts (aqueous, acetone and methanol extracts) of the tested lichens (*Parmotrema reticulatum, Evernistrum reticulatum* and *Usnea longissima*), at 50.0 µl/ml contains a broad range of spectrum (table 4.18 & 4.19).

The nature of toxicity of the **aqueous extract** (50.0 µl/ml) of *Parmotrema reticulatum* against the test pathogen *Alternaria alternate* and *Salmonella typhimurium* was static (a concentration which checks the growth but could not kill the organism), however, it was cidal (lethal) against *Trichophyton mentagrophytes* and *Pythium aphanidermatum*. The **acetone extract** (50.0µl/ml) of *Parmotrema reticulatum* was cidal against *Alternaria alternata, Trichophyton mentagrophytes, Salmonella typhimurium* and *Pythium aphanidermatum;* however, the **methonol extract** (50.0µl/ml) was static against *Alternaria alternata* and *Salmonella typhimurium* but cidal against *Trichophyton mentagrophytes* and *Pythium aphanidermatum* (Table 4.18).

Further, in case of *Evernistrum reticulatum*; the **aqueous extract** (50.0 µl/ml) against the test pathogen *Salmonella typhimurium* was static but cidal against *Alternaria alternata, Trichophyton mentagrophytes* and *Pythium aphanidermatum*. The **acetone extract** (50.0µl/ml) of *Evernistrum reticulatum* was cidal against *Alternaria alternata, Trichophyton mentagrophytes, Salmonella typhimurium* and *Pythium aphanidermatum;* while, the **methonol extract** (50.0µl/ml) was static against *Alternaria alternate* and *Salmonella typhimurium* but cidal against *Trichophyton mentagrophytes* and *Pythium aphanidermatum* (table 4.18). However, in case of *Usnea longissima*; the **aqueous extract** (50.0µl/ml) against the test pathogen *Alternaria alternate* and *Salmonella typhimurium* was static but cidal against *Trichophyton mentagrophytes,* and *Pythium aphanidermatum*. The **acetone extract** (50.0µl/ml) of *Usnea longissima* was static against *Salmonella typhimurium* but cidal against *Alternaria alternata, Trichophyton mentagrophytes* and *Pythium aphanidermatum;* while, the **methonol extract** (50.0µl/ml) was static against *Salmonella typhimurium* but cidal against *Alternaria alternata, Trichophyton mentagrophytes* and *Pythium aphanidermatum* (table 4.19).

The comparative analysis of the lichen extracts of *Parmotrema reticulatum, Evernistrum reticulatum* and *Usnea longissima*, with some synthetic fungicides viz., Mancozeb and Thiram were also investigated and recorded in table 4.20.

Table-4.9: Antifungal activities of aqueous extract of *Parmotrema reticulatum* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
Control	4.00	6.00	5.40
00.10	9.33	7.80	9.20
01.00	16.93	20.00	25.00
05.00	29.60	32.05	35.05
10.00	41.66	53.45	45.88
20.00	50.66	74.75	72.30
50.00	100.00[s]	100.00[c]	100.00[c]

[s] indicates static, [c] indicates cidal in nature; Conc. : Concentration

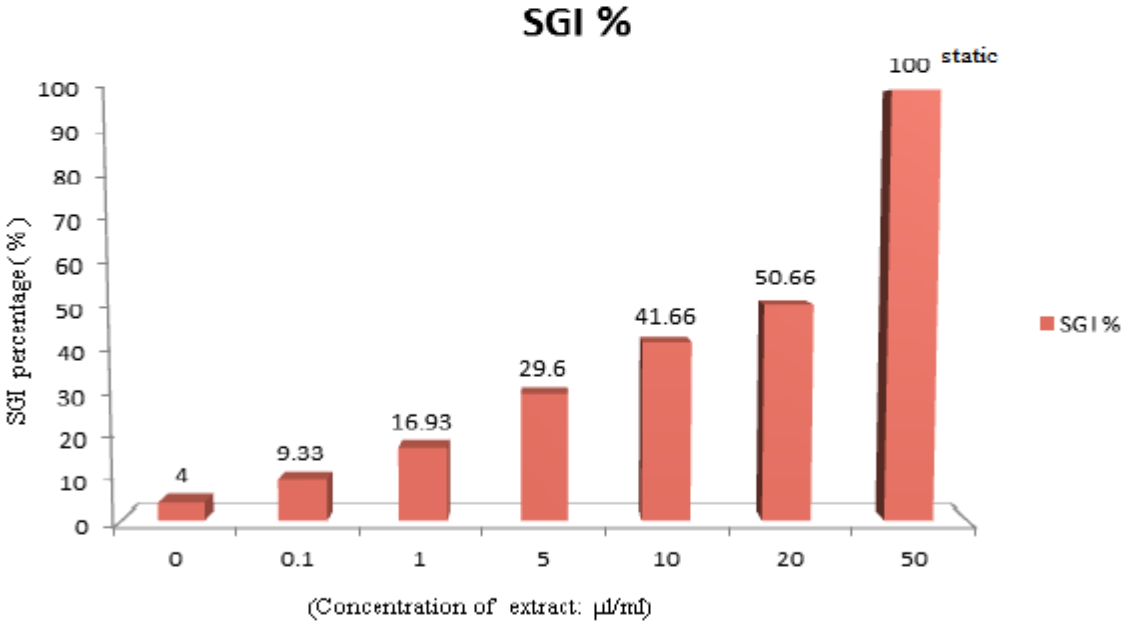

Fig- 4.7: Antifungal activities of aqueous extract of *P. reticulatum* against *Aspergillus flavus*

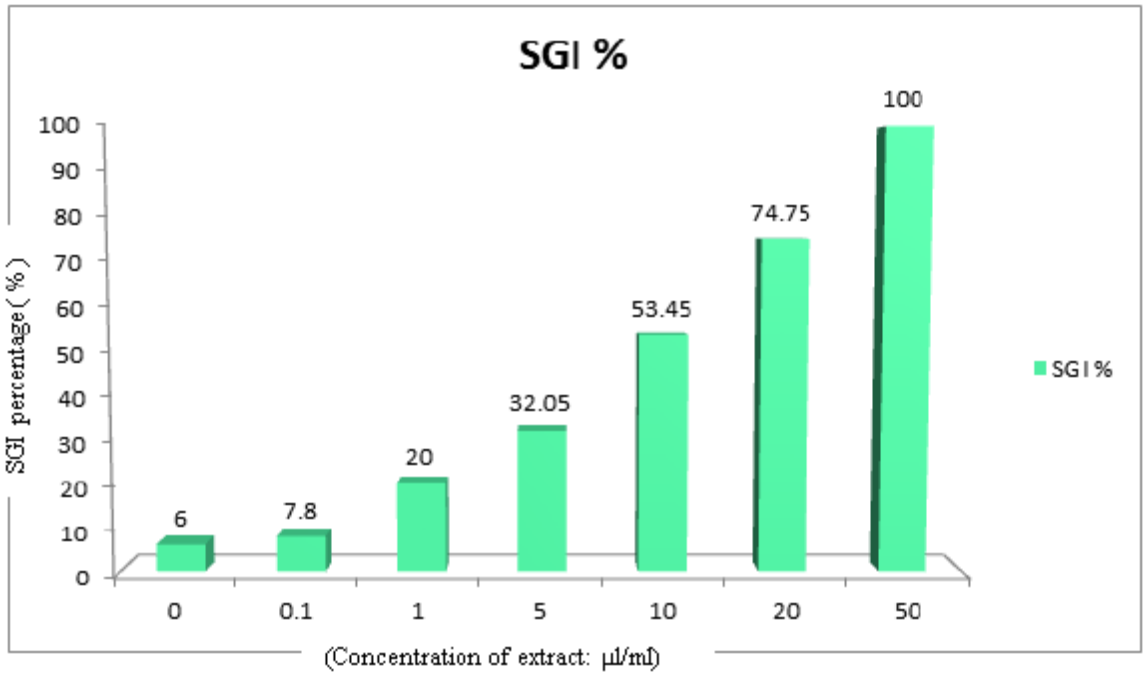

Fig- 4.8: Antifungal activities of aqueous extract of *P. reticulatum* against *C. capsici*

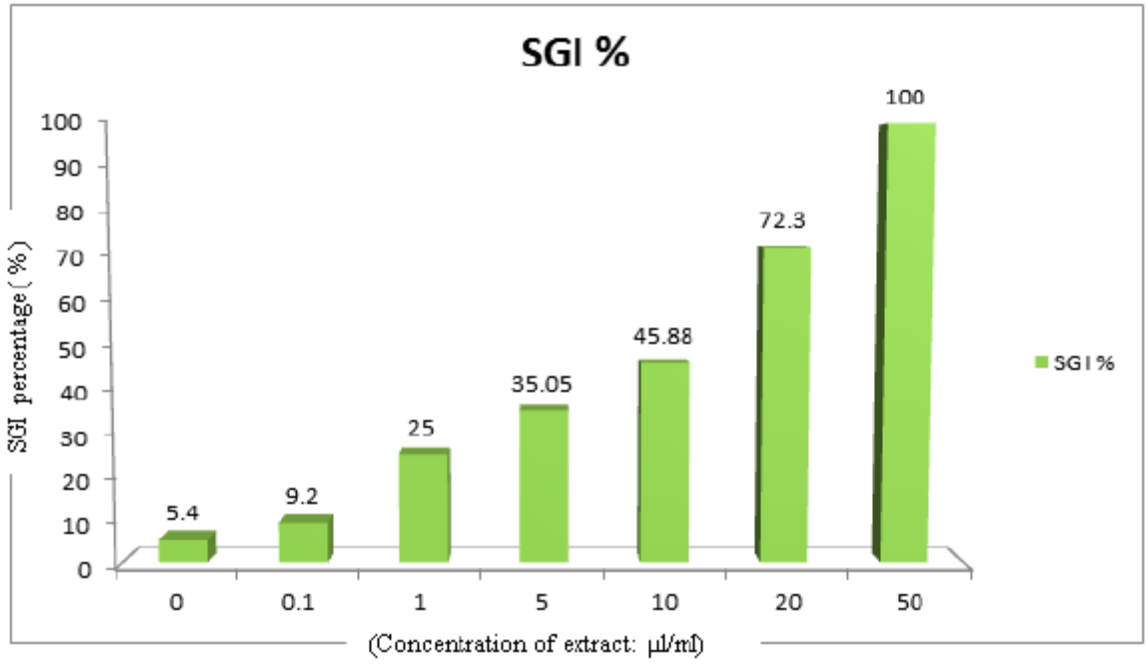

Fig- 4.9: Antifungal activities of aqueous extract of *P. reticulatum* against *F. oxysporum*

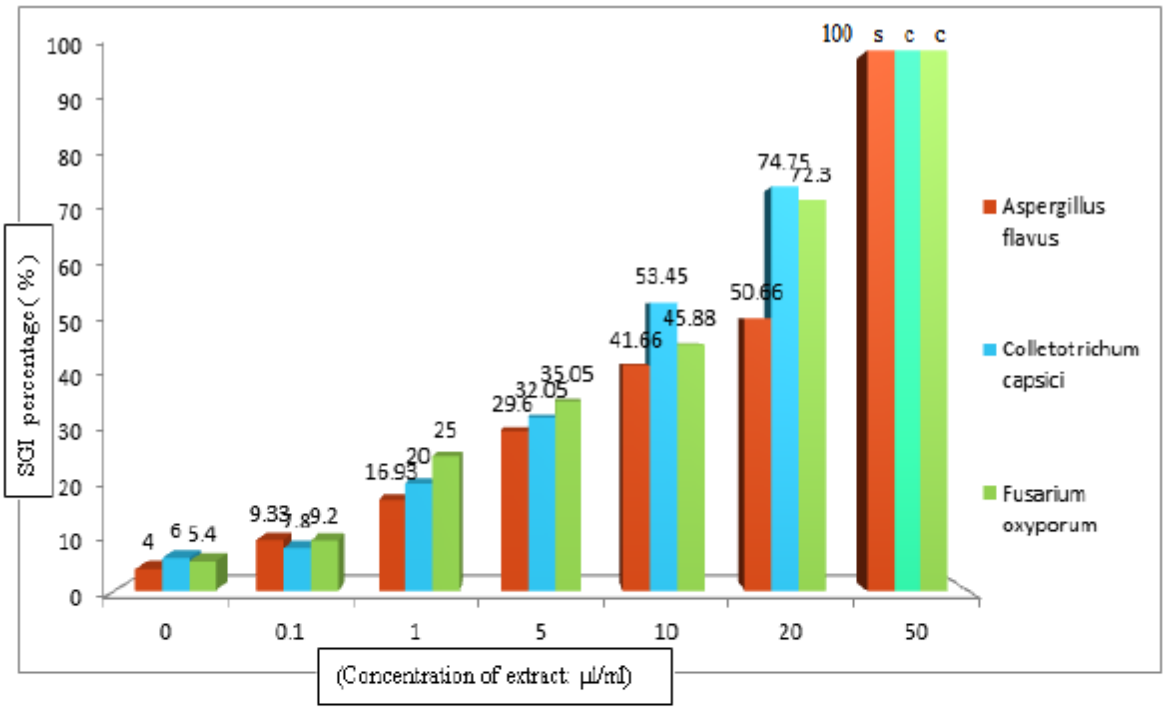

Fig- 4.10: Comparative data of SGI % of aqueous extract of *P. reticulatum* against test fungi

Table- 4.10: Antifungal activities of acetone extract of *P. reticulatum* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	8.00	9.00	7.40
00.10	17.65	12.03	16.25
01.00	28.09	24.05	28.44
05.00	56.15	43.11	54.40
10.00	61.05	55.02	63.08
20.00	100.00^{s}	87.00	100.00^{c}
50.00	100.00^{c}	100.00^{c}	100.00^{c}

^{s} indicates static, ^{c} indicates cidal in nature; Conc. : Concentration

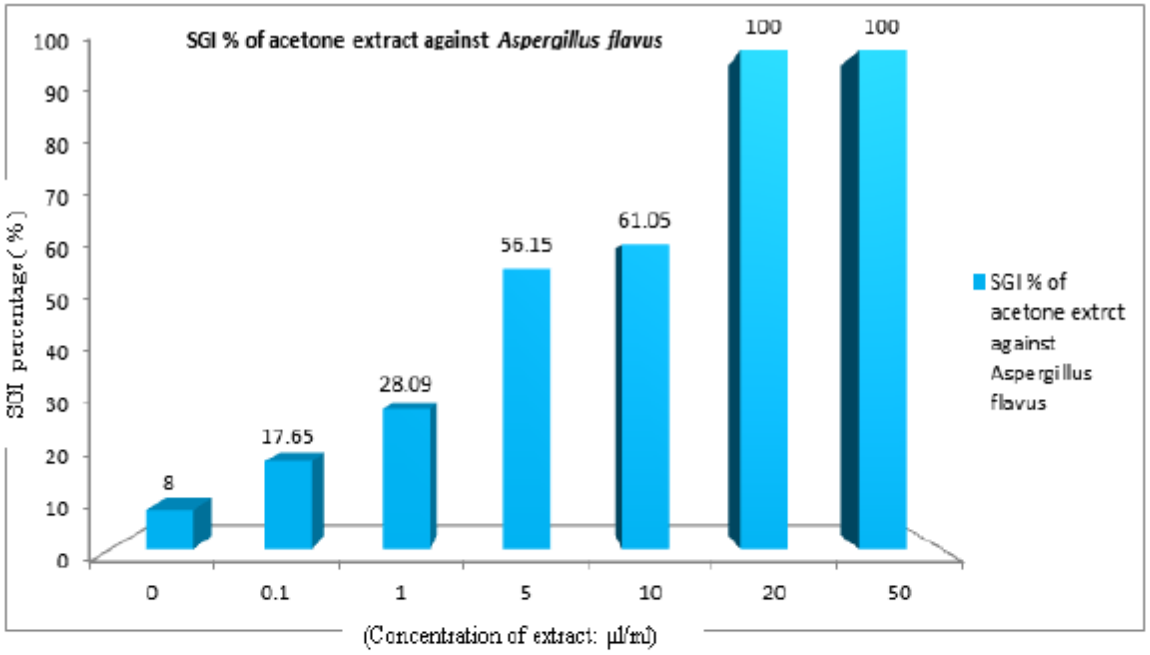

Fig- 4.11: Antifungal activities of acetone extract of *P. reticulatum* against *Aspergillus flvus*

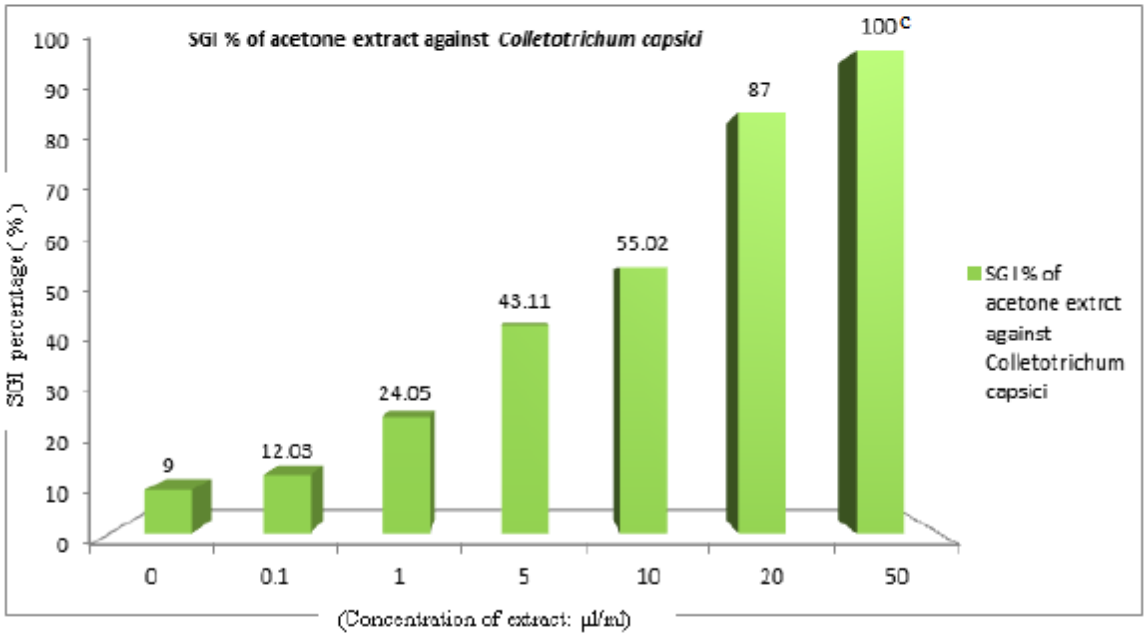

Fig- 4.12: Antifungal activities of acetone extract of *P. reticulatum* against *Colletotrichum capsici*

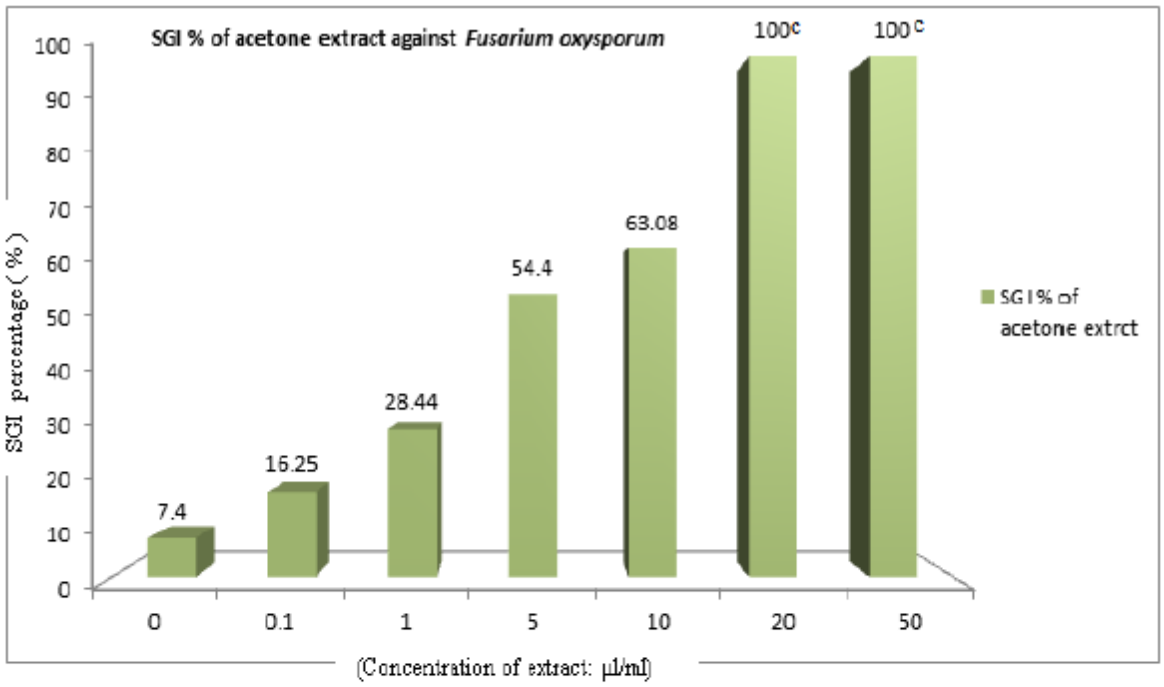

Fig- 4.13: Antifungal activities of acetone extract of *P. reticulatum* against *F. oxysporum*

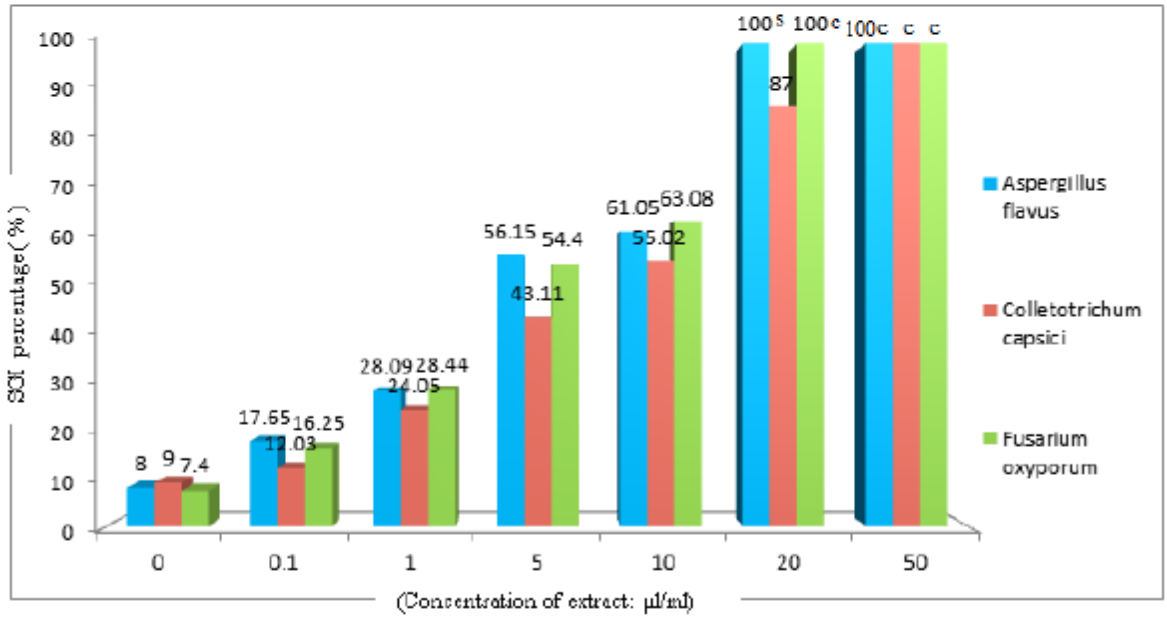

Fig- 4.14: Comparative data of SGI % of acetone extract of *P. reticulatum* against the test fungi

Table-4.11: Antifungal activities of methanol extract of *P. reticulatum* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	3.40	8.05	11.40
00.10	7.50	15.16	15.75
01.00	24.00	21.77	28.43
05.00	43.47	43.32	43.50
10.00	59.08	78.90	67.32
20.00	75.09	85.00	100.00[c]
50.00	100.00[c]	100.00[c]	100.00[c]

[s] indicates static, [c] indicates cidal in nature; Conc. : Concentration

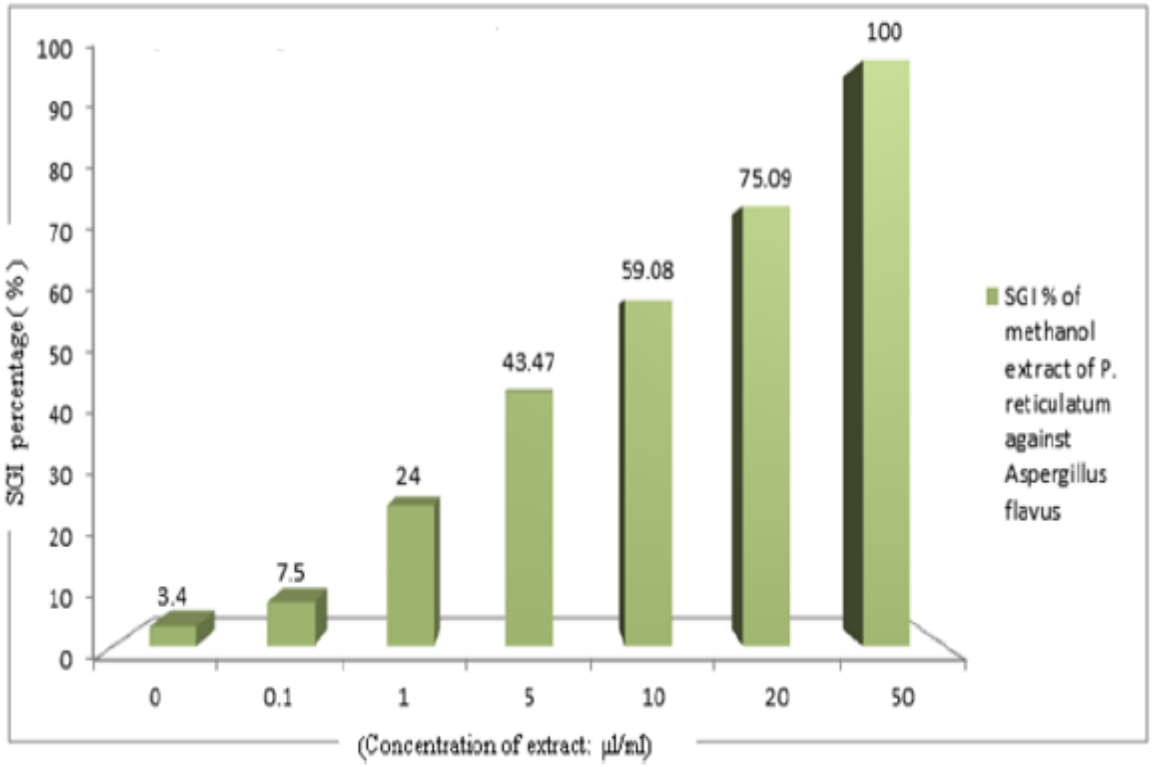

Fig-4.15: Antifungal activities of methanol extract of *P. reticulatum* against *Aspergillus flavus*

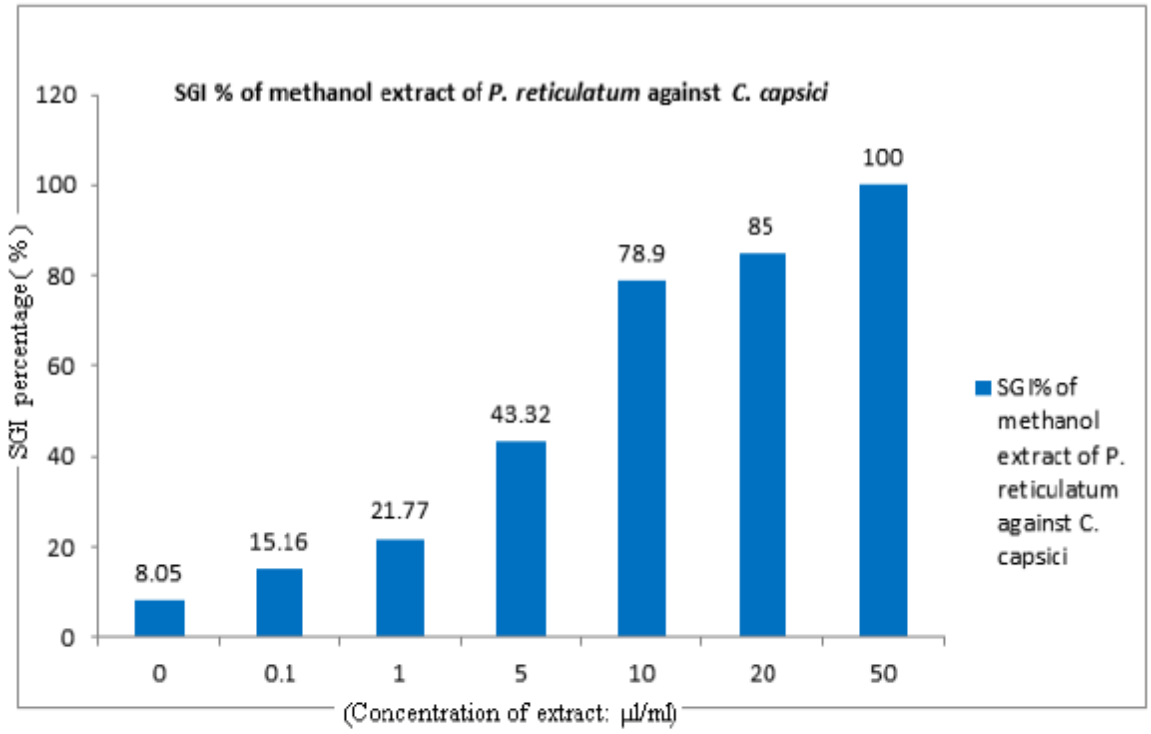

Fig-4.16: Antifungal activities of methanol extract of *P. reticulatum* against *Colletotrichum capsici*

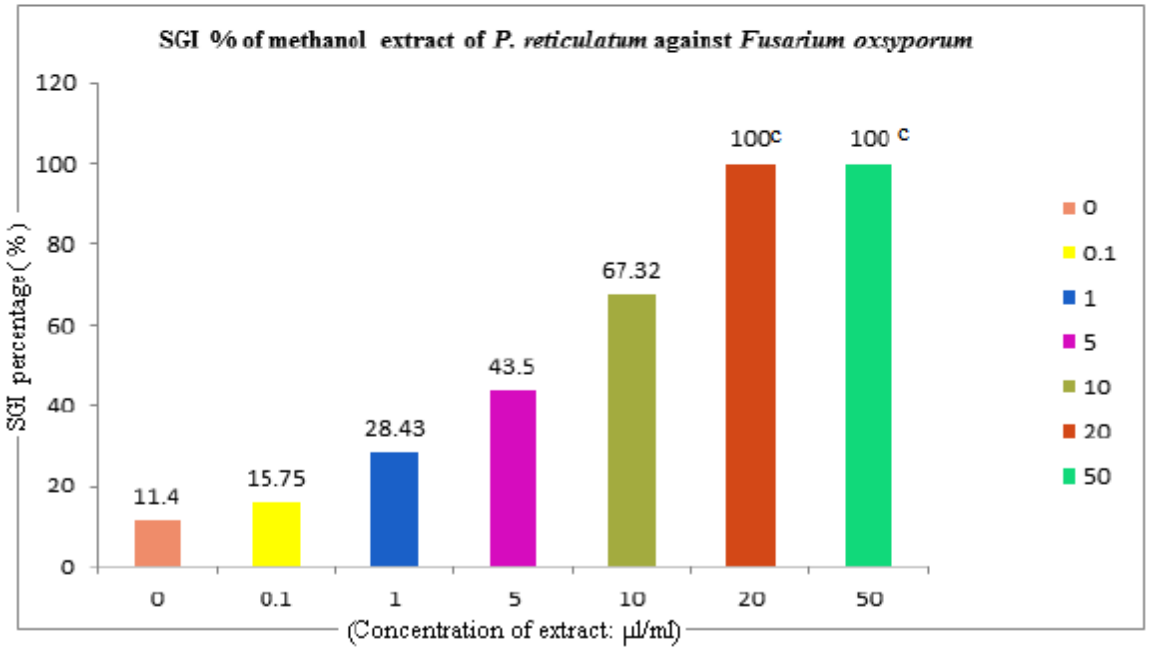

Fig- 4.17: Antifungal activities of methanol extract of *P. reticulatum* against *Fusarium oxysporum*

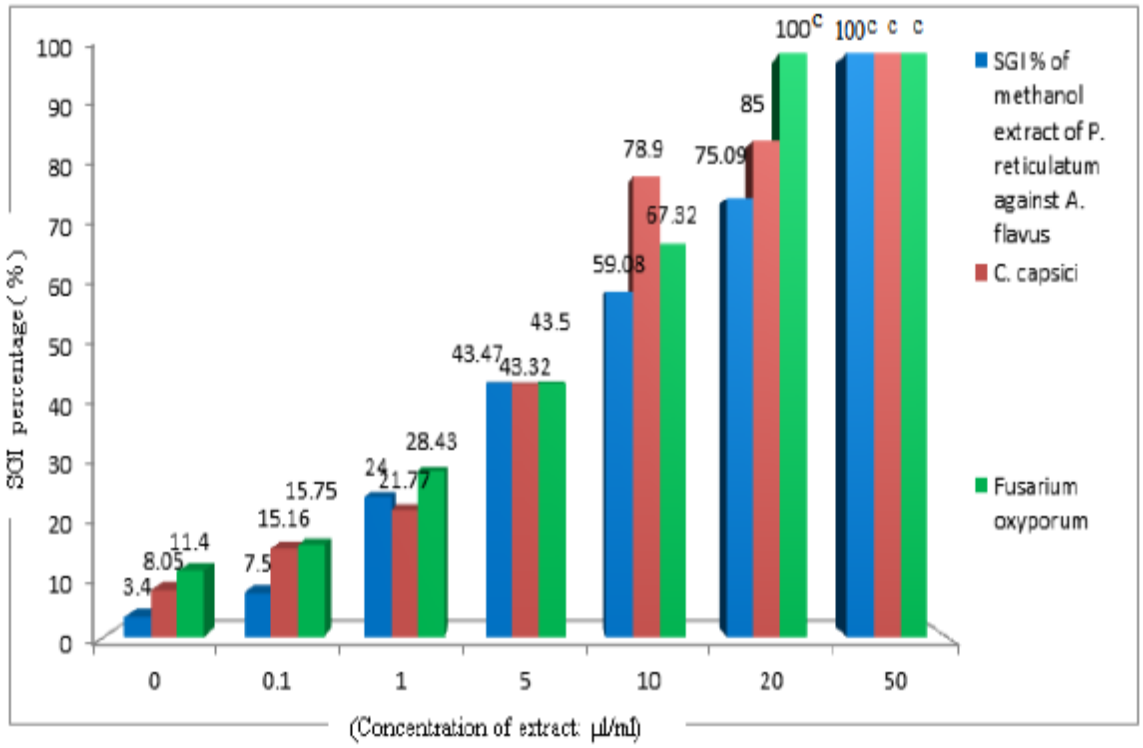

Fig- 4.18 : Comparative data of SGI % of methanol extract of *P. reticulatum* against the test fungi

Table-4.12: Antifungal activities of aqueous extract of *Everniastrum cirrhatum* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	3.00	6.00	5.40
00.10	9.53	8.80	11.20
01.00	15.93	21.00	25.09
05.00	24.60	30.05	34.05
10.00	51.66	63.45	46.84
20.00	76.66	82.75	85.20
50.00	100.00[s]	100.00[c]	100.00[c]

[s] indicates static, [c] indicates cidal in nature; Conc. : Concentration

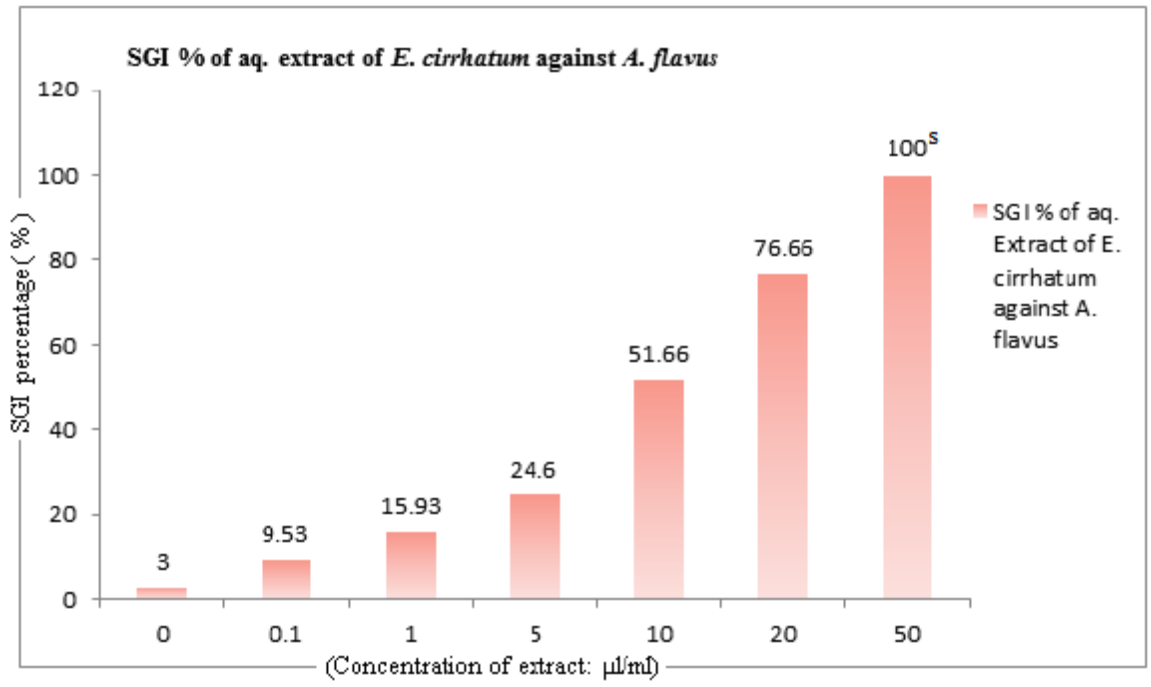

Fig- 4.19: Antifungal activities of aqueous extract of *E. cirrhatum* against the test fungi

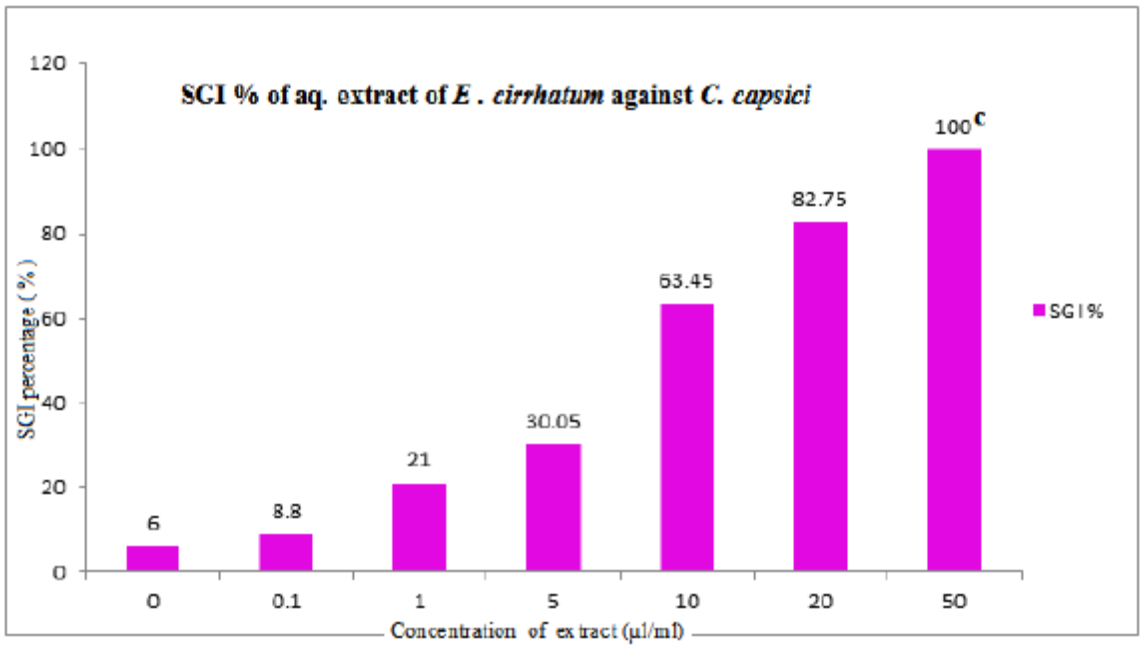

Fig- 4.20: Antifungal activities of aqueous extract of *E. cirrhatum* against the test fungi

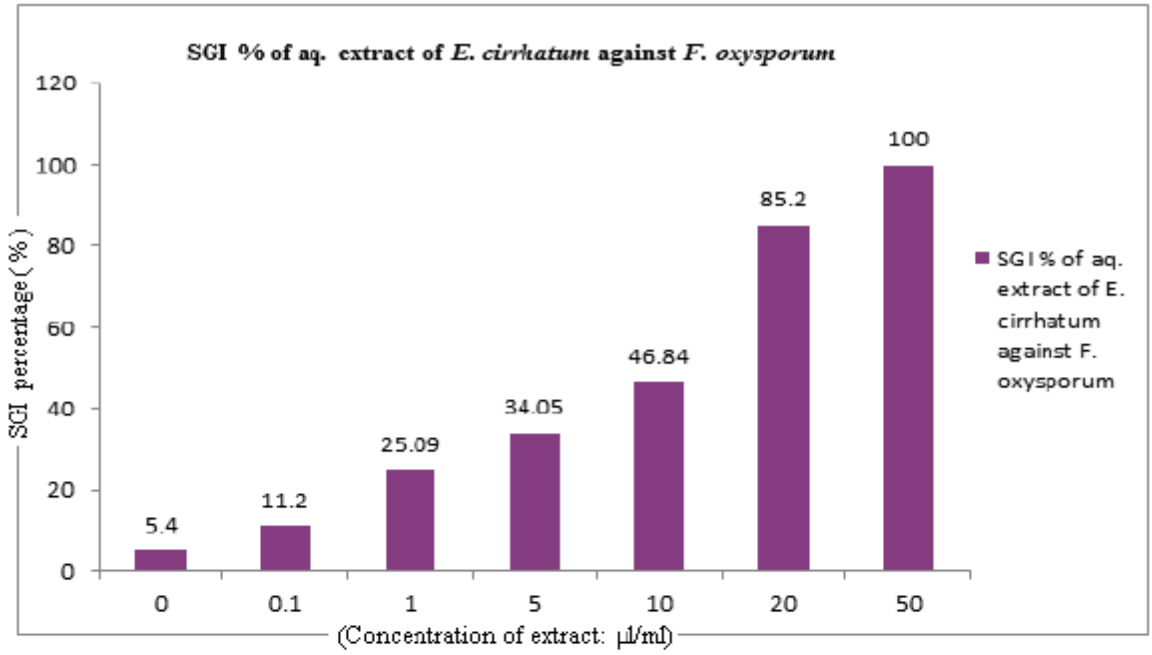

Fig-4.21: Antifungal activities of aqueous extract of *E. cirrhatum* against the test fungi

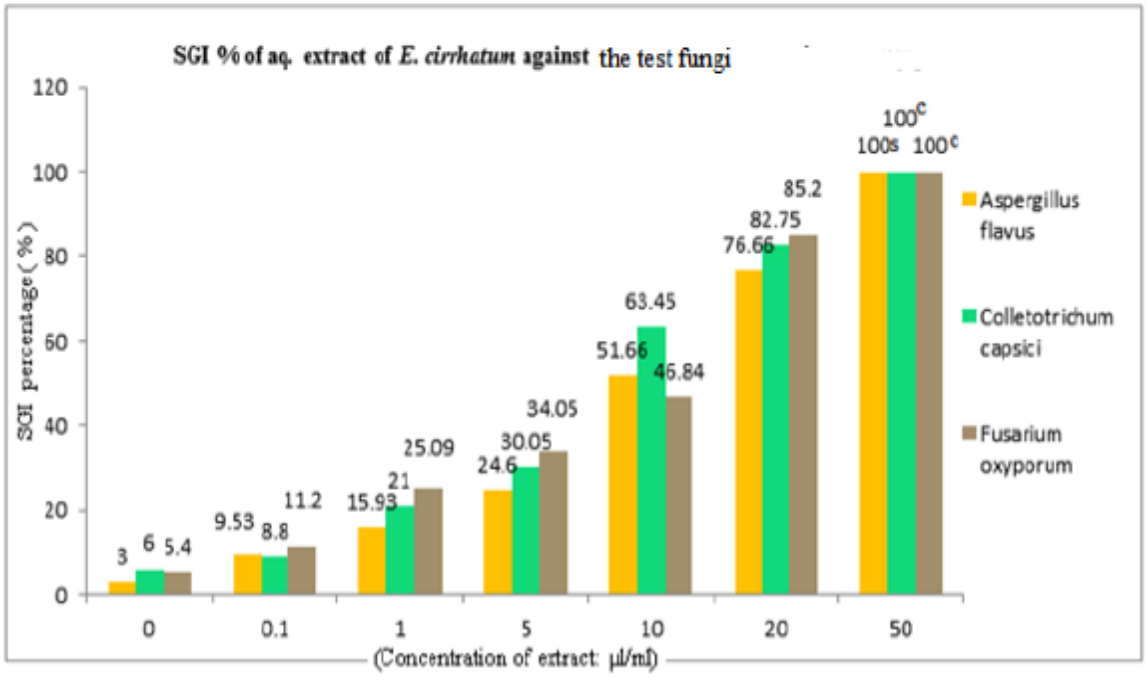

Fig- 4.22: Comparative data of SGI % of aqueous extract of *E. cirrhatum* against the test fungi

Table-4.13: Antifungal activities of acetone extract of *Everniastrum cirrhatum* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	4.00	6.00	3.40
00.10	7.65	13.03	19.25
01.00	29.05	25.05	38.04
05.00	57.10	46.10	53.40
10.00	68.05	52.08	68.43
20.00	100.00^{s}	100.00^{c}	100.00^{s}
50.00	100.00^{c}	100.00^{c}	100.00^{c}

^{s} indicates static, ^{c} indicates cidal in nature; Conc. : Concentration

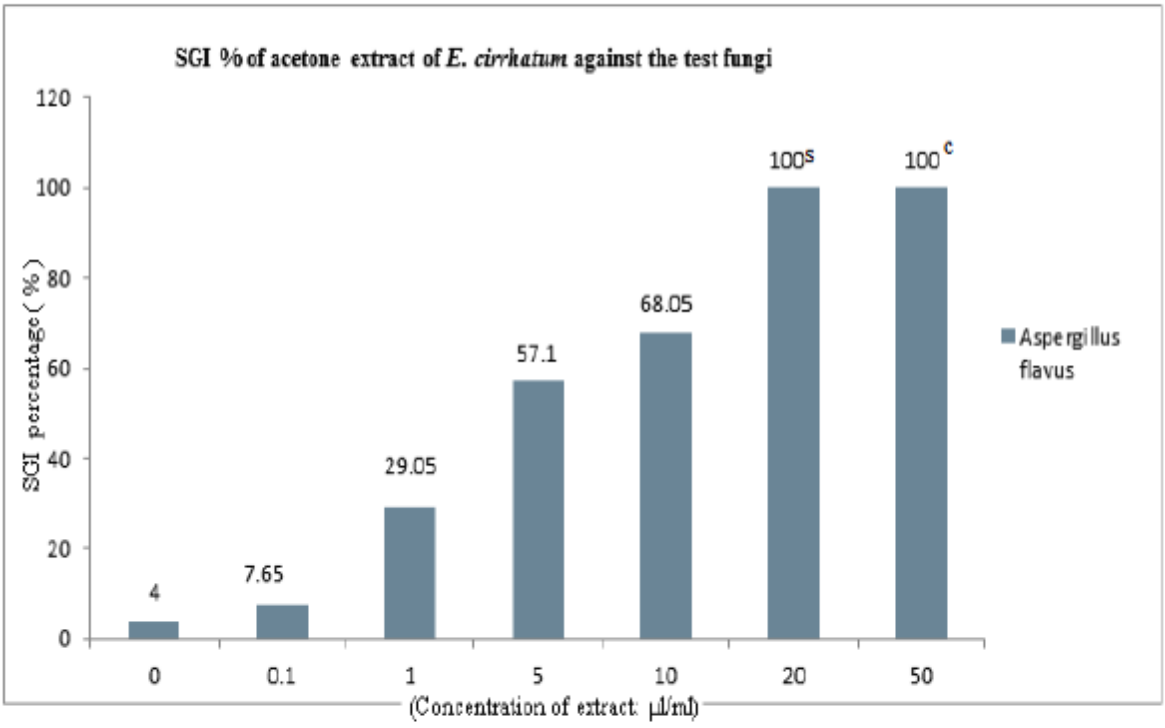

Fig- 4.23: Antifungal activities of acetone extract of *Everniastrum cirrhatum* against the test fungi

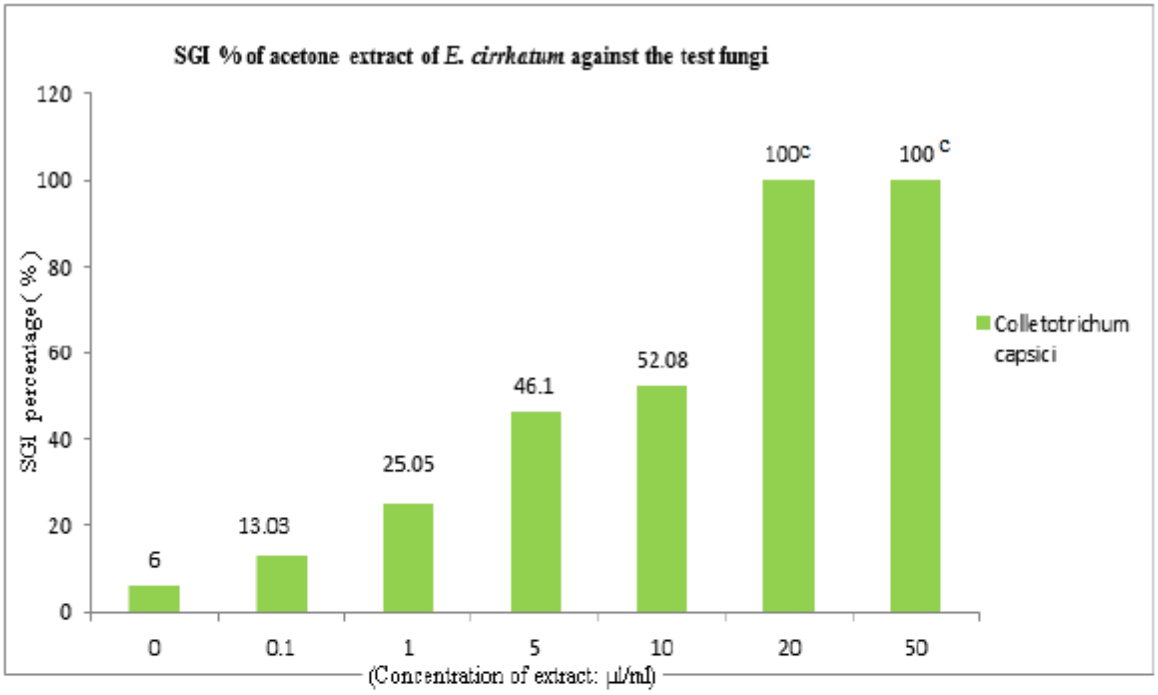

Fig- 4.24: Antifungal activities of acetone extract of *E. cirrhatum* against the test fungi

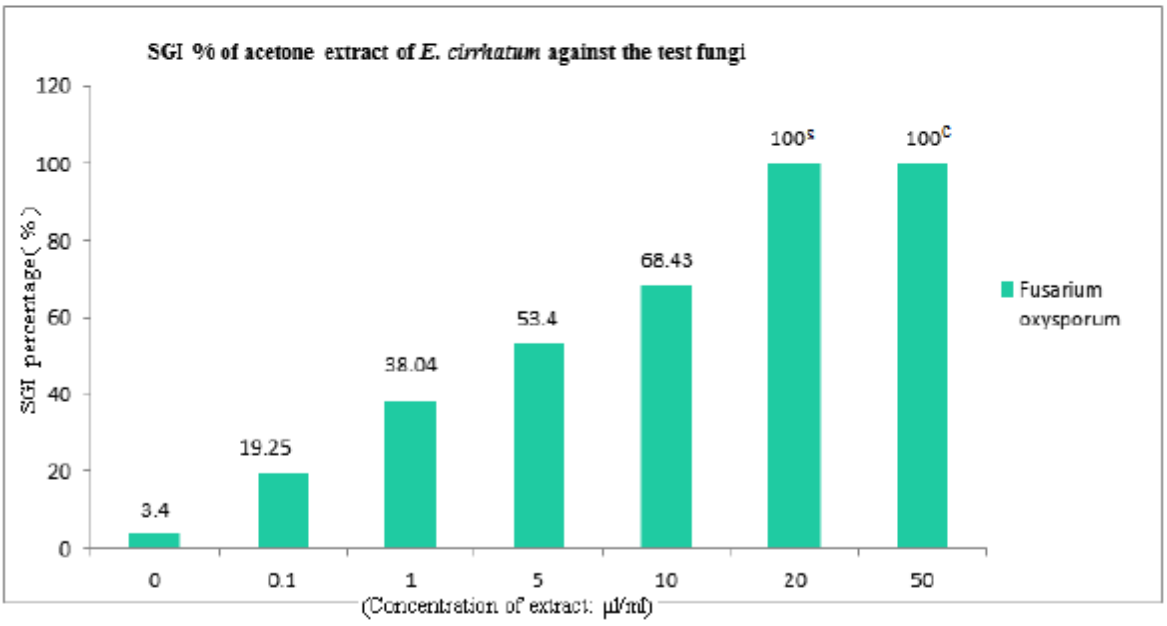

Fig- 4.25: Antifungal activities of acetone extract of *E. cirrhatum* against the test fungi

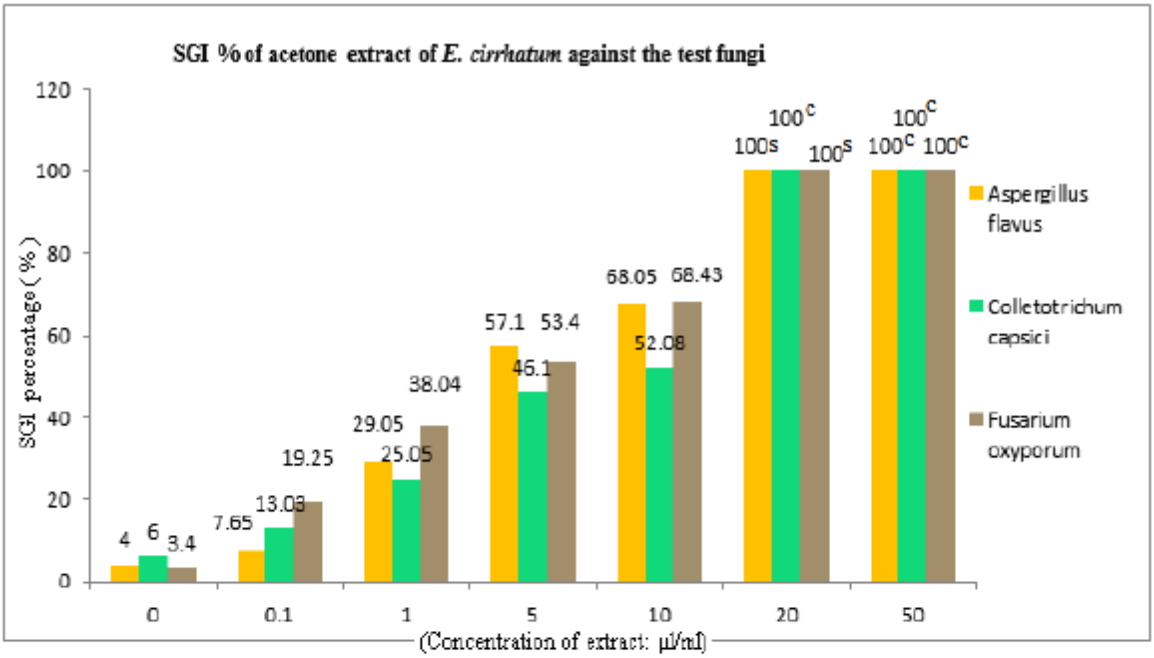

Fig- 4.26: Antifungal activities of acetone extract of E. cirrhatum against the three test fungi

Table-4.14: Antifungal activities of methanol extract of *E. cirrhatum* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	4.00	6.00	5.40
00.10	11.50	13.16	16.75
01.00	26.00	21.70	34
05.00	46.47	45.30	47.50
10.00	59.58	61.00	59.30
20.00	81.34	77.80	80.60
50.00	100.00^{s}	100.00^{c}	100.00^{s}

^{s} indicates static, ^{c} indicates cidal in nature; Conc. : Concentration

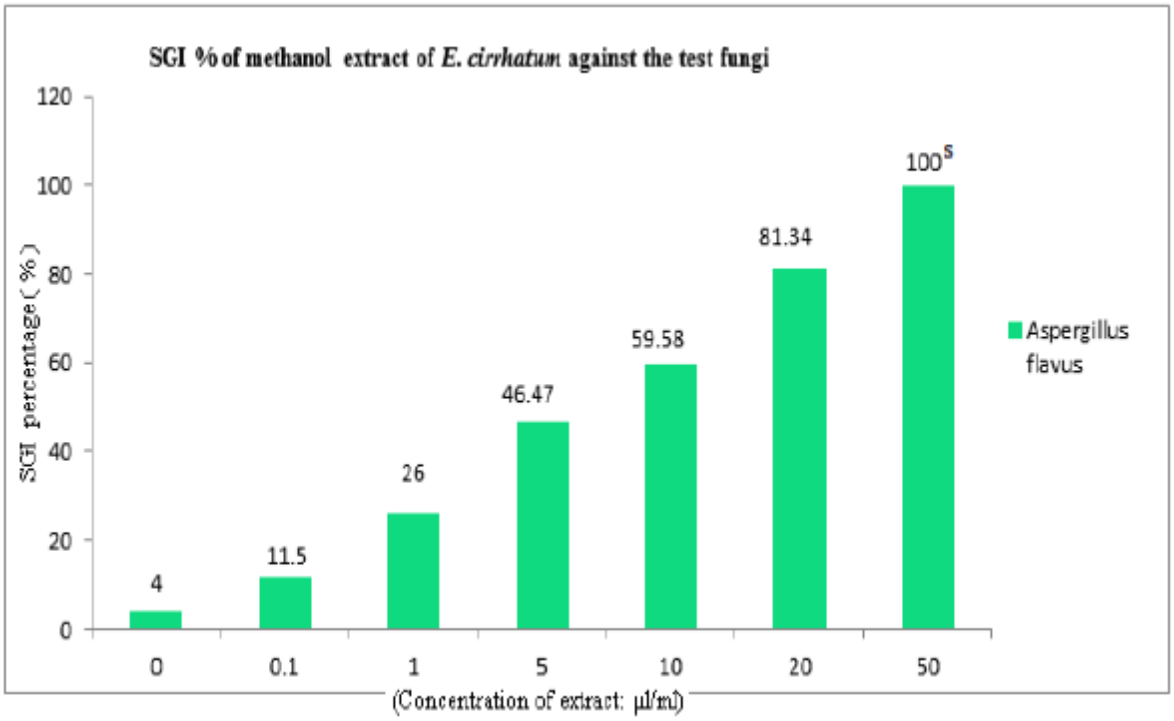

Fig- 4.27: Antifungal activities of methanol extract of Everniastrum cirrhatum against the test fungi

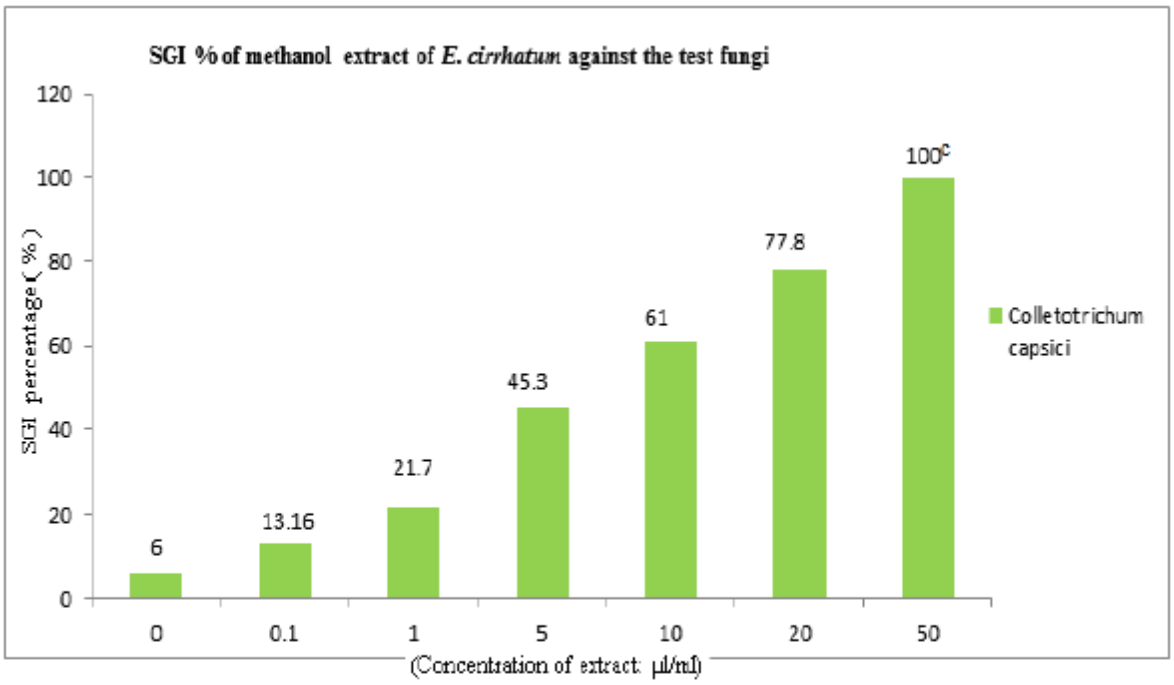

Fig- 4.28: Antifungal activities of methanol extract of E. cirrhatum against the test fungi

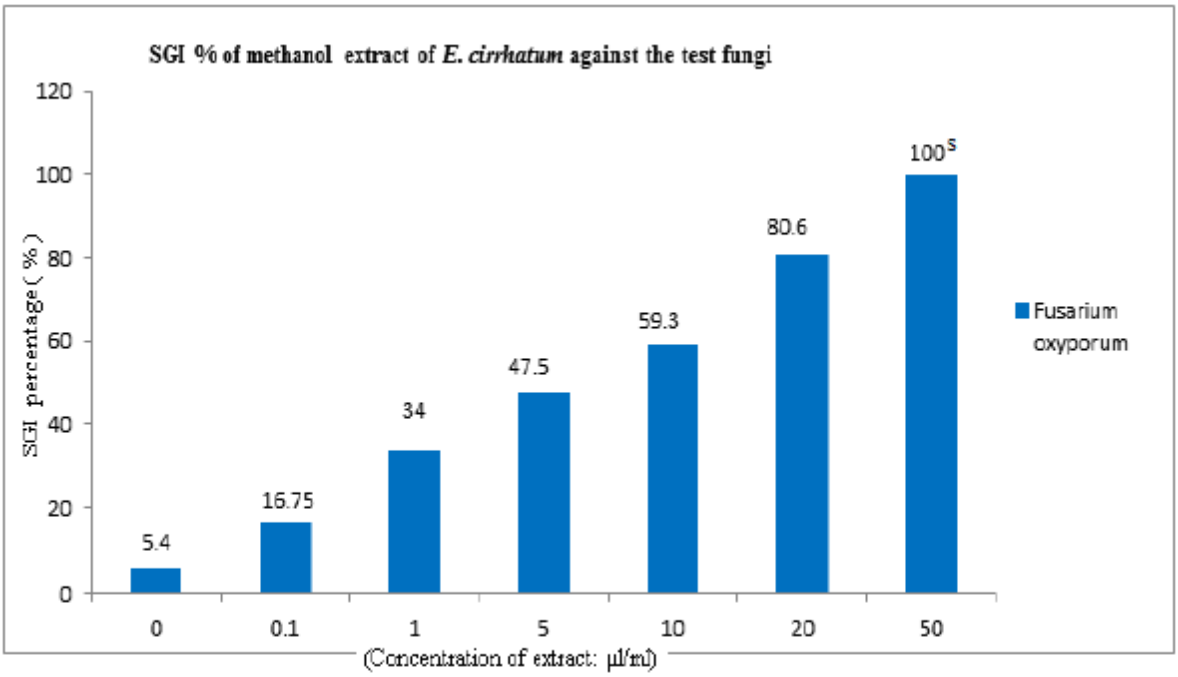

Fig- 4.29: Antifungal activities of methanol extract of Everniastrum cirrhatum against the test fungi

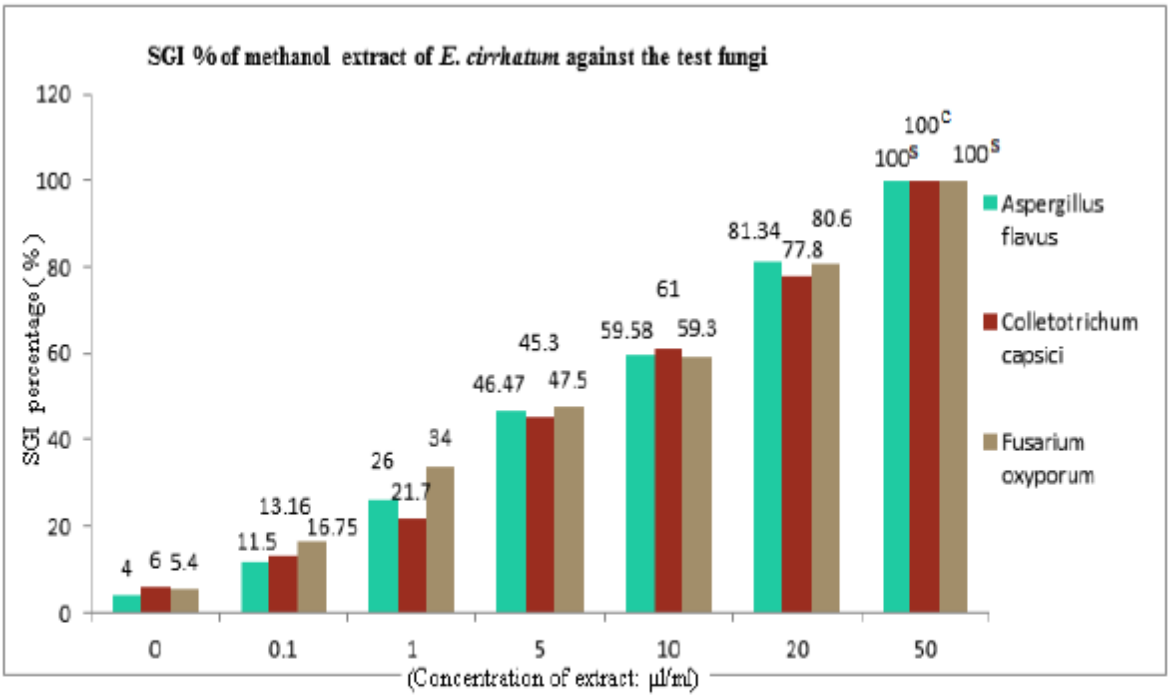

Fig-4.30: Comparative data of SGI % of methanol extract of E. cirrhatum against the test fungi

Table-4.15: Antifungal activities of aqueous extract of *Usnea longissima* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	4.00	5.00	5.40
00.10	7.34	5.80	10.20
01.00	18.73	21.06	24.00
05.00	28.90	30.06	36.15
10.00	44.60	52.40	56.00
20.00	75.60	83.05	72.30
50.00	100.00^{s}	100.00^{c}	100.00^{c}

^{s} indicates static, ^{c} indicates cidal in nature; Conc. : Concentration

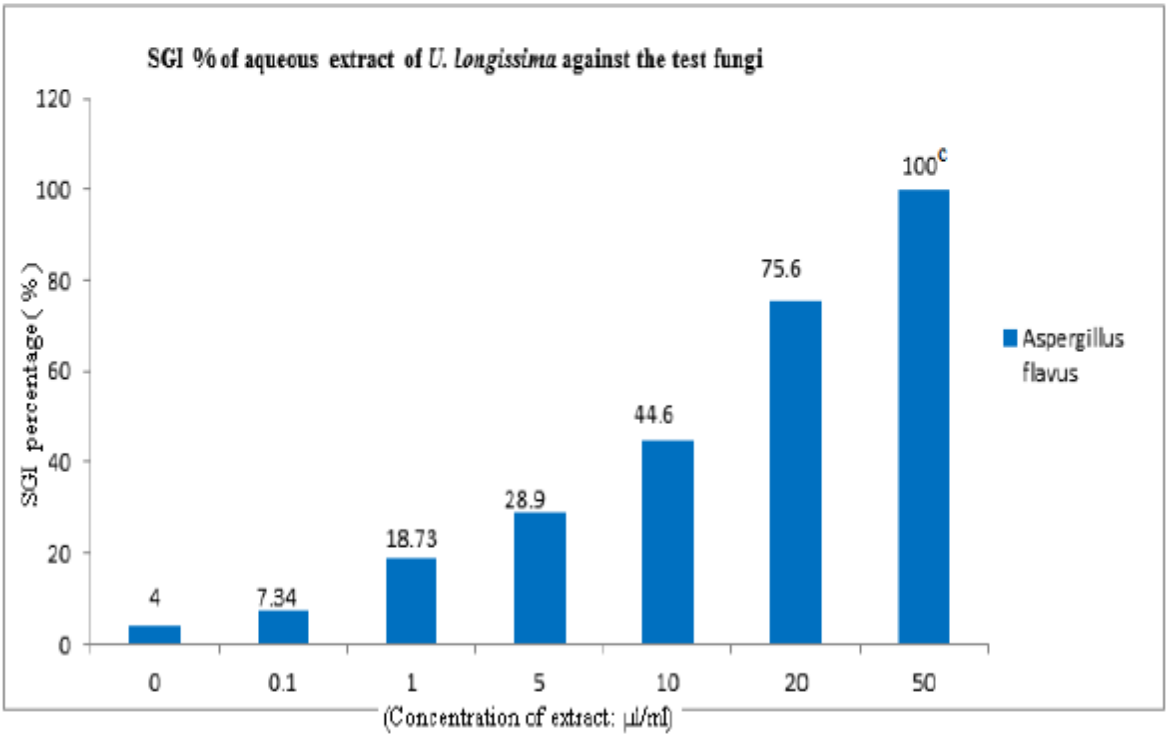

Fig- 4.31: Antifungal activities of aqueous extract of *Usnea longissima* against the test fungi

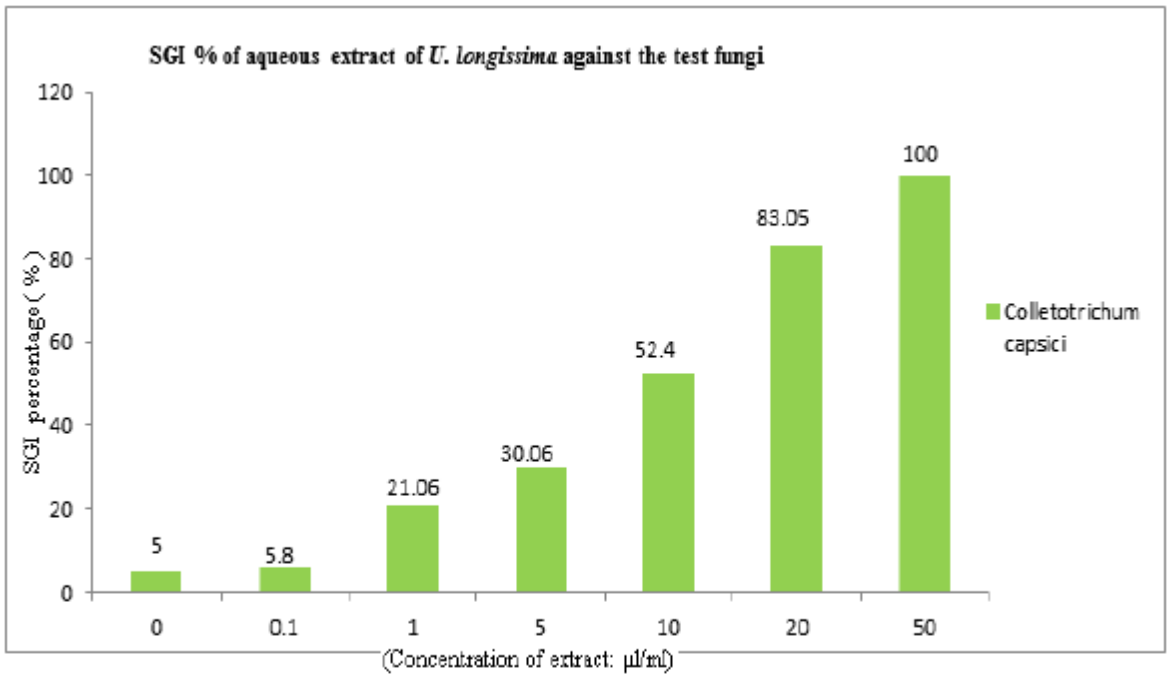

Fig- 4.32: Antifungal activities of aqueous extract of *U. longissima* against the test fungi

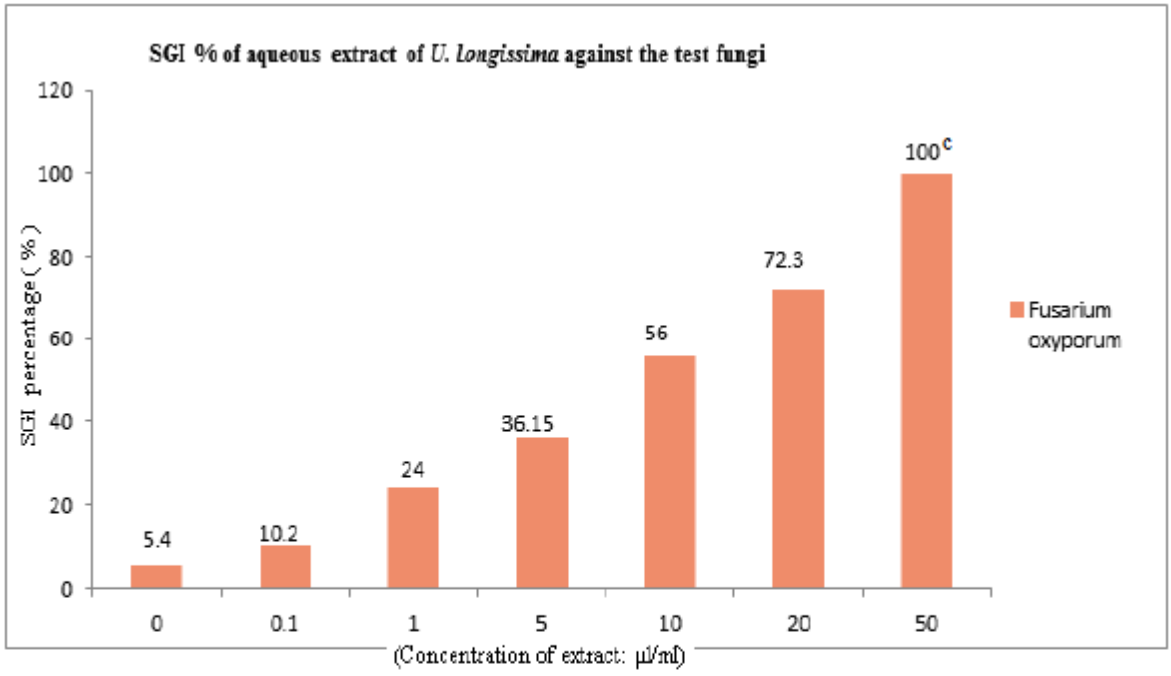

Fig- 4.33: Antifungal activities of aqueous extract of *U. longissima* against the test fungi

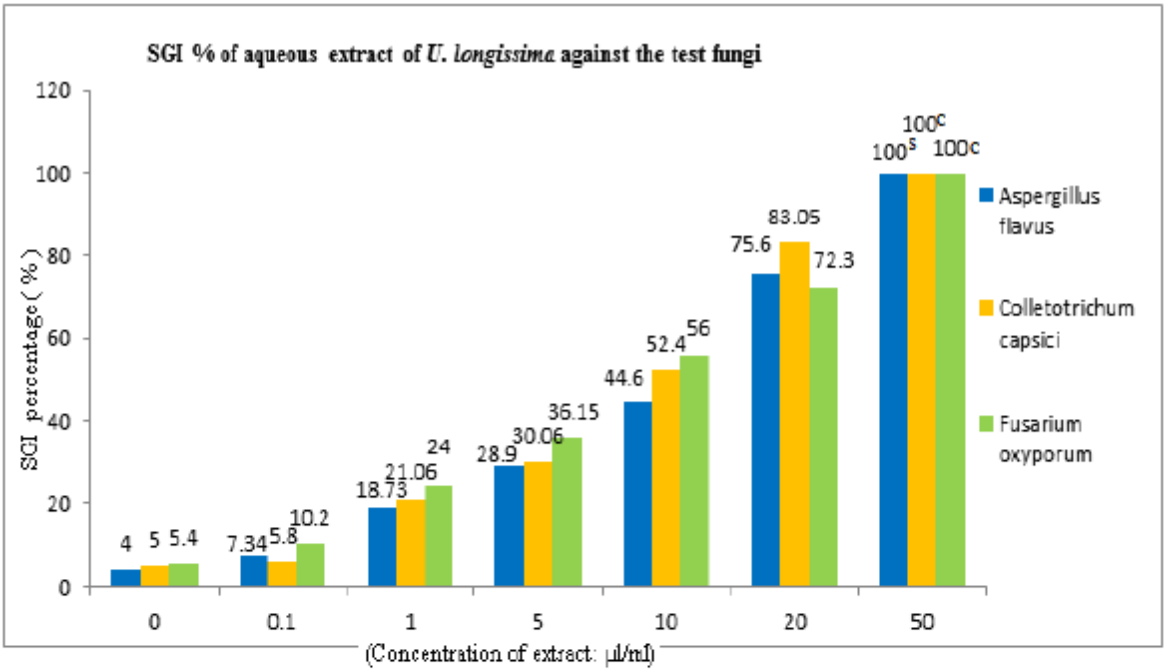

Fig-4.34: Comparative data of SGI % of aqueous extract of *U. longissima* against the test fungi

Table-4.16: Antifungal activities of acetone extract of *Usnea longissima* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	0.05	3.0	3.50
00.10	4.00	6.00	6.40
01.00	11.60	13.03	14.25
05.00	26.19	26.05	26.45
10.00	53.55	45.10	54.40
20.00	71.05	55.22	67.00
50.00	100.00^{c}	100.00^{c}	100.00^{c}

^{s} indicates static, ^{c} indicates cidal in nature; Conc. : Concentration

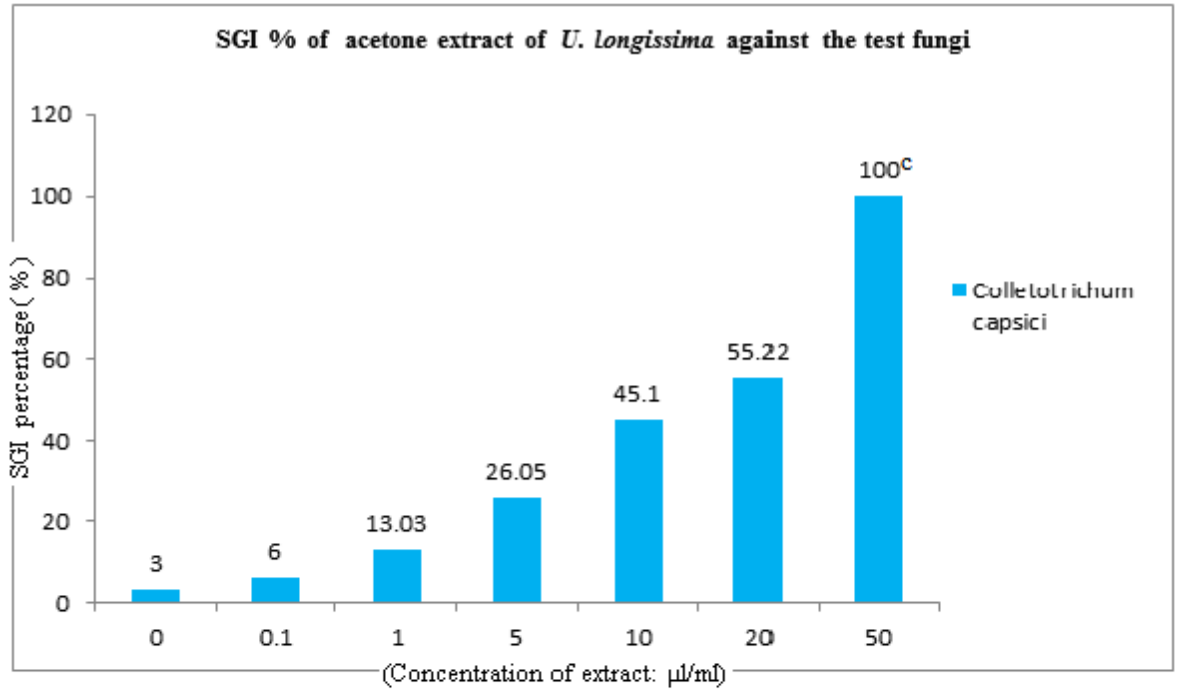

Fig-4.35: Antifungal activities of acetone extract of *Usnea longissima* against the test fungi

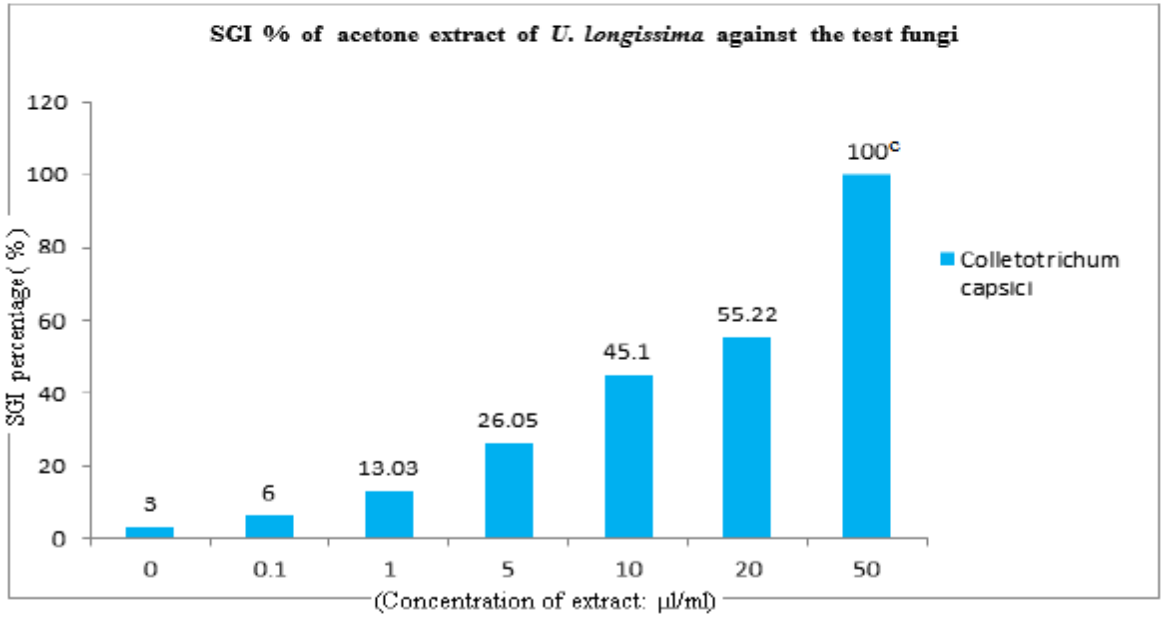

Fig- 4.36: Antifungal activities of acetone extract of *Usnea longissima* against the test fungi

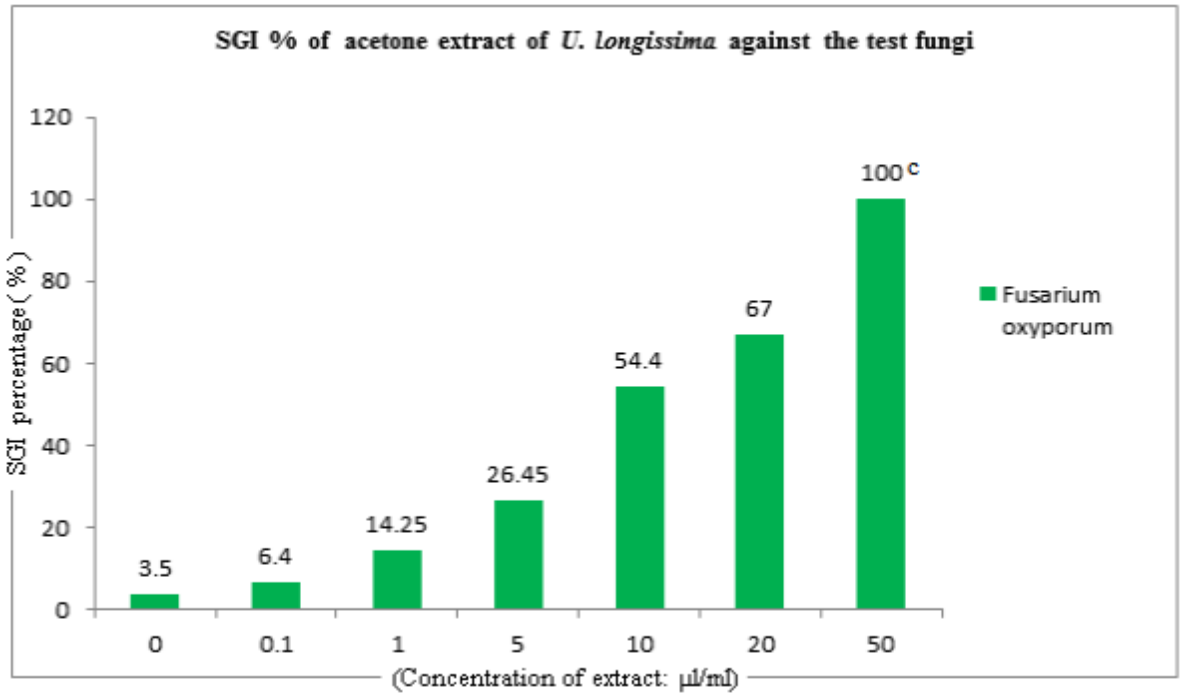

Fig-4.37: Antifungal activities of acetone extract of *U. longissima* against the test fungi

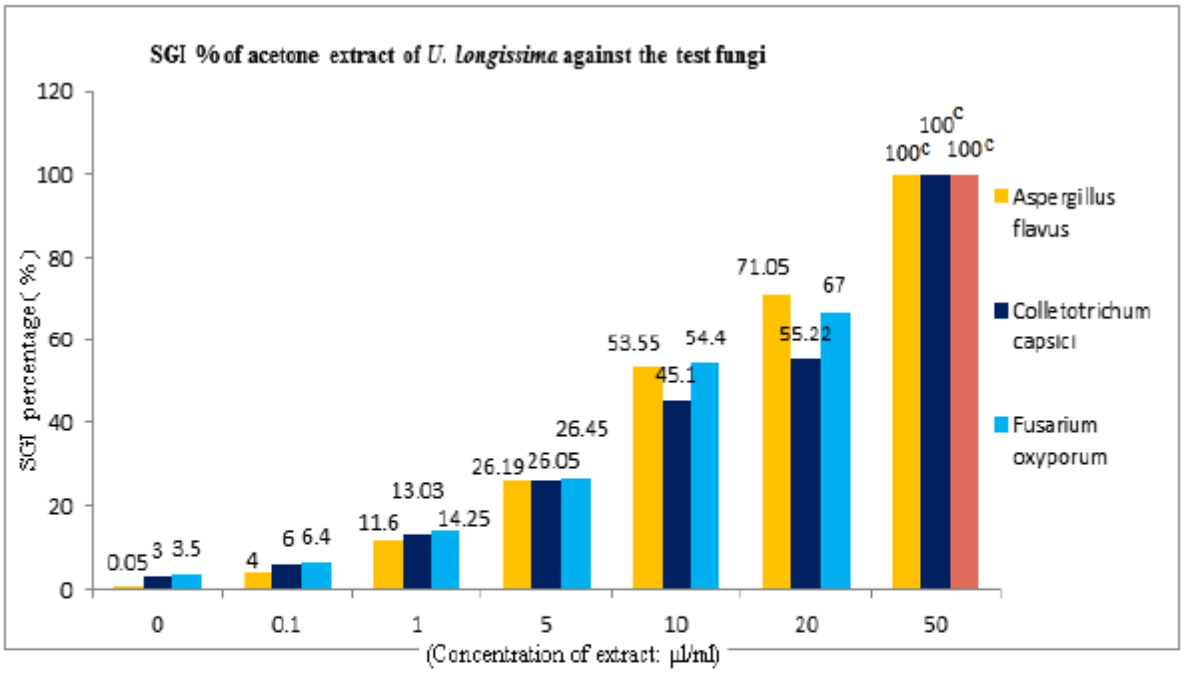

Fig- 4.38: Comparative data of SGI % of acetone extract of *U. longissima* against the test fungi

Table- 4.17: Antifungal activities of methanol extract of *Usnea longissima* against the test fungi

Conc. µl/ml	Spore germination inhibition (SGI) (%)		
	Aspergillus flavus	*Colletotrichum capsici*	*Fusarium oxyporum*
00.00	4.30	6.00	7.40
00.10	12.50	12.10	13.75
01.00	23.05	22.75	29.40
05.00	43.45	39.02	48.56
10.00	57.18	54.10	59.30
20.00	86.10	79.81	86.00[s]
50.00	100.00[c]	100.00[c]	100.00[c]

[s] indicates static, [c] indicates cidal in nature; Conc. : Concentration

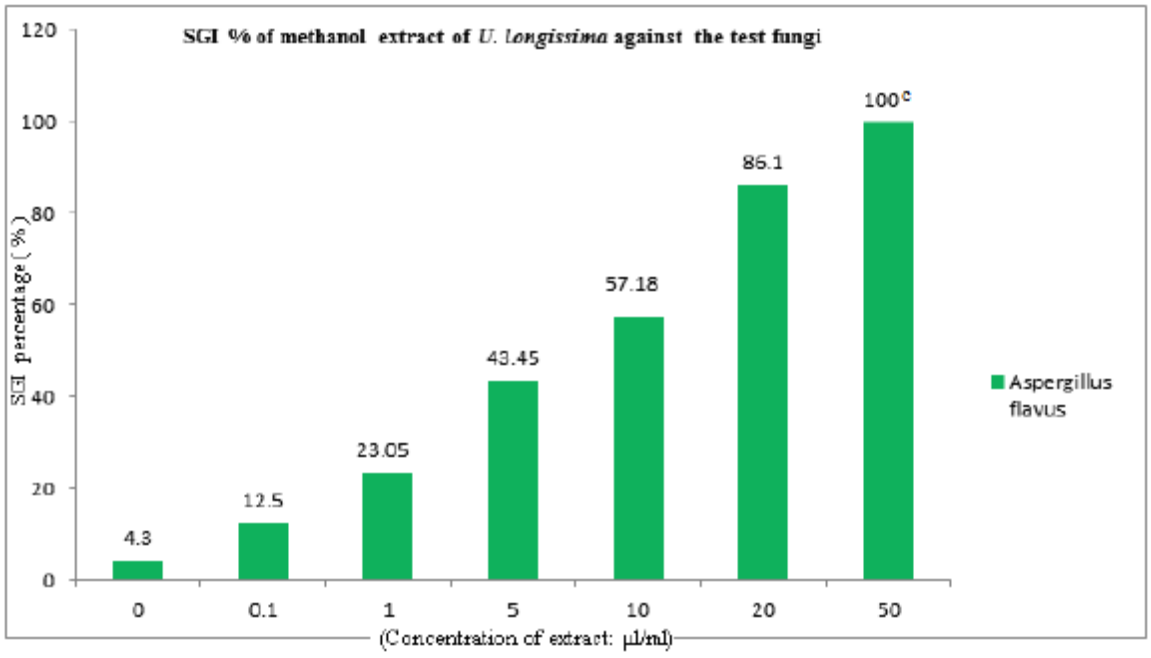

Fig- 4.39: Antifungal activities of methanol extract of *Usnea longissima* against the test fungi

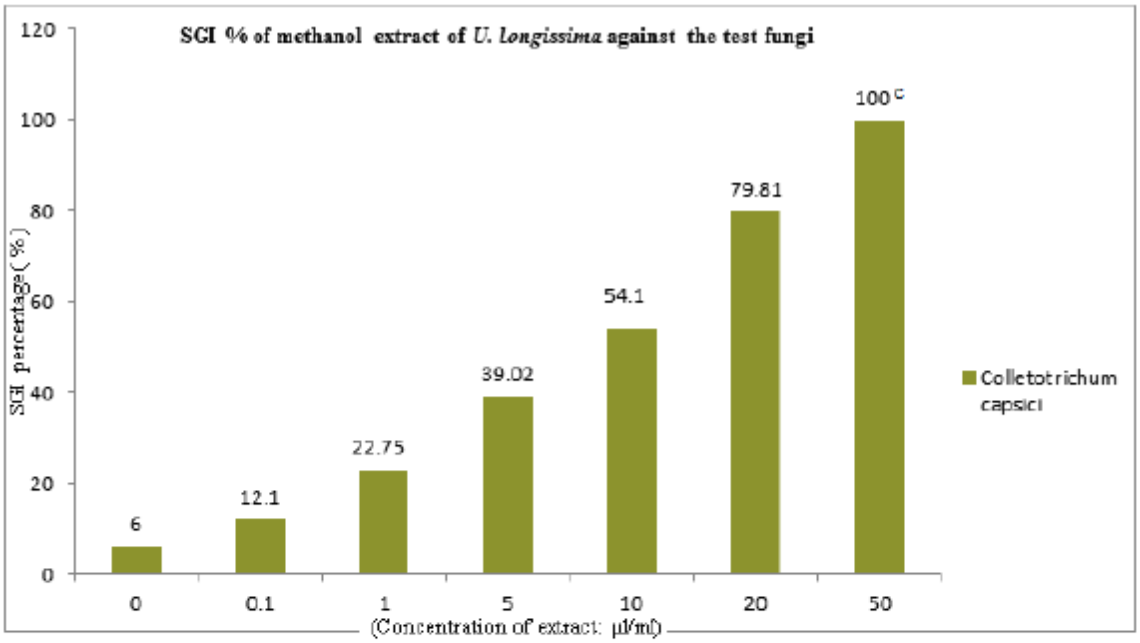

Fig- 4.40: Antifungal activities of methanol extract of *U. longissima* against the test fungi

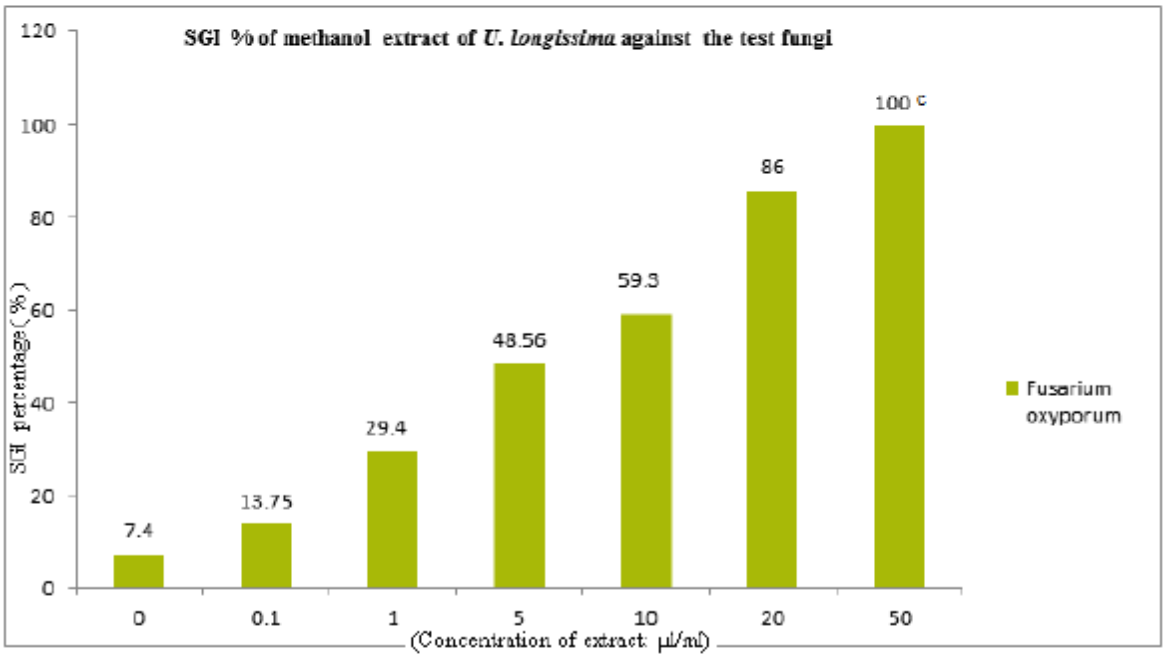

Fig- 4.41: Antifungal activities of methanol extract of *U. longissima* against the test fungi

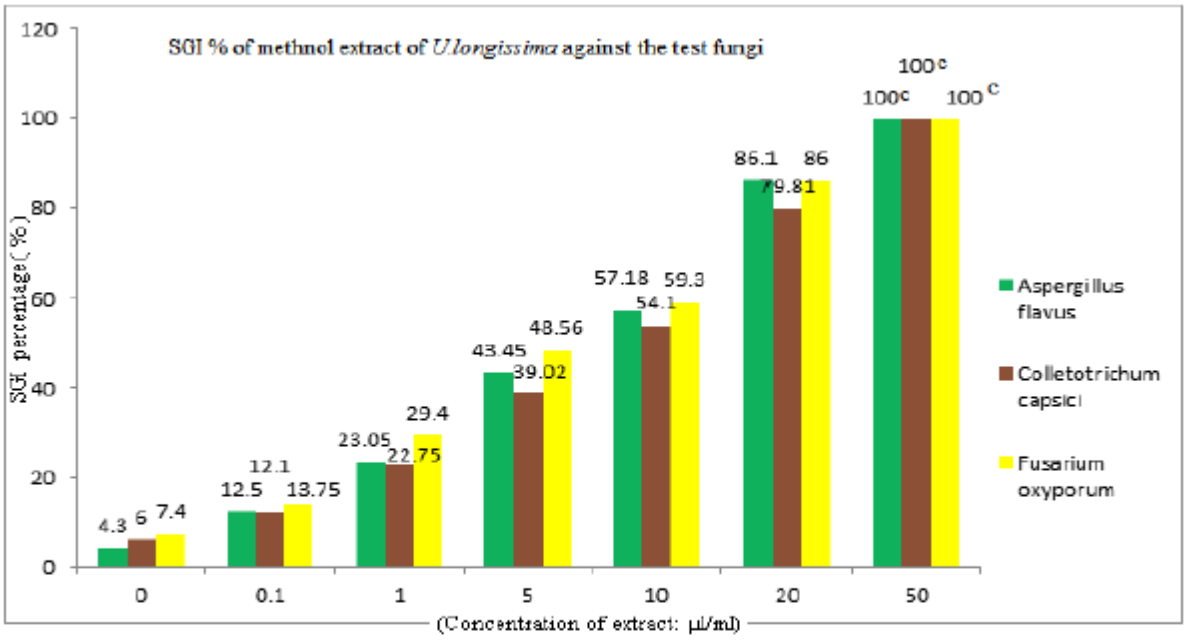

Fig-4.42: Antifungal activities of methanol extract of *Usnea longissima* against the three test fungi

Table- 4.18: Range of spectrum of *P. reticulatum and E. cirrhatum* extract against test pathogens

Fungi tested	*Parmotrema reticulatum* (conc. 50µl/ml)			*Evernistrum reticulatum* (conc. 50µl/ml)		
	Aqueous extract	Acetone extract	Methanol extract	Aqueous extract	Acetone extract	Methanol extract
Alternaria alternata	100^{s}	100^{c}	100^{s}	100^{c}	100^{c}	100^{s}
Trichophyton mentagrophytes	100^{c}	100^{c}	100^{c}	100^{c}	100^{c}	100^{c}
Salmonella typhimurium	100^{s}	100^{c}	100^{s}	100^{s}	100^{s}	100^{s}
Pythium aphanidermatum	100^{c}	100^{c}	100^{c}	100^{c}	100^{c}	100^{c}

^{s} indicates static, ^{c} indicates cidal in nature

Table 4.19: Range of spectrum of *Usnea longisima* with aqueous, acetone and methanol extracts

Fungi tested	*Usnea longisima* (conc. : 50µl/ml)		
	Aqueous extract	**Acetone extract**	**Methanol extract**
Alternaria alternata	100[s]	100[c]	100[c]
Trichophyton mentagrophytes	100[c]	100[c]	100[c]
Salmonella typhimurium	100[s]	100[s]	100[s]
Pythium aphanidermatum	100[c]	100[c]	100[c]

[s] indicates static, [c] indicates cidal in nature

Table- 4.20: Comparative efficacy of the lichen extracts with some synthetic fungicides

Trade names/ Synthetic fungicides	Active ingredient	Characteristic features	**Plant pathogen (MICs)**		
			Aspergillus flavus	*Colleotrichum capsicum*	*Fusarium oxyporum*
Parmotrema reticulatum	Salazinic acid and consalazinic acids present in TLC.	Renewable, biodegradable, non-recidual toxicity	50µl/ml	20µl/ml	20µl/ml
Everniastrum cirrhatum	Atranorin, salazinic and rotolichesterinic acid present in TLC.	Renewable, biodegradable, nonrecidual toxicity	50µl/ml	20µl/ml	20µl/ml
Usnea longissima	Barbatic, squamatic, diffractaic, evernic and fumarproto-cetraric acids present in TLC	Renewable, biodegradable, non-recidual toxicity	50µl/ml	20µl/ml	20µl/ml
Mancozeb	Zn (2%), Mn (16%), Ethylene bisithio-carbamate (62%) : **75% w/w**	Non-enewable, non-biodegradable and recidual toxicity	2.6µl/ml	2.6µl/ml	2.6µl/ml
Thiram	Tetra methyl thiram disulfide (75%)	Non-enewable, non-biodegradable and recidual toxicity	10.0µl/ml	10.0µl/ml	10.0µl/ml

MIC: Minimum Inhibitory Concentration

Chapter 5

DISCUSSION

Chapter: **5**

5. DISCUSSION

5.1 Systematic investigation

It is estimated that at present the Indian lichen flora comprises about 2303 species under 305 genera and 74 families widely distributed in tropical, subtropical, temperate and alpine regions of India (Singh and Sinha, 2010). Dr. D.D. Awasthi, Father Indian Lichenology has come a long way in India and abroad since its commencement. Comprehensive knowledge of the lichen diversity of western Himalayas and southern India has been acquired but only little progress has been made in eastern Himalayan region including North-East India in particular the study area of Mizoram. North-East India is one of the major biodiversity hotspot and is a home for numerous endemic flora and fauna. In this context, this region demands ambitious expeditions to enumerate the endemic lichen taxa. According to the India State of Forest report 2013 (FSI), Mizoram has the highest forest cover in India which is about 90.38% of its total geographical area. The most commonly encountered crustose genera are: *Astrochapsa, Bacidia, Chapsa, Cryptothecia, Fissurina, Glyphis, Graphis, Lecanora, Lopadium, Pertusaria, Phaeographis, Pyrenula Ramboldia, Thecaria,* etc. The most commonly encountered foliose genera are: *Coccocarpia, Collema, Dirinaria, Everniastrum, Heterodermnia, Hypotrachyna, Leptogium, Lobaria, Pannaria, Parmeliella, Parmotrema, Physcia, Pyxine, Relicina,* etc. *Cladonia, Ramalina,* and *Usea* are the only fruticose genera encountered.

The people of Mizoram are traditionally well versed in the knowledge about local plants and animals. In Mizo language, people referred to Lichens as **Lungsam or Lungpat** (Lung means stone; Sam = Hair, **pat** means algal growth) if it is *Saxicolous* and as **Thingsam** *or* **Thingpat** (Thing means Tree; Sam means Hair; **pat** means algal growth), if it is *Corticolous*. Few lichen genera are well recognized by the Mizos and they have vernacular names. For instance, *Parmotrema* species are called as *Patpui* and *Usnea species* as *Patzam*. The result of this study is encouraging and demands for further extensive survey for multidimentional study of lichen diversity of the state.

Documentation of 361specimens with LWG accession number revealed the occurrence of 28 families, 56 genera of lichens. The lichen family Physciaceae exhibits its dominance with 31species and 9 genera followed by Graphidaceae with 25 species and 9 genera. Other dominant family belongs to Parmeliaceae with 21 species and 6 genera followed by Lecanoraceae with 12 species and 2 genera. The genus *Usnea* exhibits dominance among the all the lichens having with 13 followed by *Heterodermia,* 12 species, *Graphis* with 9 and *Lecanora* with 8 species respectively (table 4.1 to 4.8; fig 4.1 to 4.6).

From the present study, it has become evident that Mizoram abodes a good number of lichens in its rich habitats which are getting depleted due to various factors. Microlichens need further investigations. Since most of the earlier studies on lichens of the country were based on cursory collections, therefore, amore systematic approach for exploration in the state initiated from Murlen National Park in the present study. The northeastern region of India is well known for its rich and diverse plant resources including lichens. It is reiterated that ethno-medicinal studies has tapped worldwide interest in recent year mainly due to the discovery of new drugs and conservation and utilization of plant resources for the socioeconomic development of tribal communities. Mizoram has some virgin forests with high biodiversity. This natural reservoir of wild plant resources are the best custodian of medicinal plant resources. Although a lot of plants were identified as medicinal plants, still it is belief that more plants are not yet explored and identified yet in terms of their medicinal value even by the local people. Therefore, more research work and surveyed have been carried out to explore the neglected unexplored plants i.e., '**lichens**' having high potential for pharmaceutical, cosmetics industry and ecological studies like climate change. The proper documentation of the ethnic uses of lichen as well as medicinal plants knowledge should be maintained and aware to the younger generation about their conservation of ethno-biodiversity in in-

situ and ex-situ condition in order to prevent them from extinction. However, the number of species would be definitely more, since only scattered study was made from this region. Study of lichens will be complete until the microlichens are also given due importance. Since this is the first syematic study of lichens from this part of the region there is ample scope for further studies on the macro and microlichens of this region.

5. 2 Bioprospection

The antifungal potential of differential extracts of *Parmotrema reticulatum* and *Parmotrema tinctorum* tested against four fungal plant pathogens viz., *Aspergillus flavus, Fusarium oxysporum, Penicillium citrinum* and *Colletotricum capsici*. The results of the screening on test isolates were positive and were effective in inhibiting the mycelia growth of the pathogens to a significant level. Among the three solvents used for extraction acetone extracts of four selected lichen species showed highest inhibition activity followed by methanol while aqueous extract of the same showed the least activity for the test fungi of *Aspergillus flavus*. Among the methanolic extracts, the screening results among the pathogens were in close proximity to each other with minor variations in contrast to the results given by acetone extracts. Both acetone and methanol extracts showed more or less higher antifungal activity than aqueous extracts.

Antifungal efficacy of 50% ethanolic exact from some macrolichens, *Parmotrematinctorum*, *Ramalina* sp., the *Teloschistis flavicans*; *Usnea undulata* had been tested by Dikshit (1991) against pathogenic fungi *Aspergilus flavus* only. However, in the present investigation one moulds *A. flavus* and one filamentous fungus *Colletotrichum capsici* and one soilborne fungi *Fusarium oxysporum* were selected to evaluate the broad spectrum antifungal activity of lichen extracts. Aqueous extract from *Nephroma articum*, *Heterodermia leucomela* and *Parmelia cirrhatum* were tested for their antifungal efficacy against some plant and human pathogenic fungi and found encouraging results (Shahi *et al*., 2001; Dikshit, 1991). However, in the present communication the acetone extract of *Ramalina* sp. and *Stereocaulon* have been found more effective than aqueous extracts. The antifungal activity as well as range of spectrum of aqueous and acetone extracts of *Ramalina* and *Stereocaulon* spp against the tested plant pathogenic fungi was reported for the first time by Shukla *et al*, (2011). The present study revealed and confirmed the presence of fungicidal substances in the tested extracts of lichen *Parmotrema reticulatum*. The antifungal activity with varying zones of inhibition reveals

the antifungal potency of the species. The ethnomedicinal usage of the decoction of *Parmotrema reticulatum* is also known, as household remedies to relieve from stomach indigestion and kidney disorder. Gupta *et al.* (2007) reported the antibacterial activity of this species against virulent strain of *Mycobacterium tuberculosis*.

However, in the present study, all selected test pathogens were susceptible to the extract, but showed variations depending on the type of extracting solvent and on the type of lichen species as well as selected microorganisms (table 4.9 to 4.11 as well as fig 4.7 to 4.18); since bioactive components of any medicinal plant have different solubility in different extracting solvent (Oloke and Kolawole, 1998). The acetone and methanol extracts were more effective in the inhibition of pathogenic growth as compared to the aqueous extracts. It is suggested that the polar solvents acetone and methanol are most successful in extracting secondary metabolites responsible for antimicrobial property than polar non solvents (Banso *et al.,* 2007). The selective antifungal effect of acetone and methanol extracts over chloroform extracts can be attributed to differential solubility of constituent secondary metabolites in extraction (Goel *et.al.* 2011, Halama and Haluwin, 2004).

Lichen substances as bioactive compounds are gaining edge over traditionally known chemicals due to their improved effectiveness over synthetic compounds (Huneck, 1999). Extracts of lichen thalli proved to have strong antifungal activity against various plant pathogenic fungi (Gulluce *et al.* 2006; Halama and Van Haluwin 2004). In present study the comparative better effectiveness of methanol and acetone extract of *Parmotrema tinctorum* against some well known plant pathogenic fungi, can be attributed to lichen substances like lecanoric and orsellinic acid, known for their antifungal properties (Gomes *et al.* 2002; Ranković, 2008, 2010). The selective antifungal effect of acetone and methanol extracts over chloroform extracts can be attributed to differential solubility of constituent secondary metabolites in these extracts (Goel*et.al.,* 2011) The better performance of lichenic extracts against broad spectrum plant pathogenic fungi (i.e. *Fusarium roseum, Fusarium solani, Ustilago* and *Penicillium citrinum*) suggests their superior potentials as antifungal substances (Halama and Haluwin, 2004).

Yashoda Kambar *et al* (2014) studied the antimicrobial efficacy of extracts of four macrolichens *viz*., *Leptogium ulvaceum* (Pers.) Vain., *Ramalina hossei* H. Magn and G. Awasthi, *Roccella montagnei* Bel.Em. D.D Awasthi and *Heterodermia diademata* (Taylor) D.D. Awasthi and they reported that the extracts of selected lichens were effective in inhibiting bacteria and fungi.

Based on their critical study it was reported that the extracts were effective ininhibiting bacteria and fungi and can be used to control diseases caused by pathogenic microorganisms. Further, they concluded that the inhibitory effect of lichens could be ascribed to the presence of secondary metabolites. Moreover, these lichens can be used to develop novel therapeutic agents active against pathogens.

Among various diseases of chilli, Anthracnose (both pre-harvest and post-harvest) is most important.It causes yield loss (up to 50%) and deterioration of fruit quality. The symptoms of Anthracnose on chilli fruit include sunken necrotictissues with concentric rings of acervuli. Several species of *Colletotrichum* such as *C. capsici, C. acutatum, C. gloeosporioides, C. coccodes* and *C. dematium* are implicated in causing anthracnose (Masoodi *et al*., 2013). Among these, *C. capsici* is the most important pathogen. Fungicides such as mancozeb, captan, bavistin, thiram, copper oxychloride, cosan, benlate and ziram are used to control anthracnose disease. However, the resistance against these fungicides has been noticed in most fungal pathogens including *C.capsici*. Thus, search for alternative disease control strategies are of immense interest.

Natural products have been extensively studied for the control of phytopathogenic fungi as they are cost effective and have potential efficacy with no or negligible side effects (Goel, *et al*., 2011; Susheela, 2012; Masoodi *et al.,* 2013). It has been shown that lichens and their metabolites exhibit inhibitory activity against phytopathogenic fungi. (Prashith, *et al.,* 2014) reported that the extracts of some selected macrolichens exhibited marked inhibitory effect against *C. capsici* isolated from anthracnose of chilli and the highest and least inhibitory effect was displayed by *R. hossei* and *R. montagnei* respectively. They concluded that the antifungal activity of three *Parmotrema* species against mycelial growth of *C. capsici*. *P.tinctorum* was found to inhibit the fungus to a higher extent. The extracts of selected lichens were shown to display marked inhibitory effect against clinical isolates of dental caries, burn and urinary tract infections, reference yeasts and *C. capsici*. The inhibitory efficacy of lichens could be ascribed to the presence of secondary metabolites. These lichens appear as promising candidates for the development of therapeutic agents.

Chapter 6

SUMMARY

6. SUMMARY

The research work carried out in the thesis was initiated at Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Mizoram, under the supervision of Prof. Amritesh C. Shukla, Head, Department of Horticulture, Aromatic and Medicinal Plants, and Dr. D.K.Upreti, Chief Scientist, Lichenology laboratory, CSIR-National Botanical Research Institute (CSIR-NBRI), Lucknow, as joint supervisor. The systematic collection of lichens initiated in the study area during 2011-2015 and specimens were collected. The collected specimens were dried, labeled and preserved in the department and one voucher specimen of each species was deposited in CSIR-NBRI, Lucknow. The initial segregation of species under different genera were performed on the basis of growth form, types of fruting bodies, algae present inside the thallus and chemical test with reagents. The final identification and authentication of the species was performed at Lichenology laboratory CSIR-NBRI, Lucknow. The preliminary screening of antifungal properties the solvent extracted lichens bioactive constituents was carried out at the department laboratory.

The lichen flora of Mizoram, part of the Eastern Himalayan region is inadequately known as only negligible or fragmentary work has been done in the past. A study on the systematic investigation and bioprospection of lichens of Murlen National Park, Champhai District, Mizoram, was carried out during 2011 to 2015.

The present work is the first intensive study of macro and micro lichens from Mizoram part of theEastern Himalayan. During intensive field explorations; a total of 500 specimens were collected and examined systematically. Out of 1500 samples collected from the study area, 361samples were exmined and the vouchers specimens' were deposited for LWG accession (table- 4.5-8). Out of 361 specimens vouchers, 143 numbers of lichens were enumerated systematically alongwith their original images. The family Physciaceae dominates with 26 species under 7 genera, followed by Graphidaceae (22 species under 9 genera), Parmeliaceae (19 species with 7 genera), Ramalinaceae (12 species under 5 genus), Usneaceae (13 species under 1 genus), Lecanoraceae (11species under 2 genera), etc. The genus *Heterodermia* dominates with 12 species followed by *Usnea* dominates with 13 species, *Graphis* (9 species), *Lecanora* (7 species), *Parmotrema* (6 species).

Out of 143, 14 lichen species are reported as **new record for Indian lichen flora** viz., *Buellia aeruginascens* (Nyl.) Zahlbr., *Chaenotheca chrysocephala* (Turner ex Ach.) , *Diorygma reniforme* (Fee) Kalb., Staiger & Elix, *Gassicurtia acidobaeomyceta* Marbach, *Graphis granulosa* (Mull. Arg.) Lucking, *Hafellia demutans* (Zalhbr.) Puswald, *Phyllopsora soralifera* Timdal, *Ramboldia sorediata* Kalb, *Ramboldia subnexa* (Stirt.) Kantvilas and Elix, *Relicina sublanea* (Kurok.) Hale, *Stigmatochroma adaucta* (Malme) Marbach, *Stigmatochroma gerontoides* (Stirt.) Marbach, *Stigmatochroma krypto-violascens* Marbach, *Stigmatochroma metaleptodes* (Nyl.) Marbach.

The occurrence of 143 species of lichens clearly exhibits the rich diversity of lichen species from the Park in 25 different collection sites. Among the 4 localities, MNP (East) holds highest number of species (i.e. 88 species, 47 genera and 23 families) followed by MNP (West) (i.e. 33 species, 20 genera and 14 families), MNP (North) (i.e. 27 species, 19 genera and 14 families), and MNP (South) with 32 species, 22 genera and 14 families). Different types of growth forms such as crustose, foliose, foliose, leprose and squamulos found occurs in the area. Among these, crustose show maximum species diversity with 62 species under 24 genera found exclusive to the forest type of vegetation. Among the 57 genera, two genera fall under fruticose forms, 9 genera in foliose forms, 41 genera in crustose forms, leprose and squamulose growth form are represented by single genus each.The altitudinal zone ranging 1600m alt. and above exhbits maximum occurance of lihen species, followed by an altitudinal range between 1200-1600m showing the occurance of about 83 species of lichen and 15 species of lichens occurs below 1200m alt.above mean sealevel. About 109 species of lichens are found in more than one forest type. It is evident from the study that macrolichens constitute an important component in the flora of the subtropical

forest as they play varying role in the pioneer, transition and climax ecosystems (table 4.1 to 4.8; fig 4.1 to 4.6).

Antifungal properties of aqueous, acetone and methanol extracts of the test lichens viz., *Parmotrema reticulatum, Evernistrum reticulatum* and *Usnea longissima* was investigated against three common pathogenic fungi viz., *Aspergillus flavus* Link (MTCC 8790), *Colletotricum capsici* Butler & Bisby and *Fusarium oxysporum* (MTCC 2087); and recorded strong efficacy at 50 µl/ml concentration as well as broad fungi toxic spectrum.

The observations shows that the percentage of spore germination inhibition (SGI %) with **aqueous extract** of *Parmotrema reticulatum* against *Aspergillus flavus,* was ranges from 9.33 – 100.00, against *Colletotrichum capsici* 7.80 – 100.00, and against *Fusarium oxysporum* ranges from 9.20 – 100.00 at the concentration of 0.1 - 50µl/ml, respectively; while with **acetone extract**- it was ranges from 17.65 – 100. 00 against *A. flavus*, 12.03-100.00 aginst *C. capsici* and 16.25 -100.00 against *F. oxysporum* but in case of **methanol extract,** the SGI (%) was recorded as 7.50-100.00 against *A. flavus*, 15.16-100.00 aginst *C. capsici* and 15.75-100.00 against *F. oxysporum* at the same concentrations respectively (table 4.9 to 4.11 as well as fig 4.7 to 4.18).

Similarly, the percentage of spore germination inhibition (SGI %) with **aqueous extract** of *Everniastrum cirrhatum* against *Aspergillus flavus,* was ranges from 9.53 – 100.00, against *Colletotrichum capsici* 8.80 – 100.00, and against *Fusarium oxysporum* ranges from 11.20 – 100.00 at the concentration of 0.1 - 50µl/ml, respectively; while with **acetone extract**- it was ranges from 7.65 – 100. 00 against *A. flavus*, 13.03-100.00 aginst *C. capsici* and 19.25 -100.00 against *F. oxysporum* but in case of **methanol extract,** the SGI (%) was recorded as 11.50-100.00 against *A. flavus*, 13.16-100.00 aginst *C. capsici* and 16.75-100.00 against *F. oxysporum* at the same concentrations respectively (table 4.12 to 4.14 as well as fig 4.19 to 4.30).

However, the percentage of spore germination inhibition (SGI %) with **aqueous extract** of *Usnea longissima* against *Aspergillus flavus,* was ranges from 7.34 – 100.00, against *Colletotrichum capsici* 5.80 – 100.00, and against *Fusarium oxysporum* ranges from 10.20 – 100.00 at the concentration of 0.1 - 50µl/ml, respectively; while with **acetone extract**- it was ranges from 4.00 – 100. 00 against *A. flavus*, 6.00 -100.00 aginst *C. capsici* and 6.40 -100.00 against *F. oxysporum* but in case of **methanol extract,** the SGI (%) was recorded as 12.50-100.00 against *A. flavus*, 12.10-100.00

aginst *C. capsici* and 13.75-100.00 against *F. oxysporum* at the same concentrations respectively (table 4.15 to 4.17 as well as fig 4.31 to 4.42).

Further, range of spectrum of all the extracts (aqueous, acetone and methanol extracts) of the tested lichens (*Parmotrema reticulatum, Evernistrum reticulatum* and *Usnea longissima*), at 50.0 µl/ml shows broad antimicrobial spectrum.

The nature of toxicity of the **aqueous extract** (50.0 µl/ml) of *Parmotrema reticulatum* against the test pathogen *Alternaria alternate* and *Salmonella typhimurium* was static (a conc which checks the growth but could not kill the organism), however, it was cidal (lethal) against *Trichophyton mentagrophytes* and *Pythium aphanidermatum.* The **acetone extract** (50.0µl/ml) of *Parmotrema reticulatum* was cidal against *Alternaria alternata, Trichophyton mentagrophytes, Salmonella typhimurium* and *Pythium aphanidermatum;* however, the **methonol extract** (50.0µl/ml) was static against *Alternaria alternate* and *Salmonella typhimurium* but cidal against *Trichophyton mentagrophytes* and *Pythium aphanidermatum* (table 4.18).

Further, in case of *Evernistrum reticulatum*; the **aqueous extract** (50.0 µl/ml) against the test pathogen *Salmonella typhimurium* was static but cidal against *Alternaria alternata, Trichophyton mentagrophytes* and *Pythium aphanidermatum.* The **acetone extract** (50.0µl/ml) of *Evernistrum reticulatum* was cidal against *Alternaria alternata, Trichophyton mentagrophytes, Salmonella typhimurium* and *Pythium aphanidermatum;* while, the **methonol extract** (50.0µl/ml) was static against *Alternaria alternate* and *Salmonella typhimurium* but cidal against *Trichophyton mentagrophytes* and *Pythium aphanidermatum* (table 4.18).

However, in case of *Usnea longissima*; the **aqueous extract** (50.0 µl/ml) against the test pathogen *Alternaria alternate* and *Salmonella typhimurium* was static but cidal against *Trichophyton mentagrophytes* and *Pythium aphanidermatum.* The **acetone extract** (50.0µl/ml) of *Usnea longissima* was static against *Salmonella typhimurium* but cidal against *Alternaria alternata, Trichophyton mentagrophytes* and *Pythium aphanidermatum;* while, the **methonol extract** (50.0µl/ml) was static against *Salmonella typhimurium* but cidal against *Alternaria alternata, Trichophyton mentagrophytes,* and *Pythium aphanidermatum* (table 4.19).

The comparative analysis of the lichen extracts of *Parmotrema reticulatum, Evernistrum reticulatum* and *Usnea longissima*, with some synthetic fungicides viz., Mancozeb and Thiram were also investigated and recorded in table 4.20.

The findings of the present research work will not only be helpful to know the lichen's morphology, pattern of diversity, distribution, bio-chemical profiling and their antimicrobial efficacy but can be baseline information for the future studies, and encourage the researcher and policy makers.

Further, to the best of our knowledge the antimicrobial activity as well as range of spectrum of aqueous, acetone and methonilic extracts of the samples against tested pathogenic organism is reported for the first time. Thus, the finding will be useful for the conservation of taxa also by isolation, characterization and identification of the active principle(s), which could be used (after detailed *in vitro* and *in vivo* investigations), for the development of harmless and effective antimicrobial formulations.

Besides this, there is also an urgent need of proper documentation and conservations of lichens in this very remote location of Northeastern part of the country/ Mizoram, before they last forever.

Bibliography

Systematic investigations and bioprospection of lichens from Murlen National Park, Mizoram

BIBLIOGRAPHY

Acharius E. 1803. Methodus Lichenum. Stockholm.

Acharius E. 1810. *Lichenographia Universalis*. Gottingen, Dandewerts.

Acharius E. 1814. *Synopsis Methodica Lichenum*, pp. 392. Lund.

Ahmadjian V. 1995. Lichens are more important than you think. *Bioscience,* **45**: 124.

Ahti T. and Oksanen J. 1990. Epigeic lichen communities of taiga and tundra regions. *Vegetatio*., **86**: 39-70.

Ahti T. and Upreti D.K. 2004. Two new species of *Cladonia* (*Lecanorales*) from the Himalayas. *Bib. Lich*., **88**: 9 – 13.

Ahti T., Dixi P.K., Singh, K.P., and Sinha G.P. 2002. *Cladonia singhii* and other new reports of *Cladonia* from Eastern Himalayan region of India. *The Lichenologist,* **34(4):** 305-310.

Akhtar P. & Awasthi D.D. 1980. The genus *Collema* in India. *Biol. Mem.,* **5(1):** 13-29.

Akhtar P. 1981. The lichen genus *Lempholemma* in India. *Biol. Memoir*, Lucknow, **6**: 78-80.

Akhtar P. and Awasthi, D.D. 1980. The Lichen genus *Collema* in India. *Bio Mem,* **5(1)**: 13-29.

Almborn O. 1948. Distribution and ecology of some south Scandinavian Lichens. *Botaniska Notiser*, suppl. **1**: 1-254.

Almborn, O. 1955. Lav vegetation och lavflora pa hallands Vadero. *Kungliga Svenska Vetenskapademiens Avhandlingari Naturskydaarenden,* **11**: 1-92.

Anon 2001-02. http://www.mapsofindia.com/maps/wildlife/wildlife-mizoram.htm

Archer A.W. 1997. The lichen genus *Pertusaria* in Australia. Biblioth. Lichenol., 69, J. Cramer, Berlin, Stuttgart.

Armstrong R.A. 1991. Competitive interactions between four foliose lichens on north and south facing rock surface. *Environmental and Experimental Botany*, **31**: 51-58.

Asahina Y. 1936. Mikrochemis Cher Nachweis der Flechtenstoffe I-XI. *J. Jap. Bot.* **12**: 513-525

Asahina Y. 1950. *Lichens of Japan*, I. Genus Uadonia. Tokyo, Hirokawa Publ. Co. 255.

Asahina Y. 1952. *Lichens of Japan*, II. Genus Parmelia. *Res. Inst. Nat. Res*. Shiniku, Tokyo, 162.

Awasthi D.D. & Mathur R. 1987. Species of the lichen genera *Bacidia*, *Badimia*, *Felhanera* and *Mycobilimbia* from India. *Proc. Indian Acad. Sci*., (Plant Sciences), **97(6):** 481-503.

Awasthi, D.D. (1961). Some foliose and fruticose lichens from Asssam and North East Frontier Agency (NEFA) of India. *Proc. Indian Acad. Sci*. **54 B**: 24-44.

Awasthi D. D. 1970. On *Alectoria acanthodes* Hue, *Alectoria confuse* sp.nov. and the systematic position of the genus *Alectoria. Proc. Indian Acad. Sci*. **72 B**: 149-155.

Awasthi D.D. 1973. On the species of *Anaptychia* and *Heterodermia* from India and Nepal. *Geophytology*. **3**: 113-116.

Awasthi D.D. 1975a. A monograph of the genus *Dirinaria*. *Biblioth. Lichenolog*. **2**: 1-108.

Awasthi D.D. 1975b. Linchen flora of the Pindari Glacier valley, India. *Geophytology*, **5**: 178-188.

Awasthi D.D. 1976. Lichen genus *Parmelia* in India. Subgenera *Parmelia* and *Amphigymnia*. *Biol. Memoirs*, Lucknow. **1**: 155-229.

Awasthi D.D. 1981. The typification of *Roccella montagnei* Bel. *Bryologist*, **84**: 216-219.

Awasthi D.D. 1982a. Lichen genus *Cetraria* in India and Nepal. *Bull. Bot. Surv*.India, **24**:1-27.

Awasthi D.D. 1982b. *Pyxine* in India. *Phytomorphology*, **30**: 359-379.

Awasthi D.D.1982c. Lichen genus *Parmelia* in India. II. Subgener a *Xanthoparmelia* and *Melanoparmelia*. *Indian J. of Forestry*, **4**: 198-204.

Awasthi D.D. 1983. Reproduction in Lichens. *Phytomorphology*, **33**: 26-30.

Awasthi D.D. 1985. Lichen genus *Coccocarpia* from India. Kavaka. **13**: 83-86.

Awasthi D.D. 1986. Macrolichen taxa of Teloschistaceae from India. *Proc. Indian Acad. Sci*. (Pl. Sci.) **96**: 87-97.

Awasthi D.D. 1987. A new position of *Platysma thomsoni* Stirton. *J. Hattori Bot. Lab*. **63**: 367-372.

Awasthi D.D. 1988a. Two interesting lichen taxa new to India. *Curr. Sci*. **57**: 146-147.

Awasthi D.D. 1988b. A key to macrolichens of India and Nepal *J. Hattori Bot. Lab*. **65**: 207-302.

Awasthi D.D. 1991. A key to microlichens of India, Nepal and Sri Lanka. *Bibliothec. Lichenolog*., **40**: 1-337+2.

Awasthi D.D. 2000. *Lichenology in Indian sub continent*. Bishen Singh and Mahendra Pal Singh, Publishers Dehradun, India.

Awasthi D.D. and Agrwal M.R. 1968. On the species of *Cryptothecia* from Darjeeling District, India. *J. Indian Bot. Soc*., **48**: 62-72.

Awasthi D.D. and Agrwal M.R. 1970. An enumeration of lichen from tropical and subtropical regions of Darjeeling district, India. *J. Indian Bot. Soc*., **49**: 123-126.

Awasthi D.D. and Akhtar P. 1977. The genus *Leptogium* (Sect. Mallotium) in India. Norw. *J. Bot. Soc*., **24**: 59-71.

Awasthi D.D. and Joshi M. 1982. The genus *Peltigera*. *Kavaka*, **10**: 45-62.

Awasthi D.D. and Singh K.P. 1970. A note on lichens from Kashmir. *Curr. Sci*. **39**: 441-442.

Awasthi D.D. and Singh K.P. 1971. Additions to the lichen flora of India. *Geophytology*, **1**: 97-102.

Awasthi D.D. and Singh K.P. 1980. Observations on some Graphidaceous lichen taxa. *Phyta*.**1**: 34-40.

Awasthi D.D. and Srivastava P. (1989). Lichen genera *Brigantiaea* and *Letrouitia* from India. *Proc. Indian Acad. Sci* (Pl. Sci.), 99: 165-177.

Awasthi, D.D. and Tewari, R. 1987. Lichen genus *Ochrolechia* from Indian subcontinent.*Katava*, **15(12)**: 23-27.

Awasthi, D.D. and Upreti, D.K. 1985. Lichen genus *Dermatocarpon* in India. *J. Econ. Tax. Bot.*, **7(1):** 7-12.

Awasthi. D.D. 1991. A Key to the Microlichens of India, Nepal and Sri Lanka. *Biblioth. Lichenol.*, Bd. 40, J. Cramer, Berlin, Stuttgart.

Awasthi. D.D. 1975. A monograph of the lichen genus *Dirinaria*. Biblioth. Lichenol., 2:1-108.

Awasthi. D.D. 2007. A Compendium of the Macrolichens from India Nepal and Sri Lanka. Bishen Singh Mahendra Pal Singh, Dehradun.

Balaji, P. and Hariharan, G.N. 2004 Lichen diversity and its distribution pattern in tropical dry evergreen forest of Guindy National Park (GNP), Chenai. *Indian Forester*., **130**: 1155-1168.

Balakrishnan, N.P. 1981-83. Flora of Jawai and vicinity of Meghalaya. Vol. I and II. *Bot. Surv, India,* Howrah.

Barkman , J.J. 1958. Phytosociology and ecology of cryptogenic epiphytes. *Van Gorcum,Assen, Neitherlands*.

Behera BC, Verma N, Sonone A, Makhija U. 2005. Antioxidant and antibacterial activities of lichen *Usnea ghattensis in vitro*. *Biotechnol Lett*., **27**: 991-995.

Belanger , M.C. 1838. Voyage aux Inde Orientales Anne 1825-29. Botanique II Partie, Cryptogamie par Ch. Belanger et Borty de St. Vincent 192 pp. (Lichens pp. 113-144).

Bhatia, K.K. 1957. Some observations on the lichen communities of the Western Himalayas *Bull. Bot. Soc. Univ. Sagar*., **9(1-2):** 36-39.

Biswas, K. and Awasthi, D.D. 1948. Distribution of Indian lichens. *Proc. 35th Indian Sci. Congress*, **3**: 216.

Brightman, S.H. and Seaward, M.R.D. (1978). Lichen on man made substrates. In: *Lichen Ecology* (Eds. M.R.D. Seaward). Academic Press, pp. 253-293.

Brodo, I.M. 1974. Substrates ecoloy. In: *The Lichens* (Eds. V. Ahmadjian and M.E. Hale). Academic Press, New York, pp. 229-255.

Brown, D.H. 1991a. Review of 'A.J. Shaw (ed) Haeavy metal tolerance in Plants: evolutionary aspects', CRC Press, Boca Raton. 1990. *Lichenologist*, **23(1):** 93-94.

Brown, D.H. 1991b. Lichens mineral studies, currently clarified or confused. *Symbiosis*, **11(2-3)**: 207-223.

Bruteig, I.E. 1993. Large scale survey of the distribution and ecology of common epiphytic lichens on *Pinus sylvestris* in Norway. *Ann. Bot. Fennici*. 30: 161 - 169.

Canters, K.J., Scholler, H., Ott, S. and Jahns, H.M. 1991. Microclimatic influences on lichen distribution and community development. *Lichenologist*, **23(3):** 237-252.

Cardarelli, M.A., Serino, G., Campanella, L., Ercole, P., De Cicco-Nardone, F., Alesiani, O.,Rossiello, F. 1997 : Antimitotic effects of usnic acid on different biological systems. *Cell. Mol. Life. Sci.*, **53**: 667-672.

Chinlampianga M, 2009. Collection, categorization and compilation of some Ethno-medicinal plants of Mizoram with special reference to Champhai district. *M. Sc dissertation*, Mizoram University, Aizawl.

Chinlampianga, M Amritesh C. Shukla and D.K.Upreti, 2011. Lichens of Mizoram: Present Status and Future Prospects. Proc. of International conference on Advances in Environmental Chemistry. pp. 109-113. (ISBN: 978-93-81361-53-5).

Chinlampianga M, Logesh AR, Dubey U, Shukla AC, Upreti, D.K. 2013. Preliminary studies on lichen flora of Mizoram. *Sci. Tech. J.* **1(1):** 22 – 25.

Chopra, G.L. 1934. *Lichens of the Himalayas*. Punjab Univ. Press, Lahore. Pp., 104.

Chopra, G.S. 1975. *Taxonomy of Indian Mosses*. Publications and Information Directorate (CSIR), New Delhi.

Cislaghi, C. and Nimis, P.L. 1997. Lichens, air pollution and lung cancer. *Nature*, 387: 463-464.

Coote, L. *et al.* 2008. Epiphytic of Sitka spruce (*Picea sitchensis*) plantation in Ireland and the effect of open spaces. *Biodivers. Conserv*. DOI 10.1007/s10531-007-9302-3) *CRC Handbook of Lichenology*. *Vol. 1*. CRC Press, Boca Raton, Florida, pp. 181-189.

Crespo. A. and Barreno, E. 1978. Sobre las communidads terricolas de liquenes vagantes. (Sphaerothalloi-Xanthoparmelion vagantis al. nova.) Acta Botanica Malacitana, **4**: 55-62.

Culberson, C.F. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. *J. Chromat.,* 72: 113-125.

Culberson, W.L. 1964. The life of the lichens. *The Garden Journal*. De Vera, J.P., Horneck, G., Rettberg, P., Ott, S. (2004). The potential of the lichen symbiosis to cope with the extreme conditions of outer space II: germination capacity of lichen ascospores in response to simulated space conditions. *Advances in Space Research*. 33: 1236-1243.

Degelius, G. 1964. Biological studies of epiphytic vegetation on twigs of *Fraxinus excelcior*. *Acta Harti Gothoburgensis*, **27**: 11-55.

Degelius, G. 1972. Further studies on the epiphytic vegetation on twigs. *Acta Universitatis Gothoburgensis Botanik Gothuburg*, 7: 1-58.

Divakar, P.K. & Upreti, D.K.. 2005. Permeloid Lichens in India (A Revisionary Study). Bishen Singh Mahendra Pal Singh, Dehradun, Pp. 488.

Divakar, P.K. and Upreti, D.K. 2003. New species and new records of *Parmotrema* (Parmeliaceae) from India. *The Lichenologist*, **35(1):** 21-26.

Divakar, P.K. and Upreti, D.K. 2005b. Parmeloid lichens of India, BSMPS Publications, Dehradun.

Divakar, P.K. and Upreti, D.K. 2006. Notes on some new records and new species of Cetrarioid lichens from India. *Bot. J. Linn. Soc*., **150**: 249-251.

Dubey, U., Upreti, D.K. and Rout, J. 2007. Lichen flora of Along town, West Siang District, Arunachal Pradesh. *Phytotaxonomy*, 7: 2-26.

Dubey, U. (2009). Assessment of lichen diversity and distribution for prospecting the ecological and economic potential of lichens in and around Along town, west Siang district, arunachal Pradesh. Ph. D Thesis, Assam University.

Dülger B, Gucin F, Kara A, Aslan A., 1997. Antimicrobial activities of the lichen *Usnea florida* (L.) Wigg. *Turk. J. Biol.*, **21**: 103-108.

Dülger, B., Gucin, F., Aslan, A., 1998. Antimicrobial activity of the lichen *Cetraria islandica* (L.). Ach. *Turk. J. Biol.*, **22**: 111-18.

Esimone, C.O., Adikwn, M.U. 1999: Antimicrobial activity of the cytotoxicity of *Ramalina farinacea*. *Fitoterapia*, **7**: 428-431.

Eversman, S. 1982. Epiphytic lichens of a ponderosa pine forest in south eastern Montana. *Bryologist* , 85**(2):** 204-213.

Eversman, S., Johanson, E. and Gustofson, D. 1987. Vertical distribution of epiphytic lichens on three tree species in yellow stone Natural Park. *Bryologist*, **90(3):** 212-216.

Fazio A.T., Adler, M.T., Bertoni, M.D., Sepulveda, C.S., Damonte E.B., Maier, M.S. 2007: Lichen secondary metabolites from the cultured lichen mycobionts of *Teloschistes chrysoph-thalmus* and *Ramalina celastri* and their antiviral activities. *Z. Naturforsch,* **62**: 543-549.

Ferry, D.W., Baddeley, M.S. and Hawksworth, D.L. 1973. *Air Pollution and Lichens*. The Athlone Press, London.

Fries, E. 1925.Systema Orbis Vegetabilis. Paris. I. Lund.Gadgil, M. 1994. Inventoring, monitoring and conserving India's biological Diversity. *Curr. Sci.*, **66(6):** 401-406.

Gadgil, M. and Meher-Homji, V.M. 1990. Ecological diversity; In: Conservation in Developing Countries: Problems and Prospects. (Eds. J.C. Daniels and J.S. Serrao), pp.175-198. In proceedings of the centenary seminar of the Bombay natural History society. Bombay, BNHS and oxford University Press.

Garty, J. 1996. Lichens as bioindicator for heavy metal pollution. In B. Markert (Ed.). *Plants as biomonitors*. VCH Verlagsgesellschaft mbh, Publishers Inc., New York, Germany, pp. 193-263.

Gauslaa, Y. 1985. The ecology of labarion pulmonaric and parelion caperatae in quareous dominated forests in south-west Norway. *Lichenologist* , **17**: 117-140.

Gilbert, O. 2004 *Lichens naturally Scottish.* Scottish Natural Heritage, Perth.

Goel M, Dureja P, Rani A, Uniyal P L, Laatsch H, 2011. "Isolation, characterization and antifungal activity of major constituents of the Himalayan lichen *Parmelia reticulate* Tayl. *J. Agri. and Food Chem.,* 59: 2299-2307.

Goel M, Sharma PK, Dureja P, Rani A, Unilal PL., 2011. Antifungal activity of extracts of the lichens *Parmelia reticulata*, *Ramalina roesleri*, *Usnea longissima* and *Stereocaulon himalayense*. *Archieves of Phytopath. and Pl. Protection*, **44(13):** 1300-1311. http:/dx.doi.org/10.1080/03235408.2010.496549

Gough, L.P. 1975. Cryptogram distribution on *Pseudotruga meziesii* and *Abies lasiocarpa* in the Front Range, Boulder Country, Colorado. *Bryologist*, **78**: 124-145.

Groombridge, B. 1992. *Global Biodiversity: Status of Earth's living resources*. Chapman and Hall.

Gulluce M, Aslan A, Sokmen M, Sahin F, Adiguzel A., Agar G., Sokmen A, 2006. Screening the antioxidant and antimicrobial properties of the lichens *Parmelia saxatilis, Platismatia glauca, Ramalina pollinaria, Ramalina polymorpha* and *Umbilicaria nylanderiana.Phytomedicine*, **13**: 515 - 521.

Gustafsson, L., Fiskes, O.A., Ingellog, T., Peterson, B. and Thor, G. 91992). Factors of importance to some lichen species of deciduous broad-leaved woods in southern Sweden. *Lichenologist*, **24**: 225-266.

Halama P, Van Haluwin C, 2004. Antifungal activity of lichen extracts and lichenic acids. *Bio Control*, **49**: 95-107.

Hale, M.E. 1952. Vertical distribution of cryptogams in a virgin forest in Wisconlin. *Ecology*, **33**: 398-406.

Hale, M.E. (Jr.) 1979. *How to know the lichens*. Dubuque.

Hale, M.E. 1967. *The Biology of Lichens*. Edward Arnold ltd. London, pp. 176.

Hale, M.E. 1983. *The Biology of Lichens*. 3rd Ed. Edward Arnold Ltd. London.

Haridasan, K. and Rao, R.R. 1985-'87. Forest flora of Meghalaya. Vol. I and II. Bishen Singh and Mahendra Pal Singh, Dehradun.

Harris, G.P. 1971. The ecology of corticolous lichen I. the zonation on oak and biren in south devon. *Journal of Ecology*, **59**: 431-439.

Hawksworth, D. L. 1988. Conidiomata, conidiogenesis and conidia. In: Galun, M (Ed.).

Hawksworth D.L., Hill D.J. 1984 *The Lichen-Forming Fungi*. Glasgow Blackie & Son Limited.

Hawksworth, D.L. and Rose, F. 1970. Quantitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens. *Nature*, **227**: 145-148.

Hilitizer, A. 1925. Stude sur la vegetation de la Boheme. *Publications de la Faculte de Sciences de l' universite Charles, Prague, Cislo*, **41**: 1-200.

Holien, H. 1998. Lichen in spruce forest stands of different successional stages in Central Norway with emphasis on diversity and old growth species. *Nova Hedwigia*, **66**: 238-324.

Holonen, P., Hyvarinen, M. 1991. The epiphytic lichen flora on conifers in relation to climate in the Finnish middle Boreal subzone. *Lichenologist*, **23: (1):** 61-72.

Huneck S, 1999. The Significance of lichens and their metabolites. *Naturwissenschaften*, 559-570.

Huneck, S, 1999. "The significance of lichens and their metabolites," Naturwissenschaften, **86(12):**559–570.

Hyvarien, M., Holonen, P. and Kanppi, M. 1992. Influence of stand age and structure on the epiphytic lichen vegetation in the middle-boreal forest of Finland. *Lichenologist*, 24: 165-180.

Ingolfsdottir, K, Chung, G.A, Skulason, V.G, Gissurarson, S.R, Vilhelmsdottir, M, 1998.

Ingondolfsdottir, K. 2002. Usnic acid. *Phytochemistry*, **61**: 729-736.

Jagadeesh, R.T.A.M., Sinha, G.P., Luckin, R. and Lumbsch, H.T. 2006. A new species of Chrysothrix (Arthoniales: Arthoniaceae) from India. *Lichenologist,* **38(2):** 127-129.

James, P.W. 1973. Introduction. *In*: Air Pollution and lichens (Eds. B.W. Ferry, M.S.Baddeley and D.L. Hawksworth). *Atholane Press of the University of London*, London, pp.1-5.

Jamir, N.S. and Rao, R.R. 1988. The Ferns of Nagaland. Bishen Singh and Mahendra Pal Singh, Dehradun.

Jang, C. H., Eun, J. S., Park, H. W., Seo, S. M., Yang, J. H.,Leem, K. H., Oh, S. H., Oh, C. H., Baek, N. I. and Kim, D. K.2003. An acetylcholinesterase inhibitor from the leaves of Securinega suffruticosa. *Kor. J. Pharmacong*., **34**:14-17.

Johansson, P. and Ehrlen, J. 2003. Influence of habitat quantity, quality and isolation on the distribution and abundance of two epiphytic lichens. *Journal of Ecology*, **91**: 213-221.

John, E. 1992. Distribution patterns and interthaline interactions of epiphytic foliose lichens. *Canadian J. of Bot*., **70**: 818-823.

John, E. 1995. Neighbor relation within a community of epiphytic lichens and bryophytes.*Bryologist*, **98**: 29-37.

Joshi, S. Upreti, D.K & Nayaka, S. 2012. The Lichen genus Chapsa (Graphidaceae) in India. *Mycotaxon*, **120(11):** 23-33.

Joshi, Y. 2008. Morphotaxonomic Studies on Lichen family Teloschistaceae from India. Dept.of Botany, University of Kamaun, Nanital (Ph. D. Thesis).

Kalb, K., Staiger, B. Elix, J. A. 2004. A monograph of the lichen genus *Diorygma* – a first attempt. *Symbolae Botanicae Upsalienses*, **34(1):** 133-167.

Kambar Y, Vivek MN, Manasa M, Kekuda P.T.R, Nawaz N.A.S, 2013. "Inhibitory effect of cow urine against *Colletotrichum capsici* isolated from anthracnose of Chilli (*Capsicum annuum* L.)" *Sci., Techno. and Arts Res. J.,* **2(4):** 91-93.

Kandler, O. and Poelt, J. 1984. Wiederbesiedlung der Innenstadt von Munchen durch Flechten-*Naturwiss. Rundschau*, **37**: 90-95.

Kanjilal, U,N., Kanjilal, P.C. Das, A., De, R.N. and Bor, N.L. 1934. Flora of Assam. vol. 5, Government Press Shillong.

Kappen, L., Schoeter, B., Scheidegger, C., sommerkorn, M. and Hestmark, G. 1996. Cold resistance and metabolic activity of lichen below 0°C. *Adv. Space Res*. **18(12):** 119-128.

Kataki, S.K. 1986. Orchids of Meghalaya, Forest Department, Government of Meghalaya Shillong.

Kekuda, P.T.R, Vivek, M.N, Yashoda Kambar, Manasa, M, 2014. Biocontrol Potential of *Parmotrema* species against *Colletotrichum capsici* isolated from anthranose of chilli. *J. Biolog. & Sci. Opin*, **2(2):** 116-169.

Kershaw, K.A. 1964. Preliminary observations on the distribution and ecology of epiphytic lichen in Wales. *Lichenologist*, 2: 263-276.

Kirk, P.M., Cannon, P.F., David, J.C., Stalpers, J.A. 2001 *Ainsworth & Bisby's* Dictionary of the Fungi, 9th Edition. Surrey. CABI Bioscience.

Knight, A.H., Crooke, W.M. and Inkson, R.M.E. 1961. Cation-exchange capacities of tissues of higher and related uronic-acid contents. *Nature*, 192: 142-143.

Korg, H. 1951. Microchemical studies on *Parmelia*. *Nytt Mag Natur*., **88**: 57-85.

Kristmundsdottir, T., Aradottir, H.A.E., Ingolfsdottir, K., Ogsmundsdottir, H. M, 2002. Solubilization of the lichen metabolite (+) –usnic acid for testing in tissue culture. *J.Pharm. Pharmacol*., **54**: 1447-1452.

Krystle Angelique A. Santiago, Jayne Nicholei C. Borricano, Joecela N. Canal, Denisse Marie A,Marcelo1, Myleen Claire P. Perez1, and Thomas Edison E. dela Cruz, 2010. *Philippine Science Letters*, 2: pp. 18.

Kumar, K. and Upreti, D.K. 2001. Parmelia spp. (Lichens) in ancient medicinal plant lore of India. *Economic Botany*, **5**: 458-459.

Kurokawa, S. 1966. Anaptychiae and Parmeliae. In: *The Flora of Eastern Himalaya*. (ed. H. Harao, Tokyo, pp. 605-610.

Lange, O.L. 2000. Photosynthetic performance of a gelatinous lichen under temperate habitat conditions: long-term monitoring of CO_2 exchange of *Collema cristatum*. *Bibl. Lichenol*., **75**: 307-332.

Lange, O.L. 2002. Photosynthetic productivity of the epilithic lichen under temperate habitat conditions: long-term monitoring of CO_2 exchange and its physiological interpretation I.Dependence of photosynthesis on water content, light, temperature, and CO_2 concentration from laboratory measurements. *Flora*, **197**: 233-249.

Lange, O.L. 2003. Photosynthetic productivity of the epilithic lichen *Lecanora muralis*: long-term field monitoring of CO_2 exchange and its physiological interpretation II. Diel and seasonal patterns of net photosynthesis and respiration. *Flora*, **198**: 55-70.

Lange, O.L., leisner, J.M.R. and Bilger, W. 1999. Chlorophyll fluorescence characteristics of the cyanobacterial lichen *Peltigera rufescens* under field conditions II. Diel and annual distribution of metabolic activity and possible mechanisms to avoid photo inhibition. *Flora*, 194: 413-430.

Lawrence, E. 2005 *Henderson's Dictionary of Biology*. Essex. Pearson Education Limited.

Linnaeus, C. 1753. Species Plantarum. (Stockholm). Pp. 1200.

Logesh A.R, Chinlampianga, M, Shukla, A.C, Upreti, D.K., 2015. Studies on Lichens of Mizoram, Northeast India. Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci. DOI 10.1007/s40011-015-0592-z. Pub. Online by Springer.

Longton, R.E. 1988. *Biology of polar Bryophytes and Lichens*. Cambridge University press.Cambridge.

Lumsbsch, H.T. 1994. Die *Lecanora subfusca*- Gruppe in Australasien. *J. Hattori Bot. Lab*. 77:1-175.

Mangold, A., Elix, J.A., & Lumbsch, H.T. 2009. Thelotremataceae. In Flora of Australia Volume 57. Lichens, 5 (Ed. P.M. Mc Carthy). ABRS and CSIRO Publishing, Canberra and Melbourne. Pp. 195-420.

Manojlovic, N. T, Vasiljevic, P.J, and Markovic, Z.S, 2010. "Antimicrobial activity of extracts and various fractions of chloroform extract from the lichen *Laurera benguelensis*," *J. Biolog. Res.*, **13**: 27–34.

Manojlovic, N.T, Solujic, S and Sukdolak, S. 2002. "Antimicrobial activity of an extract and anthraquinones from *Caloplaca schaereri*," *Lichenologist*, **34(1):** 83–85.

Manojlovic, N.T, Vasiljevic, P, Juskovic, M, Najman, S, Jankovic, S and Milenkovic-Andjelkovic, A 2010. "HPLC analysis and cytotoxic potential of extracts from the lichen, *Thamnolia vermicularis* var. *subuliformis*," *J. Medi. Pl. Res*., **4(9):** 817–823.

Manojlovic, T. N., Solujic, S. & Sukdolak, S. 2002. Antimicrobial activity of an extract and anthraquinones from *Caloplaca schaerei*. *Lichenologist* **34**: 83-85.

Marbbach, B. (2000). Corticole and lignicole Aeten der Flechtengattung *Buellia sensu lato* in den Subtropen und Tropen. *Biblioth. Lichenol*., Bd. 74, *J. Cramer, Berlin, Stuttgart*.

Marques, M. R, 2002. Bioactive derivatives obtained from lecanoric acid, a constituent of the lichen *Parmotrema tinctorum* (Nyl.) Hale (Parmeliaceae). *Revista Brasileira de Farmacognosia*, **12**: 74-75.

Masoodi L, Anwar A, Ahmed S, Sofi T.A. 2013. Cultural, morphological and pathogenic variability in *Colletotrichum capsici* causing die back and fruit rot in chilli. *Asian J. Pt.Path.*, **7(1):** 29-41.

Mc Cune, B. 1990. Rapid estimation of abundance of epiphytes on branches. *Bryologist*, **93(1):** 39-43.

Mc Cune, B. 2000. Lichen communities as an indicator of forest health. *Bryologist*, **103(2):** 353-356.

Mikhailova, I.N. and Vorobeichik, E.L.1999. Dimensional and age structure of population of epiphytic lichen *Hypogymnia physodes* (L)Nyl. Under conditions of Atmospheric population. Russion *J. Ecology*, **30(2):** 111-118.

Mishra, G.K. and Upreti, D.K 2015. Lichen Flora of Kumaun Himalaya. Ed. Pub. Omniscriptum Gmbh & Company Kg., pp. 620.

Mitrovic, T., Stamenkovic, S., Cvetkovic, V., Tosic, S., Stankovic, M., Radojevic, I., Stefanovic, O., Comic, Lj., Dacic, D., Curcic, M., Markovic, M. 2011: Antioxidant, antimicrobial and antiproliferative activities of five lichen species. *Int. J. Mol. Sci*., **12**: 5428-5448.

Molnar, Y and E. Farkas, E 2010. "Current results on biological activities of lichen secondary metabolites: a review," Zeitschrift fur Naturforschung-Section C. *J. Biosci*., **65(3-4)**:157–173.

Muller Argoviensis, J. 1891. Lichennologische Beitrage XXXV. *Flora*, **74**: 371-383.

Muller Argoviensis, J. 1892. Lichenes Manipurensis a.cl. Dr. G. Watt circa Manipur ad limites orientales Indiae Orientalis, 1881-82 lecti. *J Linn. Soc. Bot*., **29**: 217-231.

Muller Argoviensis, J. 1895. Lichenes Sikkimensis. Bull. Herb. Bioss., **3**: 194-195.

Nash, T.H. III and Wirth, V. (Eds) 1988. Lichen, bryophytes and air quality. *Biblitheca Lichenologica*, **30**: 1-297.

Nash, T.H. and Egan, R.S. 1988. The biology of lichen and bryophytes. In: *Lichens, Bryophytes and air quality*. (Eds. T.H. Nash and V. Wirth). Bibliotheca Lichenologica, Berlin, Germany, pp. 11-22.

National Committee for Clincal Laboratory Standards.Nccls Document, 1997; M26-P Villanova.

Nayaka, S. and Upreti, D.K. 2002. Lichen flora of Sharvati river basin, Shimoga district, Karnataka, India, with six new records. *J. Econ. Taxon. Bot*., **27(3):** 627-648.

Nayaka, S., Upreti, D.K. and Divakar, P.K. 2001. Distribution and diversity of lichens in Meghamalai wildlife sanctuary, Kambam district, Tamilnadu, India. *Biol. Memoirs*., **27(2):** 51-58.

Nayaka. S 2004. Revisionary Studies on Lichen Genus *Lecanora* Sensu Lato in India. Dept. of Botany, Dr. R.M. L Avard University, Faizabad (Ph. D Thesis).

Nayaka, S., 2013. Lichens: collection, preservation and identification. Proc. of national level training course on Classical and modern methods in Plant Systematics, organized by CSIR-national Botanical Research Institute (NBRI), Lucknow held from 4-10th March, 2013

Negi, H.R. 1999a. Lichen Community Ecology. In: *Biology of Lichens*. (Eds. K.G. Mukherji, B.P. Chamola, D.K. Upreti and R.R. Upadhyay). Aravali book International, New Delhi, pp. 17-28.

Negi, H.R. 2000a. On the patterns of abundance and diversity of macrolichens of Chopra-Tunganath in the Garhwal Himalaya. *J. Biosci*., **25(4):** 367-378.

Negi, H.R. 2001. Community Ecology of Lichens and Mosses of Nanda Devi Biosphere Reserve. In: *Plant Diversity of Himalayas* (Eds. P.C. Pande and S.S. Samant). Gyanodaya Prakashan, Nanital, pp. 291-314.

Negi, H.R. and Gadgil, M.G. 1996. Patterns of distribution of Macrolichens in Western parts of Nanda Devi Bioreserve. *Curr. Sci*., **71(7):** 568-575.

Negi, H.R. and Upreti, D.K. 2000. Species diversity and relative abundance of lichens in Rumbek catchments area of hemis national park in Ladakh. *Curr. Sci*., **78**: 1112.

Neitlich, P. , Rogers, P. and Rosetrata, R. (2003). Lichen communities indicator results from Idaho: Baseline sampling. Gen. Tec. Rep. RMRS-GTR-103 Fort Collins, Co; U.S. Department of Agriculture, Forest Service, Research Station, 14.

Nimis, P.L. 1991. Developments in Lichen community studies. *Lichenologist*, **23(3):** 215-225.

Nimis, P.L., Scheidegger, C. and Wolselcy, P.A. 2002. *Monitoring with lichens monitoring lichens*. Khuwer Academic, Dordreeht.

Nyangababo, J.T. 1987. Lichens as monitors of aerial heavy metal pollutants in and around Kampala. *Bull. Environ. Contam. Toxicol*., **38**:91-95.

Nylander, W. 1860. Synopsis Methodica Lichenum, Tomus primus, Paris.

Ochener, F. 1928. Studien uber die Epiphyten vegetation der Schweig. *Fahbucher der St. Gallischen naturwissen lichen Gesselschaft*, **63**: 1-106.

Okuyama, E., Umeyama, K., Yamazaki, M., Kinoshita, Y., Yamamoto, Y. 1995: usnic acid and diffractaic acid as analgesic and antipyretic components of *Usnea diffracta*. *Planta Med*, **61**:113-115.

Oquist, G. and Huner, N.P.A. 2003. Photosynthesis of overwintering evergreen plants. *Annu. Rev. Plant Biol*., 54: 329-355.

Patwardhan, P.G. and Nagarkar, M.B. 1979. Notes on some lichens from North East India-I: Graphidaceae. *Biovigyanam*, **5**: 131-138.

Patwardhan, P.G. and Nagarkar, M.B. 1980. Notes on some lichens from North East India-II: Thelotremataceae. *Biovigyanam*, **6**: 1- 10.

Peck, J.E., Hong, W.S. and MC Cune, B. 1995. Diversity of epiphytic Bryophytes on three host tree species, thermal meadow, Hotsprings Island, Queen Charlotte Islands, Canada. The *Bryologist*, **98(1)**: 123-128.

Perry NB, Benn MH, Brennan NJ, Burgess EJ, Ellis G. Galloway D J, Lorimer SD, Tangney S 1999. Antimicrobial, antiviral and cytotoxic activity of New Zealand lichens. *Lichenologist*, **31**: 627-636.

Peterson, E.B. and Mc Cune, B. 2003. The importance of hotspot of lichen diversity in forests of Western Oregeon. *Bryologist*, **106**: 245-256.

Pinokiyo, A. and Singh, K.P. 2006. New species and new record of foliicolous lichenized fungi from Sikkim (India). *Mycotaxon*, **97**: 57-61.

Pinokiyo, A.,Singh, K.P. and Borthakur, S.K. 2005. Foliicolous species of *Porina* (lichens) from Arunachal Pradesh (India). *Indian J. Forestry*, **27**: 407-416.

Pinokiyo, A., Singh, K.P. and Singh J.S. 2008. Diversity and distribution of lichens in relation to altitude within a protected biodiversity hotspot, orth east India. *Lichenologist*, **40(1)**: 47-62.

Prashith Kekuda T.R, Vivek M.N, Yashoda Kambar, Manasa M.(2014). Boicontrol potential of *Parmotrema* species against *Colletotrichum capsici* isolated from Anthracnose of chilli. *J. Biol Sci. Opin*, **2(2):** 166-169.http:/dx.doi.org/10.7897/2321-6328.02238

Preeti S,. Babiah, Upreti, D.K. and John, S.A. 2014. An *in vitro* analysis of antifungal potential of lichen species *Parmotrema reticulatum* against phytopathogenic fungi. *Int. J. Curr. Microbiol. App. Sci.,* **3(12)**: 511-518.

Puckett, K.J. 1988. Bryophytes and lichens as monitors of metal deposition. In: Lichens, bryophytes and air quality (Eds. T.H. Nash III and V. Wirth). *Biblioth. Lichenol*., **30**: 231-267.

Purvis, O. W., Coppins, B. J., Hawksworth, D. L., James, P. W. & Moore, D. M. 1992. *The Lichen Flora of Great Britain and Ireland*. British Lichen Society and Natural History Museum Publications, London.

Purvis, O.W. 2000. *Lichens*. Natural History Museum, London.

Quaraishi, A.A. 1928. Lichens of Western Himalayas. *Proc.* 15t *Indian Sc. Congr. Abstr.*, pp. 228.

Ranković B, Mišić M, Sukdolak S, 2008. The antimicrobial activity of substances derived from the lichens *Physcia aipolia*, *Umbilicaria polyphylla*, *Parmelia caperata* and *Hypogymnia physodes*. *World J. Microbiol. and Biotech*., **24(7)** : 1239-1242.

Ranković B, Mišić M, Sukdolak S, 2010. Antimicrobial activity of extracts of the lichens *Cladonia furcata*, *Parmelia caperata*, *Parmelia pertusa*, *Hypogymnia physodes* and *Umbilicaria polyphylla*. Biologia., **64(1)** : 53-58.

Ranković, B, Mišić, M, and S. Sukdolak, S., 2007. "Evaluation of antimicrobial activity of the lichens *Lasallia pustulata*, *Parmelia sulcata*, *Umbilicaria crustulosa*, and *Umbilicaria cylindrica,*" Microbiology, **76(6):** 723–727.

Rao, A.S. 1994. The vegetation and phytogeography of Assam-Burma. In: *Eco. and Biogeography of India*. (Ed. M.S. Mani), Hauge, pp. 204-246.

Rao, R.R. and Hajra, P.K. 1986. Floristic diversity of the eastern Himalaya in a conservation perspective. *Proc. Indian Acad. Sci. Suppl.*, 103-125.

Rasanen, V. 1950. Lichens Novi, VI. *Arch. Soc. Zool. Bot. Fernn. 'Vanamo'*, **6(2):** 80-86.

Richardson, D.H.S. 1992. *Pollution monitoring with Lichens*. Naturalists' Hanbooks 19. Richmond Publishing Co. Ltd., Slough, England.

Ritschel, G. 1974. Beitrag zur Kenntnis der Veibretung Xero-und basiphiler Erdfletchen in Mainfranken. Abhandlungen der naturwissenschaftlichen Vereins Wurzburg, **15**: 7-32.

Robert, T.M. 1972. Plants as monitors of airborne metal pollution. *J. Environ. Plant Pollution Control,* **1**: 43-54.

Rogers, R.W.1972. Soil surface lichens in arid and sub arid southeastern Australia. In: Phytosociology and geographic zonation. *Australian J. Botany*, **20**: 215-227.

Rose, F.1974. Lichenological indicators of age and environmental continuity in woodlands. *Systematics Association Spiral Volumes*. **8**: 279-309.

Rose, F. and Hawksworth, D.L.1981. Lichen recolonization in London's cleaner air. Nature, **289**: 289-292.

Rout, J. 2007. Air Pollution Biomonitoring: Lichen as an indicator species. In: *Biodiversity and Environmental Biotechnology*, Chapter 2. Scientific Publishers, Jodhpur, pp. 563.

Rout, J., Rongmei, R. and Das, P. 2005a. Epiphytic lichen flora of a pristine habitat (NIT campus) in Southern Assam, India. *Phytotaxonomy*, **5**: 117-119.

Roux, C. 1981. Etude ecologique et phytosociologique des peuplements licheniques saxicoles calicioles du Sud- Est de al France. *Bibliotheca Lichenologica*, **15**:1-557.

Rozika, R, 2005.Ramhmul damdawite (Medicinal plants) edt. pp. 43.

Saklani, A. and Upreti, D.K.1992. Folk uses of some lichens in Sikkim. *J. of Ethnopharm*., **37**: 229-233.

Sankar Narayan Sinha and Mrinal Biswas, 2011. Evaluation of antibacterial activity of some lichen from Ravangla, Sikkim, India. *Inter. J. Pharma. and Bio Sci*., **2(4b):** 23-28.

Saraswathy A, Rajendiran A, Sarada A, Purushothamam, 1990. Lichen substances of *Parmelia caperata*. *Indian Drugs*, **27**: 460–462.

Sanjeeva, N. 2013. Identification of lichens. 'In Trainining manual on classical and modern methods in plant systematics', CRIR-NBRI, Lucknow.

Schroeter, B. and Sancho, L.G. 1996. Lichens growing on glass in Antartica. *Lichenologist*, **28**: 385-390.

Seaward, M.R.D. 1988. Contributions of lichens to ecosystem. In: *Handbook of Lichenology* Vol. II, (Ed. Margalith Galun) CRC press, Boca Raton. Florida, pp. 107-129.

Selva, S.B. 1994. Lichen diversity and stand continuity in the northern Hardwoods and spruce fir forest of Northern New England and western new Brunswick. *Bryoligist*, **97**: 424-29.

Shahi SK, Shukla AC, Dikshit A, Upreti DK, 2001. Broad spectrum antifungal properties of the lichen *Heterodermia leucomela*. *Lichenologist*, **33**: 177-179.

Sharma, B., Khadilkar, P. & Makhija, U. 2012. New species and new combination in the lichen genera *Fissurina* and *Hemithecium* from India. *Lichenlogist*, **44**: 339-362.

Shukla, A.C. 2010. Bioactivities of the major active constituents isolated from the essential oil of *Cymbopogon flexuosus* (Steud) Wats and *Trachyspermum ammi* L. Sprague as a herbal grain protectants. D.Sc. Thesis, Allahabad University, Allahabad .

Shukla, A.C., Pandey, K.P., Mishra, R.K., Dikshit, A., and Shukla, N. 2011. Broad spectrum antimycotic plant as a potential source of therapeutic agent. J of Natural Products, 4: 42-50.

Shukla, A.C., Chinlampianga, M., Verma, A., Dikshit, A and Upreti, D.K, 2011. Efficacy and potency of lichens of Mizoram as antimycotic agents. Indian Phytopath. **64(4):** 367-370.

Singh, A. 1969. On some foliicolous lichens from Andaman. *Pl. Sci.,* 1: 97-100.

Singh, A. 1970a. *Strigula* and *Raciborskiella* species from Andaman Islands, India. *Bryologist*, **73**: 719-722.

Singh, A. 1970b. On foliicolous species of *Porina* from Andaman Islands, India. *Rev. Bryolog. Lichenolog.*, **37**: 973-992.

Singh, A. 1970c. On foliicolous members of Graphidaceae and Thelotremaceae from Andaman Islands, India. *Pl. Sci.,* **2**: 80-82.

Singh, A. 1971. Some unrecorded and interesting pyrenocarpou lichens from Andaman Islands, India. *Bryologist*, **74**: 195-198.

Singh, A. 1980. Lichenology in Indian subcontinent, 1966-1977. Nat. Bot. Res. Inst. Lucknow.

Singh, A. 1982. Three new species of the lichen genus *Anthracothecium* from eastern Himalayas (India). *Feddes Repertorium*, **93**: 67- 69.

Singh, A. 1983. Two new species of the lichen *Parmentaria* from south India. *Candollea*, **38**: 459-463.

Singh, A. 1984. The lichen genus *Anthracothecium* from Manipur, India. *Geophytology*, **14**: 69-73.

Singh, A. 1985a. Two new species of *Anthracothecium* from India. *Indian J. Biol. Res.*, 1: 82-85.

Singh, A. 1985b. Observations on some taxa of the lichen genus *Anthracothecium*. *Geophytology*, **15**: 98-109.

Singh, A. and Roychowdhury, K.N. 1982. Some Pyrenocarpous lichens from 24-pargannas district, West Bengal, India. 1. *Anthracothecium* – 2. *New Botanist*, **9**: 33-37.

Singh, A. and Upreti, D.K. 1984. The lichen genus *Endocarpon* from India. *Candollea*, 39:539-548.

Singh, A. and Upreti, D.K. 1986. Lichen genus *Pleurotheliopsis* from Indian suncontinent. *Geophytology*, **16**: 261-263.

Singh, K.P. and Bujarbarua, P. 2001. Lichenology in North East India with special reference to Arunachal Pradesh. *Forest news, SFRI, Itanagar, Arunachal Pradesh.*

Singh, K.P. 1977. Three new species of foliicolous lichen from India. *Curr. Sci.*, 46: 457-458.

Singh, K.P. 1978. Lichen genus *Echinoplaca* Fee, from India. *Geophytology*, 129-130.

Singh, K.P. 1979. Lichen genus *Asterothyrium* Mull. Arg. in India. *Curr. Sci*., **46**: 267-268.

Singh, K.P. 1980a. *Awasthiella,* a new lichen genus from Manipur, India. *Norw. J. Bot*., **27**:33-35.

Singh, K.P. 1980b. Lichen genus *Maronea* Massal. In India. *Geophytology,* 10: 34-36.

Singh, K.P. 1980c. Lichens new to Indian flora. *Geophytology,* **10**: 272-274.

Singh, K.P. 1981a. Macrolichens from Manipur, India. *Biol. Memoirs, Lucknow,* **9**: 105-150.

Singh, K.P. 1981b. Macrolichens from Manipur, India. *Biol. Mem.,* **6(2):** 145-168.

Singh, K.P. 1983. *Catillaria manipurensis*, a new species of lichens and a note on *Lopadium austroindicum* from India. *Curr. Sci*., **52**: 165-166.

Singh, K.P. 1984. Synopsis of lichens from Palni Hills. *Biol. Memoirs, Lucknow.,* **9**: 105-150.

Singh, K.P. 1996. *Lichens*. In: Aq contribution to the flora of Nambhadapa, Arunachal Pradesh. (Ed. P.K. Hajra). Bot. Surv. India. Howrah, pp. 23-46.

Singh, K.P. 1981. Microlichens from Manipur, India. *Geophytology*, **11(2):** 242-256.

Singh, K.P. and Awasthi, D.D. 1979. Lichen genus *Phaeographis* from India and Sri Lanka. *Bull. Bot. Surv. India*, **21(1-4):** 97-120.

Singh, K.P. and Nongkynrih, J. 1984. Lichens new to Indian lichen flora-II. *Geophytology*,**14 (2):**238-239.

Singh, K.P. and Pinokiyo, A. 2003. Foliicolous lichens and their diversity in north - east India. *Proc. Natio. Acad. Sci. India*, B (II) **73**: 177-186.

Singh, K.P. and Singh, S.R. 1982. Two new species of lichen genus *Buellia* from India. *Geophytology*, **12(1):** 126-129.

Singh, K.P. and Singh, S.R. 1984. On the species of *Buellia* and Diplotomma from Manipur, India. *Bull. Bot. surv. Surv. India,* **26 (1-2):** 62-64.

Singh, K.P. and Sinha, G.P. 1994. *Lichen flora of Nagaland*. Bishen Singh Mahendra Pal Singh, Dehradun, pp. 498.

Singh, K.P. and Sinha, G.P. 1997. Lichens. In: *Floristic diversity and Conservation strategies in India* (Eds. V. Mudgal and P.K. Hajra), Vol. 1: 195-234, Botanical Survey of India, Calcutta.

Singh, K.P. and Upreti, D.K. 1986. On the species of *Cladonia* from Arunachal Pradeah, India. *Geophytology*, **16(1):** 113-118.

Singh, K.P. and Pinokiyo, A. 2004. Four foliicolous lichens new to Indian lichen flora.*Geophytology*, **33**: 119-121.

Singh, K.P. Pinokiyo, A. and Borthakur, S.K. 2006. Foliicolous lichens of India with special reference to Arunachal Pradesh. *Indian J. Forestry*, **29**: 219-234.

Singh, K.P. Pinokiyo, A. and Upreti, D.K. 2005. Pyrenoarpous lichens from Arunachal Pradesh, India. *Phytotaxonomy*, **5**: 134-139.

Singh, K.P., Bujarbarua, P., and Dixit, P.K. 2004. A preliminary account of the lichens from Mehao wildlife sanctuary, Arunachal Pradesh, India. *Indian J. Forestry*, **27(3):** 273-278.

Singh, K.P., Sinha, G.P and Bujarbarua, P. 2002. Endemic lichens of India. *Geophytology*, **33**:1-16.

Singh, K.P., Sinha, G.P and Bujarbarua, P. 2004. Endemic lichens of India. *Geophytology*, **33(1-2):** 1-16.

Singh, K.P., Sinha, G.P. (1994). Lichen flora of Ngaland. Bishen Singh and Mahendra Pal Singh, Publishers Dehradun, India.

Singh, K.P., Wadhwa, B.M. and Sinha, G.P. 1989. Species of *Hypotrachyna* (Lichenized Ascomycotina) from North East India (Eds. M.L. Trivedi, G.S. Gill and S.S. Saini). Today and Tomorrow's printers and Publishers, New Delhi, pp. 107-113.

Singh, S. R. & Awasthi, D. D. 1981. The lichen genus *Buellia* in India. *Biol.Memoirs,* **6**:169-196.

Sinha, G.P. and Singh, K.P. 1986. Three new records of foliose lichens from Nagaland, India. *Curr. Sci.*, **55(14):** 661-662.

Sinha, G.P. and Singh, K.P. 1991. A new species of *Phyllobathelium* from Arunachal Pradesh, India. *Geophytology*, **20(2):** 164-165.

Sinha, G.P. and Singh, K.P. 1992. A new species of *Phyllobathelium* from Arunachal Pradesh, India. *Geophytology*, **20(2)**: 164-165.

Sinha, G.P. and Singh, K.P. 1987. Foliicolous lichens from Nagaland, India. *Geophytology,* **17(2):** 174-185.

Sinha, G.P. and Singh, K.P. 2005. Macrolichens of Sikkim. Botanical Survey of India, Kolkata.

Sinha, G.P. and Singh, K.P. 1989. Two new records of foliose from India. *J. Econ. Taxon. Bot.* **13(1)** : 103-105.

Sipman, H. 2005. Identification key and literature guide to the genera of lichenized fungi (Lichens) in the neotropics provisional version. Botanic Garden & Botanical Museum berlin Dahlem, free University of Berlin. Available from http://www.bgbm.org/sipman/keys/neokey A.htm.

Sipman, H.J.M. 1994. Foliicolous lichens on Plastic tape. *Lichenologist*, **26**: 311-312.

Smith, A.L. 1926. Cryptotheciaceae. A family of primitive Lichens. *Trans Brit. Mycol. Soc*. **16**: 128-132.

Smith, A.L. 1931. Lichens from Northern India. *Trans Bot. Mycol. Soc*. **11**: 189-196.

Sochting U 1999. *Lichens of Bhutan. Biodiversity and Use.* Copenhagen Botanical Institute. Department of Mycology, University of Copenhagen.

Søchting, U. 1997. Two major anthraquinone chemosyndromes in *Teloschistaceae. Bib. Lich.* 68: 135-144.

Søchting, U. 2001. Chemosyndromes with chlorinated anthraquinones in the lichen genus *Caloplaca*. *Bib. Lich*. 78: 395-404.

Somermaa, A. 1972. Ecology of epiphytic lichen in main Estonian forest types, Scripta. *Mycologica*, 4: 1-117.

Staiger, B. 2002. Die Flechtenfamile Graphidaceae. Studien in Richtung einer naturlicheren Gliederung. Biblioth. Lichenol., Bd. 85, J. Cramer, Berlin, Stuttgart.

Stirton, J. 1876. Description of recently discovered lichens. *Proc. Phil. Soc. Glasg.,* **10**: 156-164.

Stirton, J. 1879. New rare lichens from India and Himalayas. *Proc. Phil. Soc. Glasgow,* **11**:306-322.

Stirton, J. 1881. On the vegetable parasites in the tea plant, more especially that of Assam. *Proc. Phil. Soc. Glasgow,***13**: 181-193.

Schöller, H. 1997 *Flechten*. Reihe Kleine Senckenberg-Reihe.

Stone, D. 1989. Epiphytic succession on quereusgarryana branches in the Willamette valley of western Oregon. *Bryologist*, **92**: 81-94.

Susheela K. (2012). Evaluation of screening methods for anthracnose disease in chilli. Pest Management in Horticultural Ecosystems, 7(1): 29-41. http://dx.doi.org/10.3923 /ajppaj.2013.29.41.

Thomas, A.D., Hoon, S.R. and Linton, P.E. 2008. Carbon dioxide fluxes from cyanobacteria crusted soils in the Kalahari. Applied Soil Ecology. DOI: 10.1016/j.apsoil.2007.12.015.

Thomas H. Nash III 2008. Lichen Biology (eds.) Cambridge University Press

Thomson, J.W. 1967. The lichen genus *Cladonia* in North America, University of Toronto Press, Toronto.

Thor, G. 1993. The lichen flora in the former Shipyard Eriksbersgsvarvet, Goteborg, Sweden.*Graph. Scr.*, **5**: 77-84.

Tiwari, P., Rai, H., Upreti, D.K., Trivedi,S., Shukla, P. 2011. Assessment of antifungal activity of some Himalayan foliose lichen against plant pathogenic fungi. *Am. J. Plant Sci.,* **2**: 841- 846.

Tuominen, Y. and Jaakkola, T. 1973. Absorption and accumulation of mineral elements and radioactive nucleides. *In: The lichens* (Eds. V. Ahmedjian and M.E. Hale). *Academic Press*, New York and London, 185-233.

Upreti, D.K. 1987. Key to the species of lichen genus *Cladonia* from India and Nepal. *Feddes. Report*, **98**: 469-473.

Upreti, D.K. 1988. A new species of lichen genus *Phylliscum* from India. *Curr. Sci.*, **57**: 906-907.

Upreti, D.K. 1990. Lichen genus *Pyrenula* in India. I. *Pyrenula subducta* – spore type. *J. Hattori Bot. Lab.*, **68**: 269-278.

Upreti, D.K. 1991a. Lichen genus *Pyrenula* from India. IV. *Pyrenula cayennensis* – spore- type. *Cryptogam, Bryolog. Lichenolog.*, **12**: 41-46.

Upreti, D.K. 1991b. Lichen genus *Pyrenula* from India. V. *Pyrenula approximans*- spore- type. *Feddes Repert*, **103**: 279-296.

Upreti, D.K. 1991c. Lichen genus *Pyrenula* from India. The species with spores of *Pyrenula brunnea* type. *Bull. Soc. Bot. France Lett. Bot.* **138**: 241-247.

Upreti, D.K. 1992. Lichen genus *Pyrenula* from India. VII. *Pyrenula mastophora spore*-type. *Feddes Repert*, **103**: 279-296.

Upreti, D.K. 1993. Lichen genus *Pyrenula* from India. II. *Pyrenula comtospora* spore- type, III . *Pyrenula pinguis*-spore-type. *Acta Bot. Galica,* **140**: 519-523.

Upreti, D.K. 1994. Notes on corticolous and saxicolous species of *Porina* from India, with *Porina subhibernica* sp. Nov., *Bryologist*, **97**: 73-79.

Upreti, D.K. 1995. Loss of diversity in Indian lichen flora. *Environmental Conservation*, **22**:362-365.

Upreti, D.K. 1996a. Studies in Indian ethnolichenology: An overview. In: S.K. Jain, ed., Ethnobiology in human welfare. Deep Publication, New Delhi, India.

Upreti, D.K. 1997. Diversity of Himalayan lichens- *Recent Researches in Ecology Environment and Pollution*. 10. *'Himalayan Microbial Diversity'*. Today and Tomorrow Printer and Publishers, New Delhi, pp. 339-347.

Upreti, D.K. 1997. Notes on saxicolous species of *Lecanora subfusca* group in India *Bryologist*, **101**: 256-262.

Upreti, D.K. 1998. A key to the lichen genus *Pyrenula* from India, with nomenclatural notes.Nova Hedw., **66(3-4):** 557-576.

Upreti, D.K. 1998. Diversity of lichens in India. In: *Perspectives in Environment* (Eds. S.K.Agarwal; J.P. Kaushik; K.K. Kaul and A.K. Jain) A.P.H. Publishing Corporation, New Delhi, pp.71-79.

Upreti, D.K. 1998. Notes on Corticolous, K+ yellow species of *Lecanora* in India. *Feddes Repertorium*, **108(3-4):** 185-203.

Upreti, D.K. 2001. Himalayan lichens and their exploitation. In: *Plant Diversity of theHimalaya*. (Eds. P.C. Pande and S.S. Samant). Gyanodaya Prakashan, Nanital, pp. 95-100.

Upreti, D.K. 1994. Notes on corticolous and saxicolous species of *Porina* from India, with *Porina subhibernica* sp. nov. *Bryologist*, **79(1):** 73-79.

Upreti, D.K. and Aptroot, A. 1996. *Lithothelium himalayense*, new pyrenocarpous lichen from India. *Lichenoloist*, **28**: 89-91.

Upreti, D.K. and Budel, B. 1990. The lichen genera *Heppia* and *Peltula* in India. *J. Hattori Bot. Lab.*, **68**: 274-284.

Upreti, D.K. and Chatterjee, S. 1997. Notes on some Indian species of *Lecanora* sp. Str. with a dark hypothecium. *Feddes Repert*, **108(7-8):** 575-582.

Upreti, D.K. and Chatterjee, S. 1998. Lichen genus *Lecanora* subgenus *Placodium* in India. *Feddes Repert*, **109(3-4):** 279-289.

Upreti, D.K. and Chatterjee, S. 1999a. Distribution of Lichens on *Quercus* and *Pinus* trees in Almora District, Kumaon Himalaya, India. Geophytology, **28(1-2):** 41-49.

Upreti, D.K. and Divakar, P.K. 2003. Distribution of lichens in Corbett Tiger Reserve, Uttaranchal. *J. Econ. Taxon. Bot.*, **27**(Suppl.): 1043-1060.

Upreti, D.K. and Nayaka, S. 2006. *Anisomeridium calcicolum* sp. Nov. and further new records of Pyrenocarpous lichens from India. *The Lichenologist*, **38(3):** 231-233.

Upreti, D.K. and Negi, H.R. 1998. Lichens flora of Chopta-Tunganath, Garhwal Himalayas, India. *J. Econ. Tax. Bot.*, **19**: 627-636.

Upreti, D.K. and Singh, A. 1987a. Lichen genus *Opegrapha* from Andaman Islands. *Cryptogm. Bryolog. Lichenologist*, **8**: 291-300.

Upreti, D.K. and Singh, A. 1987b. *Opegrapha bengalensis,* a new lichen species from India with comments on the taxonomic status of *Schelographa sensu Zahlbruckner*. *Beitr. Biol. Pflanzen*, **62**: 233-237.

Upreti, D.K. and Singh, A. 1987c. Lichen genus *Laurera* from Indian subcontinent. *Bull. Jord. Bot. Nat. Belg*., **57**: 367-383.

Upreti, D.K. and Singh, A. 1987d. A new species of *Porina* from Andaman Islands, India. *Bot. J. Eco. Linn. Soc.,* **94**: 399-402.

Upreti, D.K. and Singh, A. 1987e. Lichen genus *Parathelium* from India. *J. Eco. Tax. Bot*. **10**: 236-237.

Upreti, D.K. and Singh, A. 1987f. Two brown spored species of the lichen genus *Polyblastiopsis*. *Brunonia*, **10**: 225-229.

Upreti, D.K. and Singh, A. 1988a. Lichen genus *Parmentaria* from Indian subcontinent. *Candollea*, **43**: 109-121.

Upreti, D.K. and Singh, A. 1988b. Revision of the lichen genus *Pyrenula* from Sri Lanka. *Geophytology*, 18: 67-77.

Upreti, D.K., Chatterjee, S. and Divakar, P.K. 2004. Addition to the lichen flora of Sikkim,India. In: *Vistas in Palaeobotany and Plant morphology*: *Evolutionary and Environmental Perspectives* (Ed. P.C. Srivastava), pp. 329-338.

Upreti, D.K., Divakar, P.K. and Nayaka, S. 2005. Commercial and ethnic use of lichens in India. *Economic Botany*, **59(3):** 269-273.

Upreti, D.K., Nayaka, S. and Satya. 2005. Enumeration of lichens from Madhya Pradesh and Chattishgarh, India. *J. Appl. Biosci*., **31(1):** 55-63.

Upreti, D.K., Nayaka, S. Tandon, J. and Bajpai, A. 2007. Lichens of Kolkata city and Indian Botanical Gardens, West Bengal. *J. Appl. Biosci*., **33(1):** 70-72.

Upreti, D.K., Pant, V. and Divakar, P.K. 2002. Exploration of lichens from Pithoragarh District, Uttaranchal. *Ethnobotany*, **14**: 60-62.

V. Shukla, V, Joshi, G. P, and Rawat, M. S. M, 2010. "Lichens as a potential natural source of bioactive compounds: a review," *Phytochemistry Reviews*, **9(2):** 303–314.

Vinayaka KS, Shetty S, Krishnamurthy YL (2011). Utilization of lichens in the central Western Ghats of Karnataka, India. British Lichenolog. Soc. Bull. 109: 56-62.

Vrablikova, H., Mc Evoy, M., Solhaug, K.A., Bartak, M. and Gauslaa, Y. 2006. Annual variation in photoacclimation and photoprotection of the photobiont in the foliose lichen *Xanthoria parietina*. *J. Photochem. And Photobiol. B: Biology*, **83**: 151-162.

Walker, F. J. & James, W. 1980. A revised guide and microchemical techniques for the identification of lichen substances. *Bull. Brit. Lich. Soc.* **46**: 13-29 (suppl.).

Walker, F.J. and James, P.W. 1980. A revised guide to the microchemical technique for the identification of lichen products. *Bull. Brit. Lich. Soc*., **46**: 13-29.

Will-Wolf, S., Essen, P.A. and Neitlich, P. 2002. Monitoring Biodiversity and ecosystem function. In: Monitoring with Lichens-Monitoring Lichens (Eds. P.L.Nimis Scheidegger and P.A. Wolseley), Kluwer Academic Publishers. Printed in Neitherlands, pp. 273-279.

Wirth, V.1972. Die Silikafletchen-Gemeinschaften im ausseralpinen Zentraeuropa.Dissertationes Botanicae, **17**: 1-306.

Wolseley, P.A. 1995. A Global perspective on the status of lichens and their conservation. Mitt. Eidgenoss. *Forsch. Anst. Wald Schnee Landsch,* 70(1): 11-27.

Yarranton, G.A. 1972. Distribution and succession of epiphytic lichens on black spruce near Cochrane, Ontorio. *Bryologist*, **75**: 462-480.

Zahlbrucker, A. 1922-40. Catalogus Lichenum Universalis, Vols. 1-10, Leipzig, Verlag Borntrager, Reprint Johnson Reprint Corporation, New York.

Glossary

Systematic investigations and bioprospection of lichens from Murlen National Park, Mizoram

Glossary

Acicular: needle-shape; one end broad and other one tapering.

Adnate: closely attached, adpressed; used for the attachment of ascomata to thallus, or thallus to substratum.

Anstomosing: a joining together to form a net.

Apices: the growing point or trip.

Apothecium [pl. apothecia]: a cup or succer like asum/fruiting body.

Areole: an angular, small portions of a crustose thallus separated from fine cracks.

Articulate: jointed like bones.

Asoma [pl. ascomata]: any asci containing structure; perithecia, apothecia, amazaedium.

Ascospores: reproductive spore formed within an ascus.

Ascus[pl. asci]: cylindrical or clavate sac with ascospores.

Bacillar: rod-shaped.

Bacilliform: cylindrical with rounded ends, bacillus like.

Biatorine: apothecial margin pale or colour [other than dark brown or bak] and lacking algal cells.

Biseriate: in two rows.

Bitunicate: with two function wall layers.

Byssoid: made up of delicate threads, cotton-like.

Capitate: head like, globular mass.

Carbonaceous: black.

Cartilaginous: consisting of a fine, dense, sometimes elastic tissue.

Chroodiscoid: like chroodiscus where apothecia is immersed in the thallus but erumpent, margin formed by the recurved lobes of the ruptured tissue which originally covers the a pothecia.

Cilium [pl. cilia]: hair like structure on margin on lobes.

Clavate: club-like.

Coalescing: joining together.

Concave: hallowed out or basin like.

Concolours: of the same colour.

Confluent: blending or running together.

Convex: equally rounded or broadly obtuse.

Coralloid: coral like often britle [usually of insidia]..

Cortex: the outermost layer of the thallus which, if present consist of compacted hyphae which may appear as either fibrous or cellular.

Corticulous: growing over barks.

Crateriform: cup or crate-like in form.

Crustose: crust-like, used for lichens Having the thallus stretching over and finally fixed to the substratum by the whole of their lower surface, such thalli generally lack r hizines and a lower cortex.

Effigurate: having a definite form or figure like, especially towards margin. Effuse: stretched out flat, especially as a spresding growth without a distinct margin.

Ellipsoid: elliptical in optical section [of spores].

Endophloeodal: immersed in bark.

Epihyminium: upper part of hyminium, consisting of apices of the paraphyses embedded in a gelatinous substance which is often colored.

Epruinose: without pruina.

Euparapletenchymatous: thick tissue with isodimertric lumina or cells.

Euthypiectenchymatous: thick tissue without cellular structure.

Exciple: tissue forming the margns or walls of an ascoma.

Farinose: like flour, fine powder.

Fawn: light brown colour.

Filiform: threads like, worm like.

Fissitunicate: ascus discharge involing the separation of wall layers.

Fissured: cracked, split.

Flexous: wavy.

Foliicolous: growing over leaves.

Foliose: type of thallus with dorsiventral, more or less leaf like appearance, mostly having rhizines on lower surface.

Furcated: forked, split into.

Fruticose: buse like; thallus attachedat one point and remaining parts either erect or hanging; usually circular or angular in cross section.

Fysiform: spindle-like: narrowing towards the ends.

Globose: a spherical or almost so.

Glossy: smooth on shine.

Halonate: surrounded by an outer circle [of spores].

Hamathecium: a neutral term for all kind of hyphae or the other tissues between asci or projecting into the locule or ostiole of an ascoma [of mostly perithecia].

Hapter: attachment organ- it consist of closely or lossely packed rhizinae which usually occur as protuberances on lower surface.

Homoiomerous: having mycobiont ang photobiont component intermixed throughout thallus.

Hyaline: transperant or colourless.

Hyminium: the layer of tissue in which asci arise.

Hypothycium: the tissue below the hyminium and generative layer.

Imbricate: overlapping.

Immarginate: without a margin or well-defined edge.

Inconspicuous: not clearly invisible.

Innate: immersed.

Involucrellum: tissue of upper part of perithecia [often pigmented].

Isidium [pl.isidia]: a corticated, photobiont containing protuberance or out growth of the cortex which may be warty, cylindrical, clavate, scale-like,.

Coralloid: simple or branched.

Laminal: on the upper surface of the thallus.

Lecideine: lacking photobiont cells in exciple, usually dark brown to black in colour.

Lecanorine: like in case of lecanora, with photobiont cells in exciple ; thalline exciple.

Lignicolous: on dead barks.

Lirellae: modified apothecia, with a long narrow disc often branching or + stellate [of family graphidacea and genus opegrapha].

Lobte: thallus divided into lobes.

Lobe: a rounded segment of a divided or incised thallus.

Lobulate: having small lobes.

Lobules: a small lobes forming from the margin or upper surface of larger lobes.

Locule: cell or cavity [of ascospore].

Matt: with a dull surface.

Mealy: pale in colour,.

Microconidium [pl. microconidia]: the smallest conidium in species with two or more conidia types.

Mischoblastiomorphic: characteristic shape of ascospore locules due uneventhickening of walls,..

Moniform: bead like.

Muriform: divided by transverse and vertical or oblique cross walls.

Oblong: twice as long as wide and with rounded or truncate ends, margins parallel.

Obtuse: rounded or blunt.

Obviate: remove.

Ostiole: the opening of perithecia or pycnidia.

Paraphysis [pl.paraphyses]: a slender,jointed,sterile filaments growing upwards in between asci.

Paraplectenchymatous: tissue composed of ispdianetric cells.

Pedicellate: stalked.

Periphysoid: shorte interascal filaments growing down from the top of a perithecia or perithecioid apothecia.

Perithecia: a subglobose or flask like ascoma in which opens by pore called ostiole.

Placodiamorphic: characteristic locule shape in ascospores formed due to uneven walls thickenings.

Placodiod: of a thallus, crustose at the centre and lobulate at the periphery, lacking rhizines on lower side.

Plicate: folted or plates like.

Polaribilocular: [of ascospores] two-celled, the two lumina separated by a thick septum through which a narrow canal passes; locules appearing like two poles; domple shaped.

Prosoplectenchymatous: tissue with thick –walled hyphae havind every minutes lumina.

Prothallus: initial structure of hyphae without algae from which a lichenized thallus develops, often visible a long the edge of the thallua or areoles.

Protuberance: state of protruding, extend beyond.

Pruina: a frost-like or flour like deposition on thallus and apothecial disc

Pruinose: with pruina.

Pulverulent: powdery, dusty.

Pustules: a pimple or blister like swelling, often eroding.

Pycnidium(pl.pycnidia) : ± flask-shaped, small sterile spore (spore) conidia) producing structure

Pycnoconidium: sterile spores produced in pycnidium.

Rammicolous: growing over twigs

Reniform: kidney-like

Rhizines: small root like structures on lower surface

Rimose: finely cracked

Saxicolous: growing over rocks

Scurfy: flaky thallus surface

Sessile: stalkless, attached directly to thallus surface (usually of apothecia)

Soredium: (pl. soredia): granular, loose, ecorticate structure arising from thallus, composed of photobiont cells and fungal hyphae; having the appearance of a powdery granule and capable of reproducing a lichen thallus; a vegetative propagules

Sparingly: moderate

Squamules: small scale-like structures with dorsiventral part attached to the substrate or to the thallus

Squamulose: with squamules

Stellate: star-like

Sterile: not producing sexual spores (ascospores) or ascomata

Stipitate: stalked

Striate: (dark) lined or differentiated into grooves or edges

Stroma: mass or matrix of vegetative hyphae (usually black) with or without tissue of the host substrate

sulcate: grooved

teretiform: circular in transverse section, either narrowing cylindrical or tapering

terricolous: growing over the soil

thallus: the vegetative body, plant body that is not differentiated in to root, stem or leaf

umbilicus: a protuberance at the centre, often the point of attachment e.g. *Umbilicaria*

unitunicate : with one layer (of an ascus which has no inner wall)

uniseriate: in one row or line

urceolate: cup-shaped, urn-shaped, concave, hallow

verrucose: rough, wart like

Curriculum vitae

Annexure - I

Annexure - I

CURRICULAR VITAE OF M.CHINLAMPIANGA

1. **Name** : M.CHINLAMPIANGA

2. **Father's Name** : S.D.LIANA
3. **Date of birth** : 21st November 1982
4. **Permanent address** : Vengthar, Champhai District, Champhai, Mizoram
   House no. : 07, Near SDEO office; Pin. : 796321
   Contact: Mb.Ph.no.: 09436173590
   Email : gualnam21@gmail.com

5. Educational Qualification:

S/no	Qualification	Subject	Year of passing	Board/ University	Percentage of Marks	Division
1	HSLC	Basic	1997	MBSE	42.3	THIRD
2	HSSLC	Science	2002	MBSE	50	SECOND
3	Bachelor/UG	B.Sc(Horticulture)	2006	C A U	78	FIRST
4	Master/PG	M.Sc(Horticulture, Aromatic &Medicinal Plants)	2009	M Z U	79.5	FIRST
5	NET (ICAR)	Horticulture	**2010**			

6. Publications : Full Research papers

2015

1. Logesh, A.R, **M. Chinlampianga**, M, Shukla, A.C, Upreti, D.K, 2015. Studies on Lichens of Mizoram, Northeast India. Proc. Natl. Acad. Sci., India, Sect. B- Biol. Sci., Pub. online by Springer. 31.07.2015. DOI 10.1007/s40011-015-0592-z

2014

1. Shukla, A.C., **Chinlampianga, M.,** Lalsangluaii, F., Gupta, R., Verma, A., Lalramnghinglova, H., 2014. Traditional use of medicinal plants among the tribal communities of Mizoram, Northeast India. *Ethnobotany,* 26 (1&2):1-9 (ISSN: 0971-1252)

2013

1. Lalsangluaii, F., Chinlampianga, M and Shukla, A.C., 2013. Efficacy and potency of *Paris polyphylla* Smith, an ethno-medicinal plant of Mizoram. *Sci. and Techno. J.* 1(1): 36-40. **(ISSN : 2321- 3388)**

2. Chinlampianga, M, Logesh, A.R, Dubey, U., Shukla, A.C and Upreti, D.K., 2013. Preliminary studies on lichen flora of Mizoram, North East India. *Sci. and Technology. Journal.* **1(1):** 22-25. **(ISSN : 2321- 3388)**

3. Chinlampianga, M., Singh, R.K & Shukla, A.C., 2013. Ethnozoological Diversity of Northeast India: Empirical Learning with Traditional Knowledge Holders of Mizoram and Arunachal Pradesh, *Indian J. Trad. Knowl.*, **12(1):** 18-30.

2012

1. **Chinlampianga, M,** Shukla, A. C., Hazarika, T.K., Nautiyal, B.P. and Malsawmkimi, 2012. Plant Resources of Mizoram. (Ed.) Opportunities for Food, Nutrition and Healthcare. Horticulture for Economic Prosperity and Nutritional Security in 21st Century, pp. 264-273. (ISBN: 978-81-85873-97-8)

2. Malsawmkimi, **Chinlampianga, M.,** & Joseph., S., 2012. Genetic Variability in Clove Bean [Ipomoea muricata (l.) Jacq.]. (Ed.) Opportunities for Food, Nutrition and Healthcare. Horticulture for Economic Prosperity and Nutritional Security in 21st Century, pp. 406-409(ISBN: 978-81-85873-97-8)

2011

1. Shukla, A.C., **Chinlampianga**, M., Verma, A Anupam Dikshit., A., and Upreti, D.K., 2011. Efficacy and potency of lichens of Mizoram as antimycotic agents. *Indian Phytopatho.* **64 (4)**:367-370.

2. **Chinlampianga, M**, Shukla, A.C., and Upreti, D.K., 2011. Lichens of Mizoram: Present Status and Future Prospects. (Ed.) Proc. International Conference on Advances in Environmental Chemistry, Mizoram University, Aizawl (Ed.) Diwakar Tiwari. Excel India Publishers, Delhi, pp 127-131 (ISBN: 978-93-81361-53-5)

3. Shukla, A.C., Kumar, A., Chinlampianga, M., Gupta, R., Rohit, K. M., Dikshit., A., 2011. Thymol and Citral Can be a Potential Source of Ecofriendly Management of Drinking Water. (Ed.) Proc. International Conference on Advances in Environmental Chemistry, Mizoram University, Aizawl (Ed.) Diwakar Tiwari. Excel India Publishers, Delhi, pp 127-131 (ISBN: 978-93-81361-53-5)

4. **Chinlampianga**, M. 2011. Traditional knowledge, Weather prediction and bioindicators: A case study in Mizoram, Northeast India. *I. J. Trad. Knowl.*, **10 (1):** 207-211.

Publications & Presentation (Research Articles/Abstracts in conference/seminar/workshop)

2015

1. Participated and presented a paper entitled *'Additional notes on Ethno-medicinal plants from Champhai District, Mizoram'* on the occasion of the National Symposium on **Ethnobotanical Importance in North East India** organized by the Department of Science, Mizoram University, Aizawl in collaboration with Society for Ethnobotanists, NBRI, Lucknow and National Medicinal Plants Board, New Delhli held from 13-15th October, 2015.

2012

1. **Chinlampianga, M,** Shukla, A. C., Hazarika, T.K., Nautiyal, B.P. and Malsawmkimi, 2012. Plant Resources of Mizoram. (Ed.) Opportunities for Food, Nutrition and Healthcare. Horticulture for Economic Prosperity and Nutritional Security in 21st Century, **at National Seminar** on *"Horticulture for Livelihood Security, Economic Prosperity & Sustainable Development"* organized by Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Aizawl, held from 24th to 26thSeptember 2012.

2011.

1. **Chinlampianga, M**, Shukla, A.C., and Upreti, D.K., 2011. Lichens of Mizoram: Present Status and Future Prospects. In **the International Conference** on *'Advances in Environmental Chemistry'* (AEC 2011), organized by Deparment of Chemistry, Mizoram University, Tanhril, Aizawl, Mizoram, India during 16th – 18th November, 2011.

2. Chinlampianga, M, Amritesh C. Shukla and B.P. Nautiyal. 2011. Bio- Indicators for Weather Prediction through Traditional Knowledge in Mizoram. In **the International Conference** on *'Advances in Environmental Chemistry'* (AEC 2011), organized by Deparment of Chemistry, Mizoram University, Tanhril, Aizawl, Mizoram, India during 16th – 18th November, 2011.

3. Chinlampianga, M, Amritesh C. Shukla and Upreti, D.K., 2012. *'Lichen in Mizoram and their Medicinal uses in Traditional Tribal system"* in the National Seminar on "**Environment, Biodiversity, veda and traditional systems**" Jointly organized by Deptt. of Zoology, Mizoram University Aizawl –796004, Mizoram , MANU – International Council for Man and Nature, Asia Chapter, and Action for Sustainable, Efficacious Development and Awareness (ASEA), Rishikesh, Uttarakhand held during 10th – 12thApril, 2012.

4. Chinlampianga, M. and Amritesh C. Shukla, 2011. *"Ethno faunal diversity of Mizoram: An approach from traditional to modern medicine"* in the National Seminar on **Emerging Trends in Biosciences and Future prospects**. By: Organized by Deptt. Of Zoology, Pachhunga University College, Aizawl, 796001 in collaboration with the Deptt. Of Zoology, Mizoram University Aizawl –796004, Mizoram , India during 29th – 30th November, 2011.

2009

1. Chinlampianga, M. and Amritesh C. Shukla, 2009. *Use of **Pheritima** sp. as medicine in ethnic group of Mizoram* , (Proc. of the conf. pp. 39), National Conference on 'Natural Resources Management ' organized by Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Tahril, Aizawl held from 24th - 25th , March **2009**.

2. Chinlampianga, M 2011. *Pseudodrynaria coronaria* Wall.exMett. *An Ethnic herbal plant with potential cure against herpes virus infection.* (ISCA-2011-13MediS-05) pp. 206. I[st] International Science Congress, 24th - 25th , December-2011.Organized by Research Journal of Chemical Sciences, Research Journal of Recent Sciences, Indore, India.

3. Laldinpuia, **Chinlamianga, M.**, and Lalrinthanga, 2012, *'Agricultural marketing in Mizoram: A case study on Cabbage crops in Serchhip district, Mizoram'*. (TS-7-O-8), pp. 123. National seminar on 'Horticulture for livelihood security, economic prosperity & sustainable development, organized by Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Tahril, Aizawl held from 24-26 September, 2012.

4. Malsawmkimi,**M. Chinlamianga** and Salikutty Joseph, 2012,*Performance analysis of Clove Bean (**Ipomoea muricata**(L.) Jacq. Genotypes*. **(TS-1-O-7), pp. 10.** National seminar on 'Horticulture for livelihood security, economic prosperity & sustainable development, organized by Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University, Tahril, Aizawl held from 24-26 September, 2012.

Conference/Symposia/Seminar/workshop/Training : Participation

2014

1. **Science Academies Lecture Workshop,** on *"Vistas Biology, Biotechnology & Biodiversity"* Organized by Department of Horticulture, Aromatic & Medicinal Plants, School of Earth Sciences and Natural resources Management, Mizoram University, Aizawl on **14 – 15th October, '2014**.

2. Participated in the short-term Course on **" Instrumentation"** Organized by UGC, Academic Staff College, Mizoram University held from 22-28th August, 2014.

3. Participated in the workshop on " Capacity Building in Effective Management of Intellectual Property Rights (IPRs) in Biotechnology by Universities and Research Institutes in Mizoram" held at Mizoram University, Aizawl from August 27-28, 2014.

2013

1. Participated and successfully completed the training course on **" Classical and Modern methods in Plant systematic",** held at CSIR-national Botanical Research Institute, Lucknow, during March 4-10, 2013

2011

1. Participated as **Resource Person** in the state level Training Course on "***Documentation and Assessment of Local Health Traditions in Mizoram***" jointly organized by NEIFM, Pasighat, Arunachal Pradesh, FRLHT, Bangalore and Department of Environmental Science, Mizoram University, Tanhril, Aizawl from 17th to 24th May 2011.

2. Participated state level workshop on " *Status and Conservation of Forest Resources in Mizoram*" (7th & 8th April 2011) organized by Department of Environmental Science ,MZU in collaboration with Regional centre, NAEB, NEHU, Shillong.

3. Participated the state level Training Course on " *Documentation and Assessment of Local Health Traditions in Mizoram*" jointly organized by NEIFM, Pasighat, Arunachal Pradesh, FRLHT, Bangalore and department of Environmental Science, Mizoram University, Tanhril, Aizawl from 17th to 24th May 2011.

4. Participated National Level workshop cum Training Programme on *" Recent Advances in Medicinal & Aromatic Plants"* organized by the department of Horticulture, Aromatic & Medicinal Plants, School of Earth Sciences and Natural resources Management, Mizoram University, Aizawl, from 11th to 25th April 2011.

5. Participated training of Master Trainers in "*Study of flora and fauna, documentation and assessment of local health practices"* and exposure visit to south Indian states sponsored by North Eastern Institute of Folk Medicine(NEIFM), Pasighat, Arunachal Pradesh under the Department of AYUSH, Ministry of Health and Family Welfare, Government of India from 17th to 25th March 2011 at the Institute of Ayurveda and Integrative Medicine, Foundation for Revitalization of Local health Traditions, Bangalore , Karnataka.

2010

1. Participated Training course on *"System approach for enhancing rice productivity*" organized ICAR-NEH Region, Umium, Shillong held from 10 to 17 August, 2010. Sponsored by National Agriculture Innovation Project (ICAR), New Delhi.

2009

1. Participated in the department of Biotechnology, Ministry of Science and technology, Government of India sponsored training course on *" Bioinformatics- General Concepts and Application"* organized by the Bioinformatics Infrastructure Facility, Department of Biotechnology, Mizoram University during March 26-27,2009.

2008

1. Participated in the ' *Training on Organic Farming'* held from 14th to 18thMay 2007 conducted by Rural Resource & Training Centre (RRTC), Umran, Meghalaya.

2006

1. Undergone short-term training in modern scientific method of rubber cultivation and processing during the period from 06-03-'06 to 10-03-2006 at Regional Rubber Training Center, Agartala.

Publications & Reprints

Annexure - II

Systematic investigation and bioprospection of lichens from Murlen National Park, Mizoram

List of some research paper/articles publication during research work

Sl. No	Authors and title	Journal / Publishers with ISBN/ISSN No
1	Logesh, A.R, **M. Chinlampianga**, M, Shukla, A.C, Upreti, D.K, 2015. Studies on Lichens of Mizoram, Northeast India.	Proc. Natl. Acad. Sci., India, Sect. B- Biol. Sci., Pub. online by Springer. 31.07.2015. DOI 10.1007/s40011-015-0592-z
2	Lalsangluaii, F., Chinlampianga, M and Shukla, A.C., 2013. Efficacy and potency of *Paris polyphylla* Smith, an ethno-medicinal plant of Mizoram	*Sci. and Techno. J.* 1(1): 36-40. **(ISSN : 2321- 3388)**
3	Chinlampianga, M, Logesh, A.R, Dubey, U., Shukla, A.C and Upreti, D.K., 2013. Preliminary studies on lichen flora of Mizoram, North East India.	*Sci. and Technology. Journal*. **1(1):** 22-25. **(ISSN : 2321- 3388)**
4	**Chinlampianga, M**, Shukla, A.C., and Upreti, D.K., 2011. Lichens of Mizoram: Present Status and Future Prospects.	(Ed.) Proc. International Conference on Advances in Environmental Chemistry, Mizoram University, Aizawl (Ed.) Diwakar Tiwari. Excel India Publishers, Delhi, pp 127-131 (ISBN: 978-93-81361-53-5)
5	Shukla, A.C., Kumar, A., Chinlampianga, M., Gupta, R., Rohit, K. M., Dikshit., A., 2011. Thymol and Citral Can be a Potential Source of Ecofriendly Management of Drinking Water.	(Ed.) Proc. International Conference on Advances in Environmental Chemistry, Mizoram University, Aizawl (Ed.) Diwakar Tiwari. Excel India Publishers, Delhi, pp 127-131 (ISBN: 978-93-81361-53-5)
6	Chinlampianga, M, Amritesh C. Shukla and B.P. Nautiyal. 2011. Bio- Indicators for Weather Prediction through Traditional Knowledge in Mizoram.	(Ed.) Proc. International Conference on *'Advances in Environmental Chemistry, Mizoram* (Ed.) Diwakar Tiwari. Excel India Publishers, Delhi, pp 73-77 (ISBN: 978-93-81361-53-5)
7	Shukla, A.C., **Chinlampianga**, M., Verma, A Anupam Dikshit., A., and Upreti, D.K., 2011.	*Indian Phytopatho*. **64 (4)**:367-370.

1. Logesh, A.R, **M. Chinlampianga**, M, Shukla, A.C, Upreti, D.K, 2015. Studies on Lichens of Mizoram, Northeast India. Proc. Natl. Acad. Sci., India, Sect. B- Biol. Sci., Pub. online by Springer. 31.07.2015. DOI 10.1007/s40011-015-0592-z *(Front Page only*

Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.
DOI 10.1007/s40011-015-0592-z

RESEARCH ARTICLE

Studies on Lichens of Mizoram, Northeast India

A. R. Logesh[1] · M. Chinlampianga[1] · A. C. Shukla[1] · D. K. Upreti[2]

Received: 13 January 2015 / Revised: 3 May 2015 / Accepted: 12 June 2015

Abstract The paper enumerates 159 species of lichens recorded from the Mizoram state of northeast India. *Buellia aeruginascens, Chaenotheca chrysocephala, Disrygma reniforme, Gassicurtia acidobacomyceta, Graphis granulosa, Hafellia dematana, Phyllopsora xoralifera, Ramboldia sorediata, R. subnexa, Relicina sublanea, Stigmatochroma adaucta, S. geronioides, 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

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

Published online: 31 July 2015

2. Lalsangluaii, F., Chinlampianga, M and Shukla, A.C., 2013. Efficacy and potency of *Paris polyphylla* Smith, an ethno-medicinal plant of Mizoram. *Sci. and Techno. J.* 1(1): 36-40. (ISSN : 2321- 3388) *(Front Page only)*

Efficacy and potency of *Paris polyphylla* Smith, an ethno-medicinal plant of Mizoram

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Received October 10, 2012 ; Accepted December 13, 2012

Abstract

Given the present biodiversity status of Mizoram (the Indo-Burma "hotspot" for biodiversity), an integrated approach comprising biodiversity and bio-prospecting documentation, sustainable utilization and conservation of valuable plant resources is urgent. Realizing the importance of *P. polyphylla* Smith., and can be characterized as one of the high value medicinal plant found in the state. This paper describes the important biochemical constituents, biological properties and pharmaceutical importance as well as traditional uses of the plant. It also addresses its propagation and cultivation practiced by some farmers and herbal practitioners' and its trading aspect in Mizoram.

Keywords: Biodiversity, Ethno-medicinal plant, phyto-chemical

Introduction

Medicinal plants are second most valuable bio-resources of Mizoram after water resources. Even though many highly demanded and globally important medicinal plants such as *Swertia* spp., *Neopicrorhiza scrophulariiflora*, *Podophyllum hexandrum*, *Taxus wallichiana*, *Podocarpus* sp. may not be available in the various agroclimatic regions of Mizoram, the state harbors many important medicinal plants which have not been scientifically explored. So far, 500 to 1000 ethnomedicinal and aromatic plants has been documented from the state [1 – 4] but *P. polyphylla* Smith, locally called *Khambal* belongs to family, Liliaceae (Trilliaceae) has not yet been documented. High value medicinal plants form the basis for modern allopathic drug development while the use of indigenous drugs from plant origin forms major part of complementary medicine[6].Conventionally, macroscopic (morphological) and microscopic characters including anatomy, cytology and advanced chemical profiling techniques (HPLC, GC-MS) are being used for characterizing chemotypes, and genotypes (DNA fingerprinting, Barcoding) [7]. Therefore, the present investigation was focused for the exploration, documentation and characterization as well as sustainable utilization and conservation of this highly valuable ethno-medicinal plant in the state.

Materials and Methods

Information was gathered by personal interaction and semi-structure questionnaires with over 25 informants from the local communities (*Paihte* and *Pawih*). These included 8 women and 17 men in the age group 40-60.

Field visits were made during 2008-2009 to the areas surrounding Champhai town and Niawhtlang village, Saiha and nearby areas where the plant is found (Fig. 1)

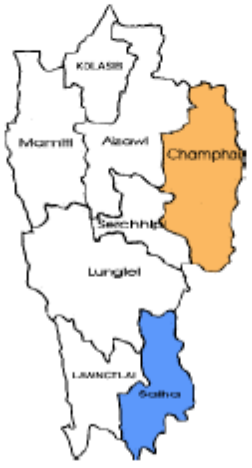

Fig. 1: Site of plant collection- (a) Champhai (b) Saiha

3. Chinlampianga, M, Logesh, A.R, Dubey, U., Shukla, A.C and Upreti,.D.K., 2013. Preliminary studies on lichen flora of Mizoram, North East India. *Sci. and Technology. Journal*. **1(1):** 22-25. **(ISSN : 2321- 3388)**

Preliminary studies on lichen flora of Mizoram, North East India

M. CHINLAMPIANGA[1], A.R. LOGESH[2], URVASHI DUBEY[2], AMRITESH C. SHUKLA[1] AND D.K.UPRETI*[2]

[1]Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizwal – 796004, India
[2]Lichenology Laboratory, Plant Biodiversity, Systematics and Herbarium Division,
CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow – 226001, Uttar Pradesh
Corresponding author's email: upritidknbri@gmail.com ; amriteshmzu@gmail.com

Received September 4, 2012 ; Accepted December 9, 2012

Abstract

Among the different states of India, Mizoram state is poorly explored for the study of lichens. In the present investigation, an enumeration of ten lichen species from the state is provided with brief description of each of the species.

Key words: Lichenized ascomata, Floristic distribution, Northeastern states

Introduction

Indian subcontinent is represented by the occurrence of 2450 lichen species. Fairly good number of lichen records from most of the states of the country are available, however the state of Mizoram is poorly represented for lichens as only 2 species (*Cladonia fruticulosa* Kremp. and *Cladonia submultiformis* Asahina) are known from the area while Tripura has so far not been explored for its lichen wealth [1,2]. Northeastern states are represented by 1165 taxa of lichens of which Arunachal Pradesh represents 480 followed by Nagaland with 304, Manipur with 295, Meghalaya with 184 and Assam with 150. Recently the lichenological investigations in the state of Mizoram were initiated by the Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawal and one of the authors (MC) has collected some interesting lichen species from the different localities in and around Mizoram city both from evergreen and dry deciduous forests.

Materials and Methods

The present study is based on the examination of about 100 specimens of lichens collected during the month of June 2012. The specimens were examined morphologically, anatomically and chemically. The chemical components of the lichens were identified by the standardized TLC methods[3] and crystallography. Chromatograms were developed in the solvent system A (Toluene: Dioxan: Acetic Acid, 180:60:8). The specimens were identified and authenticated following literature on lichens by Awasthi[1,4]. The voucher specimens were deposited in the Herbarium of National Botanical Research Institute, Lucknow (LWG).

Species Description

Bulbothrix setschwanensis (Zahlbr.) Hale, Phytologia 28: 480. 1974, (Parmeliaceae).

Thallus corticolous, foliose, adnate, to 10 cm across; lobes 6 mm wide, bulbate cilia along margins, lower side pale brown, densely rhizinate; medulla white. Medulla K + yellow turning red, C-, KC-, P+ orange-red. Salazinic acid present.

Specimen examined: The species grows on trunk of trees in open forest areas near the city. Tlangnuam, alt. 1200 m, on barks, 07.07.2012, M. Chinlampianga. 12-018694 (LWG).

Chrysothrix candelaris (L.) Laundon, Lichenologist 13(2): 110. 1981, (Chrysothricaceae).

Thallus corticolous, leprose, granular, thin, yellow with slight orange or greenish tinge or greenish yellow, KC+ orange red, P+ orange. Pinastric acid present.

Specimen examined: The species form powdery mass on trunk of trees in evergreen forest. Chawnpui, alt. 1120 m, on barks of *Azadivachta* sp., 06.06.2012, M. Chinlampianga. 12-018693 (LWG).

Cryptothecia lunulata (Zahlbr.) Makhija & Patw., Biovigyanam 11(1): 6. 1985, (Arthoniaceae).

Thallus corticolous, crustaceous, well developed,whitish to whitish brown; powdery to thin layered, 8-spored asci, spores with 7-9 transverse septate, ellipsoid, curved, 33-56 × 13-17 µm. Thallus C+ red. Gyrophoric and barbatic acids present.

Specimen examined: The species grows on trees forming white patches in open forest areas. Zuangtui, alt. 1100 m, on barks, 07.07.2012, M. Chinlampianga. 12-018686 (LWG).

4. Chinlampianga, M, Shukla, A.C., and Upreti, D.K., 2011. Lichens of Mizoram: Present Status and Future Prospects. (Ed.) Proc. International Conference on Advances in Environmental Chemistry, Mizoram University, Aizawl (Ed.) Diwakar Tiwari. Excel India Publishers, Delhi, pp 127-131 (ISBN: 978-93-81361-53-5)

AEC-068

Lichens of Mizoram: Present Status and Future Prospects

M. Chinlampianga[1], Amritesh C. Shukla[1] and D.K. Upreti[2]
[1]Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl–796004, India
[2]Lichenology Laboratory, CSIR-National Botanical Research Institute, Lucknow (U.P), India
e-mail: amriteshmzu@gmail.com

Abstract—**The Mizoram state is located in the extreme corner of the North East India. The unique topography and climate of the state provide suitable conditions for different plant groups to colonize including lichens. A large number of studies regarding the lichens of eastern Himalayas regions are available, however so far not a single report on lichens of the state of Mizoram is available. Lichens are peculiar group of plants well known for their use in pollution monitoring studies and also used as food, fodder, spices, perfumery and dye industries in different regions of the world. In Indian context the studies on antibiotic activity and dying properties of few lichens are known. Recent researches shows that lichens have bioactive compounds which can be a potential source of antifungal, antibacterial, anticancerus, and antiherbivores as well as neutraceuticals in functional foods. Being moist humid regions in north eastern Himalayas, the state exhibit the luxuriant growth of some potential medicinal lichens so far not described. Hence, there is a lot of scope for collection, compilation and documentation of lichens diversity in Mizoram, and their IPR concern as well as their bio-efficacy before they lost forever. A preliminary survey in different forest of Mizoram state reveals the occurrence of 15 species of lichens with luxuriant growth of the species of Ramalina, Cladonia and Parmeloid lichens which are well known for their potential secondary metabolites.**

Keywords: Bio-monitors; diversity of lichens; Mizoram.

I. Introduction

Lichens are self-supporting symbiotic associations formed by a fungus and several algal or cyan bacterial components as primary partners and feed off each other in order to ensure survival. Due to their unique nature the lichens are able to grow in any perennial and stable substrate in varied climate condition. Once one colony has been established, it makes it easier for other colonies to grow and flourish. The distinctive colors of many lichens result from the massive accumulation of diverse secondary compounds, the so called "Lichen substances" which comprises up to 20% of lichen's dry weight. However, colorless substances tend to accumulate in parts of the thallus not exposed to direct sunlight.

Even these days, ethnic peoples in Mizoram still continue their age-old use of lichens for foods, beverages and traditional medicine. Some herbal practitioner's in Mizoram using *Usnia* species of lichen as home remedy against indigestion, stomach problems, etc. Some lichens species are also important ingredients in their herbal formulations prescribed for immune regulators and other dreadful diseases treatments. Not only in the current era but also in ancient times lichens have a household item in India [1]. Literature reveals that lichens collected from the temperate region of the Himalayas are using indigenously and also exported. The present paper summarizes the present and future prospects of lichens in Mizoram based on field observations as well as ethno-medicinal investigations. It also attempts to gather baseline information about the lichens in some parts of Mizoram, northeast India, where deforestation and other anthropogenic pressures are causing the degradation of important plant resources including lichens.

II. Materials and Methods

A. Study Area

The area under study (Fig.1) covering an area of 21,087 sq km and is situated between Myanmar (Burma) and Bangladesh. It lies at altitude ranges of 40 mt up to almost 2157m above msl. The state is a hotspot of the biodiversity of not only in the north eastern region but also in the country. The average annual rainfall is 250cm and temperature at the range of 10°C-29°C. Pleasant and equable warm climate throughout the year with moderate to chilly winter during November - January at higher altitudes.There are a variety of forest types and 8 nos. of protected areas in the state.The primary aim of this research work is to provide an initial picture of the ethnic use of lichens, exploration of lichens, present and future prospects of lichens in Mizoram. The climatic condition is much more congenial for growing different types of lichens species are growing luxuriantly and a lots of lichen populations lying on their door steps.

B. Research Methodology

The initial field survey for collection of lichen specimens was conducted during April 2008 at Reiek Tourist Resort, (about 20km away from Aizawl city) where undisturbed forest area covering about 5sq km is protected. A subsequent field observation also undergone in different seasons (February, June and

5. Shukla, A.C., Kumar, A., Chinlampianga, M., Gupta, R., Rohit, K. M., Dikshit., A., 2011. Thymol and Citral Can be a Potential Source of Ecofriendly Management of Drinking Water. (Ed.) Proc. International Conference on Advances in Environmental Chemistry, Mizoram University, Aizawl (Ed.) Diwakar Tiwari. Excel India Publishers, Delhi, pp 127-131 (ISBN: 978-93-81361-53-5)

AEC-043

Thymol and Citral Can be a Potential Source of Ecofriendly Management of Drinking Water

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***Abstract*—Water is the most common and important chemical compound on earth. Water is used for several purposes by humans but the level of purity of the water being consumed is very crucial since it has a direct effect on health. Although there are numbers of synthetic purification systems available in the market, they have several side effects. Plants are the richest source of natural therapeutic agents and can also be a potential water purifier against the water borne bacterial pathogens-which are responsible for diarrhoea, dysentery, typhoid, cholera and several hepaticas diseases and other intestinal infections.**

During *in vitro* antibacterial investigations of some bioactive plant constituents-thymol (the active constituents of *Trachyspermum ammi* L.) andcitral (the active constituents of *Cymbopogon flexousus* (Steud) Wats were found to be most effective constituents against *Escherichia coli*, and *Vibrio cholerae*. The minimum inhibitory concentration (MIC) of thymol was 0.089 mg/mL and 0.039 mg/mL respectively but, in the case of citral it was 0.061 mg/mL, and 0.017 mg/mL, respectively. However, the integrated approach of thymol and citral in 1:2 ratios at 0.025 mg/mL shows bactericidal in nature, heavy inoculum density, quick killing activity, broad antimicrobial spectrum, thermostable, with long shelf life. Further, the fruitful preliminary *in vivo* investigations prompted us for detailed *in vivo* and clinical investigations too, which is still in progress at the Biological Product Laboratory, University of Allahabad. Only after that, the formulations for the herbal treatment of the drinking water can be made eco-friendly.

Keywords: Herbal treatment, thymol, citral, water-borne pathogens, drinking water, NCCLS.

I. Introduction

Worldwide distribution of diarrhea accounts for more than 5–8 million deaths occurred in each year in infants and small children less than 5 year especially in developing countries [1]. According to WHO estimation for the year 1998, there were about 7.1 million deaths due to diarrhoea [2]. India is one of the developing countries where the vast population is residing in the rural areas. They are basically dependent on the supply of untreated water, and mostly on river, ponds and dug wells. This water is unsafe for drinking purposes having a lot of water borne disease causing bacteria such as *Escherichia coli, Vibrio cholerae, Salmonella typhi, Shigella* sp., *Staphylococcus aureus* and *Klebsiella* sp. etc. These bacteria in water are responsible for a variety of diseases like cholera, typhoid, dysenteries, bacillary dysentery, etc. in human and livestock [3].

For a long period of time, plants have been a valuable source of natural products for maintaining human health, especially in the last decade, with more intensive studies pertinent for natural therapies. Previous researches showed that 80% of the rural population depends on traditional medicines for their primary healthcare needs [4, 5]. Plant essential oils are a potentially useful source of antimicrobial compounds. The main constituents of essential oils (EOs) are phenylpropanoides such as carvacrol, thymol, eugenol and cinnamaldehyde [6]. EOs are aromatic oily liquids obtained from different plant parts and have broad activities. Other than antibacterial and antiviral effects, most EOs investigated possesses insecticidal, antifungal, acaricidal, cytotoxic and antioxidant properties [7-9]. Similarly, in the present investigation, active constituents of *Trachyspermumammi* L. (Sprague) and *Cymbopogon flexousus* (Steud) have also recorded as the most effective constituents against *E. coli* and *V. cholera*, the bacteria causing water borne disease. The detailed *in vitro* investigation was carried out using the broth micro-dilution method [10, 12].

II. Materials and Methods

A. Test Organisms

Two bacterial strain *Escherichia coli* MTCC 723 and *Vibrio cholerae* MTCC 3906 isolates procured from microbial type culture collection (MTCC), Chandigarh, India were stored at -20°C. These microorganisms were selected for assay study, as these are most disease causing bacteria. The pure cultures were maintained by routine sub-culturing at one-week interval in nutrient agar slants.

B. Essential Oils

With the help of Clevenger's apparatus [11], essential oil was extracted from the seeds of *T. ammi*and leaves of *C. flexuosus*. The oil samples – brownish colour (*T. ammi*) and light yellow colour (*C. flexuosus*) were collected in the test tubes and the excess water content was removed with sodium anhydrous and makes the oil pure.

6. Chinlampianga, M, Amritesh C. Shukla and B.P. Nautiyal. 2011. Bio- Indicators for Weather Prediction through Traditional Knowledge in Mizoram. In **the International Conference** on *'Advances in Environmental Chemistry'* (AEC 2011), organized by Deparment of Chemistry, Mizoram University, Tanhril, Aizawl, Mizoram, India during 16th – 18th November, 2011.
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Bio-Indicators for Weather Prediction through Traditional Knowledge in Mizoram

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***Abstract*—The tribal people of Mizoram formerly forecasted rainfall through traditional knowledge in relation to some bio-indicators. These bio-indicators were based mainly on the recognition of unique situations, the behaviour of insects, birds and mammals, characteristics of plants and location timing and patterns of clouds, lightning, wind, moon, sun and stars. The successful application of the rainfall predicting knowledge is based on comparison with events, good prognosis, closed observation and a thorough understanding of the local environment. Community members, cultural leaders and local elders have observed and noticing these recent anomalies in the weather, unusual rains, gradual decrease of winter season and abrupt changes in temperature. Besides, many plants species have also been observed as they changed their growth pattern including time of flowering and other phenophases during abrupt changes in temperature and humidity. This type of traditional knowledge has excellent potential for wider application not only in north eastern states (Mizoram) but also at the global level for the weather prediction. Hence, there is an urgent need to document the traditional knowledge/ folklore amongst the ethnic communities before they lost forever.**

Keywords: Bio-indicators; traditional knowledge; phenology; weather prediction.

I. Introduction

Indigenous peoples of Mizoram in the far North-eastern part of India, (the Indo-Burma "hotspot" of biodiversity) are closely associated in various ways with their surrounding environment and resources, mainly plants and animals for their day-to-day requirements. About 50% of the State's population comprises of rural villagers and they still follow their traditional beliefs including botanical folklore that were pass down from generation to generation by words of mouth and still adhere to the traditional ways of conserving biodiversity. Some domestic animals, crop species and some insect are not only used as food items but also as bio-indicators in predicting the weather and forecasting natural calamities, and in alleviating bad fortune [1]. Therefore, in the present investigation an attempt has been made to integrate the collective wisdom of humanity for the conservation of biodiversity and to build awareness of the immense values of indigenous knowledge. Besides this, to understand the weather anomalies and to reduce risks by preliminary measures provoked in diverse environmental and cultural systems throughout the Mizoram.

Fig. 1: Study Area

II. Materials and Methods

A. The Study Area

The study was conducted involving all communities of Mizoram particularly among Paihte (Zomi) community in Champhai district (92°.15'E to 93°.29' E Longitude and 21°.58' N to 24°.35' N Latitudes) with the population of 1,091,014 as per 2011 census. It is a land of rolling hills, valleys, rivers and lakes at an altitudes ranging from 40 m (Bairabi) to 2157m (Phawngpui,Blue Mountain) above msl. As many as 21 major hills ranges or peaks of different heights run through the length and breadth of the state, with plains scattered here and there. Although Mizoram is a tiny state having an area of only 21081 sq. km., it has as much as 404 km. of international border with Myanmar and 318 km. with Bangladesh. It forms the southernmost tip of India's North East region (**Figure 1**).The climate of the area is monsoon and divisible into three seasons: summer (March to May), rainy season (June to October) and winter (November to February). The annual rainfall ranges from 650mm to 2400mm and is largely restricted to the period of June to September. Pre monsoon showers occurs during March (locally called Khengpuizun *Khengpu* means long dry spell and "zun" means urine) and may reoccur during April-May. Post monsoon showers occurs during November

7. Shukla, A.C., **Chinlampianga**, M., Verma, A Anupam Dikshit., A., and Upreti, D.K., 2011. Efficacy and potency of lichens of Mizoram as antimycotic agents. *Indian Phytopatho*. **64 (4)**:367-370.

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RESEARCH ARTICLE

Efficacy and potency of lichens of Mizoram as antimycotic agents

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ABSTRACT: Antifungal property of aqueous and acetone extracts of two lichens was investigated against plant pathogenic fungi viz., *Alternaria alternata, Aspergillus flavus* and *Penicillium italicum* shows strong efficacy against the test fungi. Acetone extracts of both the lichen spp. were more effective than aqueous extracts. Aqueous and acetone extracts of *Stereocaulon* sp. were more effective than *Ramalina sp.* The aqueous and acetone extracts of *Ramalina* sp. and *Stereocaulon* sp. at 50 µl/ml concentration contains broad fungi toxic spectrum. Based on these findings as well as after detailed *in vitro* investigations, the active constituents of lichens can be synthesized and used as a potential substitute of synthetic fungicides.

Key words: Antifungal activity, lichens, synthetic fungicides

Lichens produce a diverse range of secondary metabolites/ chemical products, many of which have been found to have antimicrobial activity (Lawrey, 1986; Elix, 1996; Land and Lundstrom, 1998; Shahi *et al.*, 2001, Boustie and Grube, 2005). Most of these antimicrobial substances are phenolic derivatives (e.g. usnic acid) and have extremely low solubility's in water. The present finding deals with the evaluation of aqueous as well as acetone soluble substances from *Ramalina* sp. and *Stereocaulon* sp. against some common plant pathogens.

MATERIALS AND METHODS

Maintenance of fungus culture

The test fungi, *Alternaria alternata* (Fr.) Keissler, *Aspergillus flavus* Link, and *Penicillium italicum* Wehmer were maintained on potato dextrose agar medium. Seven day old cultures of each fungus were used for antifungal testing.

Isolation of active constituents

Lichens material (thallus) were collected from sub temperate climates of Mizoram, India; washed with distilled water and dried at room temperature. A stock solution of aqueous and acetone extract were prepared by macerating 10 g of lichen material in 20 ml each of sterile distilled water and acetone respectively, using a pestle and mortar followed by filtering through muslin cloth and a Millipore filter (pore size 0.22 mm).

Antifungal screening

The antifungal activity of the extracts was determined following the modified spore germination inhibition technique (MSGIT) of Shahi *et al* (1997) with a slight modification of Shukla (2010). Potato dextrose broth was prepared and amended with Penicillin G (5 mg/l) and Streptomycin sulphate (5 mg/l) in the medium at 40°C in order to prevent bacterial growth, as suggested by Gupta and Banerjee (1970). Culture discs containing spores (5 mm diameter) cut out from the 7 day old cultures, grown in petri dishes were transferred aseptically in flasks (100ml) containing the broth, and shaken well for even distribution of spores. The numbers of spores were counted per microscopic field using 'Modified Cytometer Technique' (MCT) (Shahi *et al*, 1997). The diameter of Microscopic field was measured by using micrometer and then the area and volume of microscopic field was calculated by the formula:

$$AMF = \pi r^2 \qquad VMF = (AMF)\ h$$

where,

AMF = area of microscopic field;
VMF = volume of microscopic field;
h = thickness of medium (in between slide and cover glass) 0.1 mm.

The number of spores (average count value of 5 microscopic fields) was counted just by eliminating the overlapped spores. The number of spores in the volume of microscopic fields (NSV) was calculated by the formula:

$$NSV = ANS/VMF$$

where,

ANS = average number of spores in microscopic field.

The volume of liquid medium (VLM) per microscopic field was calculated by the formula:

$$VLM = 2rh$$

The total inoculum density (TID) was calculated in the initial volume of medium as per formula:

$$TID = (NSV/VLM)\ IVM$$

where,

IVM = initial volume of medium.

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