DIVERSITY ASSESSMENT OF BRYOPHYTES IN MIZORAM AND PHYTOCHEMICAL STUDY OF IMPORTANT MEDICINAL SPECIES

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

LALHRIATPUIA

MZU REGISTRATION NO: 325 of 2006-07

Ph.D REGISTRATION NO: MZU/Ph.D/674 of 23.05.2014

DEPARTMENT OF BOTANY

SCHOOL OF LIFE SCIENCES

NOVEMBER, 2020

DIVERSITY ASSESSMENT OF BRYOPHYTES IN MIZORAM AND PHYTOCHEMICAL STUDY OF IMPORTANT MEDICINAL SPECIES

BY

LALHRIATPUIA

DEPARTMENT OF BOTANY

SUPERVISOR

Dr. J. LALBIAKNUNGA

SUBMITTED

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN BOTANY OF MIZORAM UNIVERSITY, AIZAWL

MIZORAM UNIVERSITY
(A Central University Established by an Act of Parliament of India)

J. Lalbiaknunga Ph.D.
Assistant Professor

Department of Botany
School of Life Sciences
Tanhril-796009
Aizawl, Mizoram
Phone: 91-7005207050
Email: biaknunga@gmail.com

CERTIFICATE

This is to certify that the thesis work entitled**, "Diversity Assessment of Bryophytes in Mizoram and Phytochemical study of important medicinal species"**, submitted by Lalhriatpuia (**Regd. No. MZU/Ph.D/674 of 23.05.2014**) in partial fulfillment of the requirement of the degree of Doctor of Philosophy in Botany is a record of bonafide work carried out by him under my supervision and guidance.

(Dr. J. LALBIAKNUNGA)

Supervisor

DECLARATION

I, Lalhriatpuia, hereby declare that the subject matter of this thesis 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 do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any degree in any other University/Institution.

This is being submitted to the Mizoram University for the degree of Doctor of Philosophy in Botany.

(LALHRIATPUIA)

(Dr. R. LALFAKZUALA)
Head of Department

(Dr. J. LALBIAKNUNGA)
Supervisor

ACKNOWLEDGEMENT

I am very grateful to have had the opportunity to study at Mizoram University through my bachelors and now my Ph.D.

I sincerely thank my supervisor Dr J. Lalbiaknunga for his support throughout my Ph.D studies. He gave me encouragement, suggestion and correction when needed.

I want to express my heartfelt thanks and gratitude to my ex-supervisor Prof. R.C. Laha (L) for his guidance and support to carry out this work at the beginning.

A sincerely thanks to Dr. Virendra Nath, CSIR-Emeritus Scientist, Former Chief Scientist, CSIR-National Botanical Research Institute, Lucknow who has helped me in identification of my specimens.

I am very grateful to Dr M. Nihal Aziz, Scientist in charge, and Dr Pamela Saha, Central National Herbarium, Botanical Survey of India, Kolkata for their kind help in identification and consultation of herbarium.

I sincerely thank Scientists of Botanical Survey of India, Eastern Circle, Shillong for their kind help in identification and consultation of herbarium.

I thank University Grants Commission for financial support through Rajiv Gandhi National Fellowship.

I am grateful for my family who has supported me through all the years of my study.

I thank my fellow research scholars, faculty and staff of Botany department for their countless help and support.

Above all I thank almighty God for his guidance throughout the year to fulfill this research work.

Place : Aizawl

Date : 24.11.2020 (LALHRIATPUIA)

Abbreviations and Symbols

viz.	=	*videlicet*; namely
sp.	=	species
etc	=	Et cetera
et al.	=	*et alia*; and others
%	=	Percent
i.e.	=	*id est* (that is)
spp.	=	species pluralis
µg/ml	=	microgram/millilitre
km^2	=	Square kilometre
km	=	Kilometre
N	=	North
E	=	East
°C	=	Degree celcius
mm	=	Millimitre
m	=	Metre
msl	=	Mean sea level
GPS	=	Global Positioning System
cm	=	centimetre
BSI	=	Botanical Survey of India
ml	=	Millilitre
w/v	=	weight/volume
HCL	=	Hydrochloric acid
H_2SO_4	=	Sulphuric acid

DPPH	=	1,1-Diphenyl-2-picrylhydrazyl
mM	=	Millimolar
BHT	=	Butylated Hydroxytoluene
nm	=	nanometre
UV	=	Ultraviolet
IC50	=	Half maximal inhibitory concentration
µl	=	microlitre
ATCC	=	American type culture collection
mg	=	Milligram
DMSO	=	Dimethyl sulfoxide
µm	=	Micrometre
MNP	=	Murlen National Park
alt.	=	Altitude
TWS	=	Tawi Wildlife Sanctuary
TTWS	=	Thrangtlang Wildlife Sanctuary
DTR	=	Dampa Tiger Reserve
+	=	Present
-	=	Absent
±	=	plus or minus
SD	=	Standard deviation
≤	=	Less than or equal to

TABLE OF CONTENTS

List of figures

List of tables

CHAPTER-I

INTRODUCTION

1.1. Bryophytes

Bryophytes are a large group of plants that includes mosses, liverworts and hornworts. They occur on every continent and in every location habitable by photosynthetic plants which play vital role in the ecosystem. They grow in moist and shady places on different habitats viz. on soil, rocks, stones, barks of the tree, leaf surface as well as on dead and decaying logs. They are habitually known as 'Amphibians of the plant kingdom' as they need water to complete the process of fertilization (Glime, 2007). The group is phylogenetically significant showing close affinity to Algae and Pteridophytes. Bryophytes are more complexed in morphology than the algae but are less complexed than the Pteridophytes. They share some common features with the algae in the nature of photosynthetic pigment, cell wall component, photosynthetic product and flagella. Besides, water is necessary for sexual reproduction in both the groups. Bryophytes share with Pteridophytes the common life-cycle pattern of heteromorphic alternation of generations and the multicellular, jacketed sex organs Antheridia and Archegonia. Besides, the zygote and embryo are permanently retained within the archegonium in both the groups. In contrast to vascular plants, they rarely grow as single stems but in groups, which form turfs, cushions, wefts or other growth forms (Mägdefrau, 1982). There are a few aquatic forms such as *Fontinalis antipyretica*, *Riccia fluitans*, *Ricciocarpus natans* and *Riella* sp. etc. Moreover, *Cryptothallus* and *Buxbaumia* are saprophytic genera of liverworts and mosses, the rest of the Bryophytes are autotrophic.

Bryophytes are poikilohydric, which means that their water content is directly regulated by the ambient humidity. Most species are termed ecto-hydric because they take up water through the whole surface of the plant. It is not necessary for them to develop a root system to draw water from the soil. This alternative strategy enables them to grow on very hard surfaces such as rocks and tree trunks that are inhospitable to most vascular plants.

Liverworts are the most ancient phylum of green plants, being the first to have colonized terrestrial habitats on earth. Mosses that usually grow in tufts or mats, contribute much in the aggregate, to the green color of forests, mountains and moors, especially in rainy weather (William, 1954). A number of mosses evolved in response to special ecological, morphological and physiological adaptations to demanding environmental conditions in which the other group of plants generally fail to survive and also tend to be highly specific for particular microenvironment (Alam *et al*., 2011).

Bryophytes are simple in structure, tiny, non-vascular and non-flowering as well as fascinating due to varied colours, which add beauty to the nature. These plants widely grow in moist and shady places on different habitats viz. on soil, rocks, stones, barks of the tree, leaf surface as well as on dead and decaying logs. They are unique group of plants as they are strictly habitat specific, shade and moisture loving and any disturbance to the microclimate causing threat to the existence. The changes in the microhabitat of Bryophytes may seriously affect the species composition very rapidly and thus upset the ecological balance (Dash *et al.*, 2009).

1.2. Classification

The term 'Bryophyta' was first used by Braun (1864) but he included algae, fungi, lichens and mosses in this group at that time. Schimper (1879) placed Bryophyta at the level of division excluding algae, fungi, and lichens since then it occupies the same rank till date. A number of botanists: Howe (1899), Campbell (1918, 1940), Smith (1938, 1955), Takhtajan (1953), Schuster (1953, 1958) divided the Bryophyta into three classes: Hepaticae, Anthocerotae and Musci. Rothmaler (1951) changed the name of classes from Hepaticae to Hepaticopsida, Anthocerotae to Anthoceropsida and Musci to Bryopsida as per the recommendations of International Code of Botanical Nomenclature. Proskauer (1957) suggested that the name the class- Anthoceropsida should be changed to Anthocerotopsida.

Bryophyta has been divided into three classes:

1. Hepaticopsida (Hepaticae - liverworts)
2. Anthocerotopsida (Anthocerotae - Hornworts)
3. Bryopsida (Musci - Mosses)

1.2.1. Hepaticopsida has been divided into six orders

1. Calobryales
2. Jungermanniales
3. Metzgeriales
4. Monocleales
5. Sphaerocarpales
6. Marchantiales

The class Hepaticopsida is mainly characterized by dorsiventrally flattened gametophytes, which may be thalloid, either simple or internally differentiated or leafy - differentiated into axis and leaves. The thalli of most liverworts are branched either dichotomously, sympodially through subapical innovations, or monopodially with multiple ramifications occurring along the stems. In some cases, branches are dimorphic, with ventral ones acting as anchoring organs. The sex organs are always dorsal in position and are formed by superficial cell of dorsal surface of thallus. In *Marchantia* and its relatives, the thallus is composed of a ventral layer of hyaline storage cells, a dorsal layer of green cells and a unistratose epidermis. The photosynthetic layer includes air chambers that open through superficial pores (Vanderpoorten and Goffinet, 2009). Oil bodies are a unique feature of liverworts among land plants and 90% of liverworts develop oil bodies. Their size, shape, number, colour, distribution and chemical composition vary among taxa and therefore these characters offer critical taxonomic information. Leafy liverworts compose the largest group, including about 80% of the taxonomic diversity (Gradstein, 1990). The leaves develop along three longitudinal parallel lines and the stem bears two lateral rows and one ventral row of leaves. The insertion of the underleaves is always transverse, whereas the lateral leaves are commonly inserted obliquely with the line forming either an acute or obtuse dorsal angle with the axis depending on the orientation of the apical cell.

1.2.2. Bryopsida has been divided into seven orders

1. Sphagnales

2. Andreaeales

3. Takakiales

4. Andreaeobryales

5. Polytrichales,

6. Tetraphidales

7. Bryales

The vegetative body differentiated into axis and spirally arranged leaves. The leaves are always sessile; they lack a petiole and the lamina is thus inserted directly on the stem at its base. A single layer of cells composes the blade of a typical moss leaf, except for the median axis, which is often thickened to a multistratose midrib or costa. Many pleurocarpous mosses have leaves with a double costa. The midrib of many acrocarpous species is very prominent and in some, it even occupies much of the width of the leaf. Antheridia and archegonia originate at the apex of the stem or branch, forming conspicuous terminal clusters. In some mosses, isolated archegonia are formed in the axils of leaves. Groups of gametangia associated with multicelullar uniseriate paraphysis are typically surrounded by differentiated leaves that protect the delicate sex organs and also the young embryo. Clusters of archegonia and their associated leaves are called perichaetia, whereas similar male structures are referred to as perigonia. The archegonium is stalked and consists of a slightly inflated venter harbouring a single egg and mounted by a narrow neck whose central canal cells disintegrate at maturity. The cylindrical antheridium is also stalked but contains numerous sperm cells. The sporophyte consists of foot, seta and capsule is of determinate growth and partially independent due to presence of chloroplasts and stomata in the capsule wall. Foot is embedded in the apical gametophytic axis, the

seta serves to raise the capsule above the perichaetial leaves protecting the developing sporophyte. The amphithecium forms the capsule wall and the parenchyma as well as, in the region above the annulus, the teeth around the capsule the peristome. The endothecium forms the columella and the spore sac. The columella is a sterile axis that extends through the sporogenous region and connects to the operculum. The capsule is generally cylindrical, bears stomata, dehisces subapically through the loss of a lid and bears one or two rings of teeth lining the mouth. Peristome is an important feature of the moss capsule and helps in spore dispersal. Protonema, a short intervening phase is present in between the spore and adult gametophyte. After germination, a single spore can give rise to a number of gametophytes by producing buds in the protonema which develop into adult gametophytes. The rhizoids are multicellular and obliquely septate.

1.2.3. Anthocerotopsida has only one order

1. Anthocerotales

The vegetative body of hornworts is a flattened bilaterally symmetric, dorsiventral, lobed thallus without any internal tissue differentiation except for the presence of *Nostoc* and mucilage chambers. Rhizoids are smooth walled. The photosynthetic cells, including the epidermal cells of the gametophyte, typically possess a large solitary chloroplast with conspicuous pyrenoid bodies. Gametangia are produced at the dorsal thallus midline. Antheridia are endogenous in origin formed by the hypodermal cell, present in groups or singly within the androecial chamber. Sperm cells are protected by a unistratose jacket subtended by a short stalk. The archegonia develop from an epidermal-initial and remain mostly sunken at

maturity with only the apex of the neck protruding from the surface. The sporophyte is differentiated into capsule and foot that develop from the basal meristem. The peripheral cells of the foot form a haustorium that penetrates the surrounding gametophytic tissue to form the placenta, characterized by a large exchange surface between the two generations, favouring the efficient nourishment of the sporophyte. The entire endothecium develops into the central sterile portion called columella. The outer cylinder, or amphithecium, develops into the epidermis, the assimilative layer and the sporogenous tissue. The basal meristem remains active throughout the life of the sporophyte, except in *Notothylas*.

1.3. Life Cycle and Reproduction

Bryophytes have dioecious and monoecious representatives on the basis of their sexual mode of reproduction. About 70% of liverworts species are dioecious, 60% of moss species are dioecious whereas in hornworts monoecy is dominant (Wyatt 1982, 1994; Vanderpoorten and Goffinet, 2009).

The life cycle of Bryophytes involves a heteromorphic alternation of generation between sporophytic and gametophytic generations that differ in form and function. The actual plant is represented by the dominant gametophytic generation, which is the most evolved haploid generation in the whole plant kingdom (Zechmeister *et al*., 2003). The spores germinate to form a branched or thallose protonema which develops into haploid gametophytes that produce gametes in the sex organs. The male reproductive organs are called antheridia which have a short or long stalk and spherical to elongated or clavate to cylindrical antheridial body. The

antherozoid mother cells are protected by a single layer of sterile jacket. Each of the antherozoid mother cell gives rise to a single ciliated motile antherozoid. The female reproductive organ is the archegonium, which is flask shaped. The archegonium consists of an axial row of number of neck canal cells, a ventral canal cell and a single, large egg, which are surrounded by sterile jacket. The mature antheridium dehisces and releases antherozoids. Water is needed for fertilization to take place. The antherozoids swim in the film of water to reach the neck of the arehegonium, the neck canal cells disintegrate and the antherozoid swims upto the archegonial venter and fertilizes the egg. After successful fertilization, the zygote develops into a multicellular embryo, which differentiates into the sporophyte. The cells of the archegonial venter actively divide to form a protective covering around the developing sporophyte called calyptra. The sporophyte consists of foot, seta and capsule.

The sporophytic generation which remains attached to the haploid gametophytic plant is nourished by the gametophore. The spore mother cells, after meiotic division, form spore tetrads having haploid spores. The elater mother cells form elaters, which help in the dispersal of spores. Bryophytes are homosporous. Under suitable conditions, the spores germinate to form new gametophytes. Many species also reproduce asexually which enables them to survive in unfavourable conditions.

1.4. Distribution

Bryophytes are the second largest group of plants after flowering plants, with estimated 15,000 (Hallingbäck and Hodgetts, 2000; Gradstein *et al*., 2001) to 25,000 species worldwide (Crum, 2001). Bryophytes tend to be most abundant and luxuriant in humid climates. Their diversity often corresponds with habitat diversity. The destruction of seed plant vegetation results in the elimination of the Bryophytes that are dependent on that vegetation for shelter. The survival of seed plant vegetation is also intimately linked to the bryophyte vegetation; Bryophytes are important in the retention of soil moisture, nutrient recycling, and seedling survival, as well as for providing habitat for other organisms that are vital for vegetation health.

Bryophytes are also sensitive to natural fluctuations in humidity. Many species are, therefore, restricted to microhabitats with specific microclimates (Jeglum, 1971; Pospisil, 1975). They comprise very diverse plant groups like peat-mosses, lantern-mosses, leafy liverworts with quite diverse biological characteristics i.e., structure, size, ecology, reproduction, survival, etc. These plants are widely distributed altitudinally from sea level to the snow deserts but generally dominate in between the altitude 1000-8000 metres. East and Southeast Asia are extremely rich and diverse in bryophyte taxa, especially in mosses since they are very diverse in topography, climate and vegetation (Hallingbäck and Hodgetts, 2000). A total of 2489 taxa of Bryophytes has been reported from India, (Dandotya *et al*., 2011).

1.5. Importance of Bryophytes

Bryophytes contribute to a substantial proportion of the global biomass in a range of ecosystems and hence play a major role in the cycling of carbon and nutrients through growth and decomposition of peat. Peatlands are often characterized by a bryophyte mostly *Sphagnum* species cover of 90-100% of the ground layer. Peatlands are peculiar ecosystems accumulating organic matter as a consequence of an imbalance between net primary production and decomposition. *Sphagnum* plays a vital role in global biogeochemical cycles for sequestering large quantities of carbon (Vitt and Wieder, 2009).

Epiphytic Bryophytes are of utmost ecological importance regarding the water and nutrient cycles. They display an extremely high water holding capacity that reaches up to about 1500% of their dry weight (Proctor, 2009). In epiphyte-rich forests, such as temperate and tropical rainforests, Bryophytes may collectively retain about 15000 kg of water per hactare (Kurschner and Parolly, 2004), which is equivalent to the canopy storage capacities in young, closed canopy coniferous forests without significant epiphyte populations.

Bryophytes are an important component of the vegetation in many regions of the world. They play a vital role in functioning of ecosystem, and constitute a major part of the biodiversity in moist forest, wetland, mountain, and tundra ecosystems. Bryophytes may promote soil formation by accelerating physical and chemical weathering, by trapping wind-blown organic and inorganic material, and by contributing directly to undecomposed organic matter. They help stabilize the soil surface against wind and water erosion by binding erosion-prone soil particles into

more stable soil aggregates. This enhances soil infiltrability and contributes to the redistribution of runoff across the landscape, thereby reducing water erosion (Eldridge, 1998).

They are important components of the hydrological, chemical, and organic matter cycles (Hofstede *et al.*, 1993; Rhoades, 1995). They play important roles as colonizers and soil stabilizers in areas where soil surface conditions have declined as a result of increased infiltration (Eldridge, 1993), a food source for birds and mammals (Longton, 1992), as nesting material and protective habitat for amphibians, various Bryophytes are used as herbal medicines (Flowers, 1957) for the treatment of cardiovascular diseases, boils, eczema, cuts, bites, wounds, and burns (Wu, 1977; Ding, 1982; Ando, 1983). Mosses such as *Sphagnum* were frequently used for surgical dressing by the people in armies since it has a better absorbent than cotton in addition to its antibiotic qualities (Schofield, 1969).

Bryophytes hold rich reservoir of unique phytochemicals imparting them a strong defense mechanism to survive under highly diverse habitats despite having a non-lignified structure. There is huge potential to utilize this untapped resource in modern healthcare as eco-friendly antibiotics and antioxidants (Kandapal *et al*., 2016). They are potential sources of new antibiotics and anticancerous substances (Chopra and Vasishtha, 1994). Bryophytes can be used as indicator species of air pollution (Taoda, 1972; Greven, 1992; Rao, 1982; Maschke, 1981; Mäkinen, 1987).

Bryophytes are also suitable as bio-indicators of water pollution (Glime and Saxena, 1991). Bryophytes are, in general, considered to be just as sensitive to air pollution as lichen (Dässler and Ranft, 1969). Recently it has been observed that

bryophyte has significantly more commercial value than other group of plants. The plants are being used in horticulture practices, fuel, paper industry, medicinally, in soil management and in rock binding etc. (Nath and Asthana, 1995). Bryophytes have also some ethnic values and possess antimicrobial and wound healing properties (Kumar *et al*., 2000; Singh *et al*., 2006). In Japan, growing mosses is a traditional part of horticulture and used in gardening and as ornamental material for cultivation in landscape trays (Ishikawa, 1974; Perin, 1962; Hirota, 1981).

1.6. Scope and Objectives

Bryophytes are one of the richest groups of plants in India and occupy a wide range of substrata. India has a rich and varied Bryophyte flora due to its diversified topography, variable climatic condition, and geographical position are important components of species diversity and flourish well in tropical, subtropical and temperate forest. Northeast India is unique from the biodiversity point of view that harbours rich Bryophytic wealth among bryogeographical regions of the country. The combination of different factors climatic, edaphic, temperature, precipitation, humidity, altitude, forest types favors growth of rich and luxuriant vegetation of Bryophytes. In spite of above facts, there is no floristic account of Bryophytes as well as utilization of plant resources of this region is available.

Bryophytes have been used as bio-indicators of water pollution (Glime and Saxena, 1991). Bryophytes possess a large variety of secondary metabolites (Zinsmeister *et al.*, 1991) and thus provide considerable potential for biotechnological and biopharmaceutical applications. Several secondary metabolites

and chemicals were isolated so far from different species but the mechanisms behind their activity are still widely unexplored (Beike *et al.,* 2010).

Many Bryophytes are used as herbal medicines; the mosses and liverworts are medicinal plants and are said to possess certain biological activity and effect (Asakawa, 2001). Basile *et al.,* (1999) isolated and identified seven pure flavonoids from mosses which showed pronounced antibacterial effects. The work of Asakawa (2007) in the field of investigation of biologically active substances of cryptogams is very promising which gave clear idea about the use of Bryophytes for medicines with a number of isolated compounds which possess interesting pharmacological activities. Antibacterial activity against gram-positive and gram-negative bacteria was reported from mosses (Merkuria *et al.*, 2005; Zhu *et al.*, 2006) and liverworts (Asakawa, 2007).

All workers have insisted that enough focus has not been given to study the bryoflora in India. They have so far been ignored for many reason especially their relatively less economic value. But recent studies have proven that they could be the resource of many phytochemical and pharmaceutical compounds (Alam, 2012). At present different anthropogenic activities like population growth, destruction of habitat particularly forest, urbanization, agriculture, traditional slash and burn agriculture, clear felling practice together with monoculture, infrastructure development result in the alteration of the microclimate leading to the complete habitat loss, destabilization of traditional management system have cause tremendous threat to the existence of bryophyte in Northeast India. No attempt had been made to assess the diversity of Bryophytes of Mizoram. In view of this knowledge gap, the

present study focused on diversity and phytochemical analysis of Bryophytes growing in ecologically important forest sites of Mizoram.

The following aims were set to carry out the proposed work in this study under captivity:

1. Collection and identification of Bryophytes from selected sites.
2. Phytochemical screening and antioxidant activity of selected species.
3. To study antimicrobial activity of selected species.

CHAPTER-II

REVIEW OF LITERATURE

Bryophytes are said to be the second largest group of plants after flowering plants, with estimated 15,000 (Hallingbäck and Hodgetts, 2000; Gradstein *et al*., 2001) to 25,000 species worldwide (Crum, 2001; Renzaglia *et al*.,2000). A total of 2489 taxa of Bryophytes are reported from India, comprising 1786 species in 355 genera of mosses, 678 species in 121 genera of liverworts and 25 species in 6 genera of hornworts (Dandotya, 2011). Out of which a total of 340 species are endemic to India, of which 269 species are of mosses, 67 are of liverworts and 4 are of hornworts.

The present knowledge on the Bryophytes of India began with studies by European bryologists. Montagne (1842) reported 100 species of mosses from Nilgris (Tamil Nadu) in his Cryptogamae Nilgheriensis, Müller (1853) reported over 100 species of mosses from Nilgris in his Musci Neilgherrenses, Mitten (1859) reported over 700 species in his Musci Indiae Orientalis. Brotherus (1899) reported 86 species, Varde (1928) described 100 species of mosses from the tropical rain forests of Silent Valley in Kerala, from the Western Ghats of Madurai in his Musci Madurensis, Foreau (1961, 1964) listed 368 species from the Palni hills which included 95 new species and 15 varieties, and Raghavan and Wadhwa (1968, 1970) from Agumbe and Hulical ranges in Shimoga district of Karnataka.

The present knowledge of liverworts and horworts relies mostly on the works of Mitten (1861) who reported 290 species of liverworts in his Hepaticae Indiae Orientalis, Stephani (1900-1924), Benedix (1953), Kashyap (1915, 1929, 1932),

Chopra (1938, 1943), Bharadwaj (1948, 1950, 1958, 1960), Kachroo (1969, 1970a, 1970b, 1973), Kachroo *et al*., (1977), Udar (1976), Proskauer (1951), Udar and Srivastava (1975, 1977), Joshi and Biradar (1984), Asthana and Srivastava (1991), Nath and Asthana (1998), Asthana *et al*., (1995), which pertain to different localities in southern India. The works of Dixon (1909, 1914, 1921, 1930, 1937), Daniels (1998, 2001), Daniels and Daniel, (2003a, 2003b, 2003c, 2004), Kumar and Maniselvan (1994), Maniselvan and Kumar (1998), Maniselvan and Kumar (2000), Nair and Madhusoodhanan (2001, 2002), Easa (2003), Parihar *et al*., (1994), Singh (1994, 1997) and Srivastava and Srivastava (2002), Srivastava (1964), Lal, (2005, 2007), Singh and Singh (2007) contain records of collections from India.

Several bryologists of India have assessed the moss flora of different bryological regions from time to time, such as Gangulee (1969-80) published "Mosses of Eastern India and Adjacent regions" in eight fascicles which included 990 species. Chopra (1975) dealt with nearly 2,000 species belonging to 329 genera under 56 families. Lal (2005) published "A checklist of Indian mosses" and listed 1623 taxa of mosses from India. Nair *et al*., (2005) studied the Bryophytes of Western Ghats, Manju *et al*., (2008) reported the checklist of the Bryophytes of Kerela with up to date nomenclatural changes.

Research on the distribution of liverworts in the Great Himalayan National Park was carried out by Singh and Singh (2009) and the presence of 92 species in over 39 genera and 23 families was recorded. This accounts for about 11.3% of the total Indian liverworts and hornworts in just 0.04% of its geographical region. Many workers have made important contribution to the Bryophyte flora of the eastern

region of India and adjacent plains (Gangulee, 1969-1980), Meghalaya (Singh and Nath, 2006; Singh *et al*., 2008; Bansal and Nath, 2012), Nagland (Bansal *et al*., 2011). Mitten (1861) made the study on bryophyte collection from Assam and Khasi hills and provided a comprehensive account of Indian mosses and liverworts. The comprehensive work of Gangulee (1969-1980) on mosses of eastern India and adjacent plains are very important contribution and gives information on distribution and habitat of Indian mosses. Singh and Nath (2007) carried out the study of Bryophytes in the Meghalaya state which helped in documentation of the Hepatic wealth of the region and very promising findings in the form of discovery of new species and new records were made. Barukial (2011) studied Bryoflora of Assam and recorded a total of 162 taxa of Bryophytes under 90 genera and 39 families with their proper habitats making an important contribution considering both taxonomical and ecological aspects. Recently, some studies on Bryophytes of Assam, India have come up and reported several Bryophytes from the state (Barukial and Gogoi, 1998; Barukial *et al*., 2002a, 2002b; Barukial, 2011a, 2011b, Barbhuiya and Singh, 2012).

Singh and Barbhuiya (2008) made a study on Hepaticae and Anthocerotae of Mizoram and described three new taxa of *Frullania* from the State. Ramachandra Laha and Lalhriatpuia (2015) reported 41 species of Bryophytes distributed under 34 genera and 23 families from Aizawl district of Mizoram. Lalhriatpuia and Ramachandra Laha (2015) reported a total of 65 species of Bryophytes distributed under 50 genera and 36 families from Mamit District of Mizoram. The presence of 25 species of mosses distributed under 23 genera and 17 families has been recorded

from Murlen National Park by Lalhriatpuia *et al*., 2018. Singh (2018) described four species of *Marchantia* L. collected from different parts of Mizoram.

Scientists have found innumerable kinds of biological activity in compounds from Bryophytes, even in a single species, one might find multiple kinds of activity. Bryophytes are immune from bacterial and fungal infections owing to the production of chemical compounds with repellent and anti-microbial properties (Parker *et al*., 2000). The extracts of moss and liverworts are used for protecting crops (Frahm, 2004).

Bryophytes contain biologically active compounds such as carbohydrates, lipid, protein, steroids, polyphenols, terpenoids, flavonoids, alkaloids, glycosides, saponins, anthraquinons, sterols, organic acids, fatty acids, aliphatic compounds, acetogenins, phenylquinones, and aromatic and phenolic substances (Pant and Tewari, 1990; Asakawa, 2001) which show significant bioactivities and the bioactive constituents of mosses and liverworts are used as antibacterial, antifungal, antitumor, cytotoxic, and insecticidal (Asakawa, 2007; Ucuncu *et al*., 2010).

Studies on antimicrobial activity of methanolic extract of Bryophytes showed positive results and antioxidant properties (Sawant and Karadge, 2010). The most widely known use of Bryophytes determined by its appearance is that of *Marchantia polymorpha* to treat liver and other ailments; the surface suggests the cross section of liver (Miller and Miller, 1979). In China, it is still used to treat the jaundice of hepatitis and as an external cure to reduce inflammation (Hu, 1987). It has gained the reputation of cooling and cleansing the liver and the Europeans used it to treat pulmonary tuberculosis (Bland, 1971).

The use of *Rhodobryum giganteum* to cure angina was successfully demonstrated through clinical research by Chinese scientists. An ether extract contains volatile oils, lactones, and amino acids; when given to white mice, the extract reduced the oxygen resistance by increasing the rate of flow in the aorta by over 30% (Wu, 1982). *Polytrichum commune* has been used in China to reduce inflammation and fever (Ding, 1982), and as a detergent, diuretic, laxative, and hemostatic agent (Hu, 1987). Mosses contain polyunsaturated fatty acids that are already known to have important potentials in human medicine, such as preventing atherosclerosis and cardiovascular disease, reducing collagen-induced thrombocyte aggregation, and lowering triacylglycerols and cholesterol in plasma (Radwan, 1991).

The use of Bryophytes for antibiotic had been studied as early as 1952, inhibition of microorganisms in products of Bryophytes was found in *Sphagnum portoricense, Sphagnum strictum, Conocephalum conicum, Dumortiera hirsuta. Dicranum scoparium* strongly inhibited all bacteria tested but gram negative *Escherichia coli* (Pavletic and Stilinovic, 1963). McCleary and Walkington (1966) considered that non-ionized organic acids and polyphenolic compounds might contribute to the antibiotic properties of Bryophytes and found eighteen mosses that strongly inhibited one or both of gram-positive and gram-negative bacteria, the most active being *Atrichum, Dicranum, Mnium, Polytrichum*, and *Sphagnum.*

The occurrence of antibacterial activity in extracts of *Barbula* species, reaching as high as 36.2% was reported by Gupta and Singh (1971). Asakawa *et al*., (1982) isolated three prenyl bibenzyls from *Radula* spp. and demonstrated that these

bibenzyls could inhibit growth of *Staphylococcus aureus* at concentrations of 20.3 µg/ml. Antimicrobial activity in extracts of the liverworts *Pallavicinia* and *Reboulia* was reported by Belcik and Wiegner (1980) and Isoe (1983) reported it from *Porella*.

CHAPTER- III

STUDY SITE

3.1. A brief information about study site

The study was confined to four districts of Mizoram i.e. Aizawl, Lunglei, Champhai and Mamit. The following protected areas were selected for study sites *viz*. Murlen National Park located in Champhai district, Dampa Tiger Reserve located in Mamit district, Tawi Wildlife Sanctuary located in Aizawl district and Thorangtlang Wildlife Sanctuary located in Lunglei District. The Forest Cover in the State is 18,005.51 km^2 which is 85.41% of the State's geographical area. Two National Parks and eight Wildlife Sanctuaries constitute the Protected Area network of the State covering 5.89% of its geographical area (ISFR, 2019).

3.1.1. Location:

Mizoram is located in the far northeastern part of India lying in between coordinates 21°56'N to 24°31'N latitude and 92°16'E to 93°26'E longitude. It has an area of 21,081 sq.km and the tropic of cancer passes through the state at 23°30’N latitude. It has international border with Myanmar to the east and south; and with Bangladesh to the west. It also has inter-state boundary with Assam, Manipur and Tripura.

3.1.2. Climate:

Mizoram has a climate ranging from moist tropical to moist sub-tropical. It enjoys a moderate climate, it is neither too hot nor too cold and falls under tropical monsoon type of climate. The temperature ranges from 11°C to 24°C during winter

and it varies from 18°C to 29°C during summer. The annual rainfall ranges from 2100 mm to 3500 mm. The region is influenced by south west monsoon and it usually rains from May to September.

3.1.3. Physiography:

A land of rolling hills, valleys, rivers and lakes characterized by rugged hills and steep mountains, the hills run in the north-south direction. Mountainous terrain with parallel ranges forming deep gorges culminating into several streams and rivers. The elevation ranges from 40 metres to about 2200 metres above sea level.

3.1.4. Vegetation:

According to Champion and Seth (1968) Mizoram has been broadly divided into three categories

i) Tropical Wet Evergreen Forest

ii) Tropical Semi-Evergreen Forest

iii) Montane Sub-tropical Pine Forest

3.2. Murlen National Park

Situated in Champhai district Murlen National Park is located in between $23^{o}32'$N to $23^{o}42'$N latitude and $92^{o}13'$E to $92^{o}27'$E longitude. The park is situated about 245 km east of Aizawl, and is close to the Chin Hills. It covers an area of approximately 100 km^2. The altitude ranges from 400 m to 1900 m above msl; it receives an annual rainfall of 2100 mm to 2500 mm. It was initially notified as Murlen Wildlife Sanctuary in 1989; later in the year 1991, it was declared as Murlen National Park by Government of Mizoram vide notification No. B. 11011/13/84-FST

dated 8.7.1991 for the purpose of protecting, propagating or developing wildlife therein and its environment. Its fringe villages are N. Khawbung, Rabung, Murlen, Vapar, Ngur, Hmunhmeltha, Tualpui, Khualen.

The tropical, semi-evergreen and sub-montane Forests of Murlen National Park are home to a rich variety of flora and fauna. The common flora include *Ceropegia mizoramensis, Ceropegia murlensis, Schima Wallichii, Michelia Champaca, Pinus Kesiya, Chimonobambusa callosa, Rhododendron arboreum, Rhus semialata, Prunus spp, Myrica spp, Quercus spp, Betula spp,* Canes and Bamboos, a variety of Orchids, Bryophytes and Lichens. The fauna include Tiger, Leopard, Himalayan Black Bear, Serrow, Hollock Gibbon, Sambar, Barking Deer, Wild Boar etc. Murlen Park is one of the most important bird areas supporting several threatened species of birds like Hume's Pheasant, Common partridges, Hill myna, dark rumped swift, Peacock, Pheasant, Sunbird, etc. Several rivers, rivulets and brooks flow through this park providing abundant water to its existing wildlife.

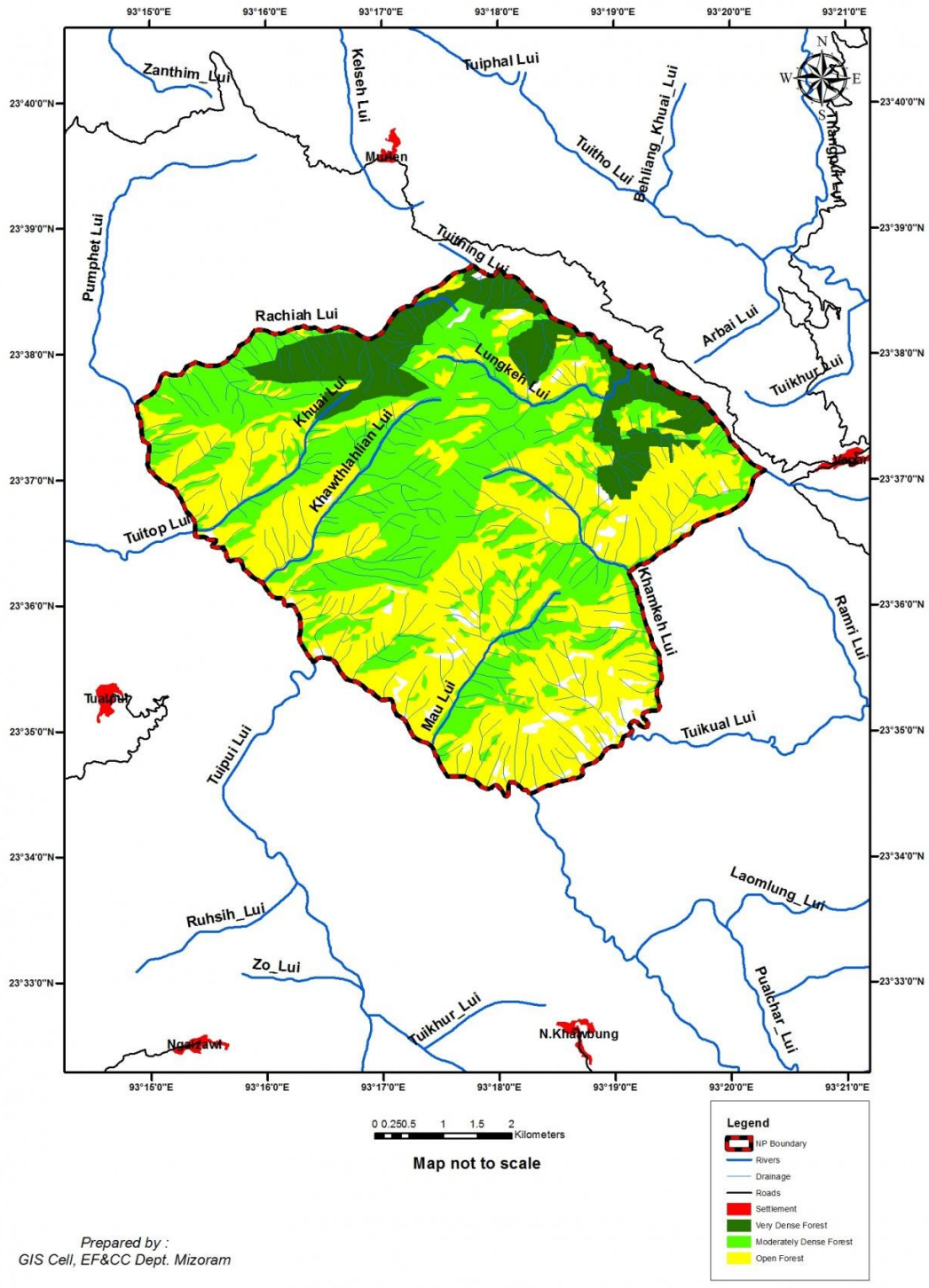


Figure 1. Map of Murlen National Park

3.3. Dampa Tiger Reserve

Dampa Tiger Reserve in Mamit district is situated in the western part of Mizoram on the international border with Bangladesh about 127 km from Aizawl. Located between 23°32'N to 23° 41'N latitude and 92°13'E to 92° 27'E longitude, it covers an area of about 500 km^2 at an altitude range of 200 m to1200 m above msl. It receives an annual rainfall of about 2000 mm to 2500 mm. The protected area was initially established as Wildlife Sanctuary in 1985; it was declared a Tiger Reserve in 1994 and is part of the Centrally Sponsored (Plan) Scheme 'Project Tiger'. Its fringe villages are W. Phaileng, Teirei, Damparengpui, Tuipuibari, Lallen, Saithah, Serhmun, Phuldungsei, Pukzing, Khawhnai, W. Phulpui and Silsuri. The region falls within the sub-tropical rain forest region.

The forests of Dampa Tiger Reserve are home to a diverse flora and fauna. It consists of forest interpolated with steep precipitous hills, deep valleys, jungle streams, ripping rivulets, natural salts licks. The common flora of this a variety of species such as *Adina cordifolia*, *Dipterocarpus turbinatus*, *Dipterocarpus marcocarpus*, *Eleocarpus floribundus* , *Terminalia myriocarpa*, *Michelia champaca, Mesua ferrea*, *Sterculia vilosa*, *Mangifera sylvatica, Stereospermum personatum*, *Toona ciliata*, *Chukrasia tubularis*, *Syzygium cumini*, *Gmelina arborea* etc. and a variety of Bamboos, Canes, Orchids, Lichens and Bryophytes. It harbours important animals like Tiger, Bison, Elephant, Bear, Leopard, Jungle Cat, Wild dog, Serow, Wild boar, Assamese macaque, Stump-tailed macaque, Leaf monkey, Hoolock bibbon, King cobra and important birds such as Great Indian Hornbill, Wreathed Hornbill, Pied hornbill, Imperial pheasant, Bhutan peacock pheasant, Khaleej pheasant, Red jungle fowl, etc.

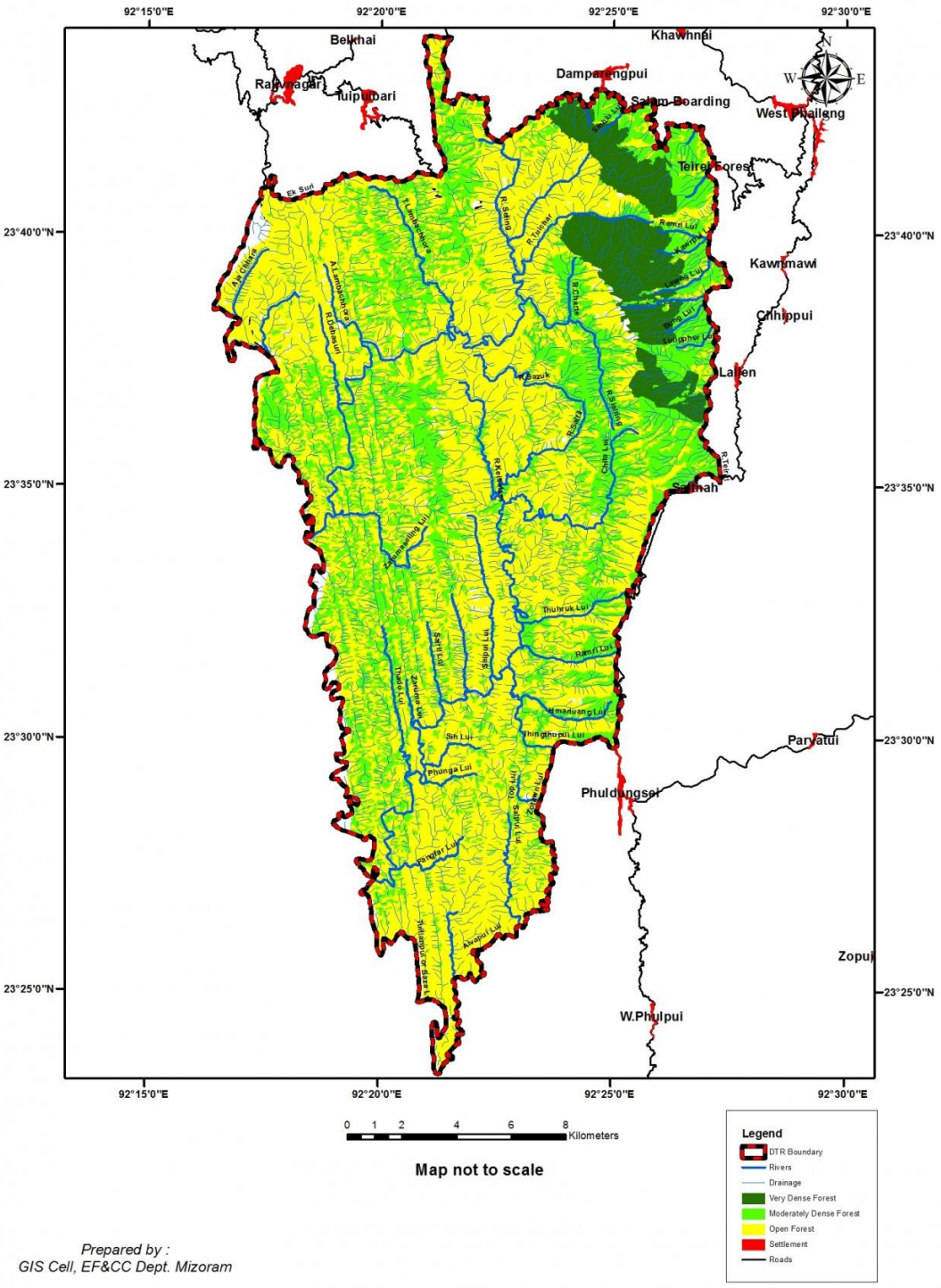


Figure 2. Map of Dampa Tiger Reserve

3.4. Tawi Wildlife Sanctuary

Tawi Wildlife Sanctuary is located in Aizawl district, at a distance of about 101 km from Aizawl, the capital of Mizoram. It covers an area of about 35.75 km^2 and ranges in altitude from 400 m to 1800 m above msl at $23^o30'$ North latitude and $93^o00'$ East longitude. It was notified as a sanctuary in the year 1978. The temperature ranges from 20^oC to 30^oC during Summer and 16^oC to 20^oC during Winter. It receives an annual rainfall of about 2000 mm to 2500 mm. Its Fringe villages are Hualtu, Hmuntha, Maite, Lenchim, Tawizo, and Mualpheng.

The Tropical Evergreen Forests, Semi Evergreen Forests and Scrub forests hosts a variety of rare and endangered species of flora and fauna. Flora of Tawi Wildlife Sanctuary mainly comprises *Gmelina arborea, Schima wallichii, Michelia champaca, Parkia roxburghii, Macaranga denticulata, Callicarpa arborea, Buddleja asiatica, Duabanga grandiflora*, species of Bamboos and Canes, Orchids, Bryophytes and Lichens. Tawi Wildlife Sanctuary hosts a variety of fauna such as Tiger, Leopard, Golden cat, Leopard cat, Marbledf cat, Jungle cat, Serow, Ghoral, Himalayan black bear, Malayan sun bear, Jackal, Civets, Dark Rumped Swift, Hill Myna, Common langur, Hoolock Gibbon, Barking Deer, Red Jungle Fowl, Kallej Pheasant, Great Indian hornbill, Wreathed Hornbill, Pied hornbill, Khaleeej Pheasnt, Bhutan peacock pheasant, White cheeked partridge, Imperial pigeon etc. A number of unique and endangered species of wild animals are also the inhabitants of this sanctuary.

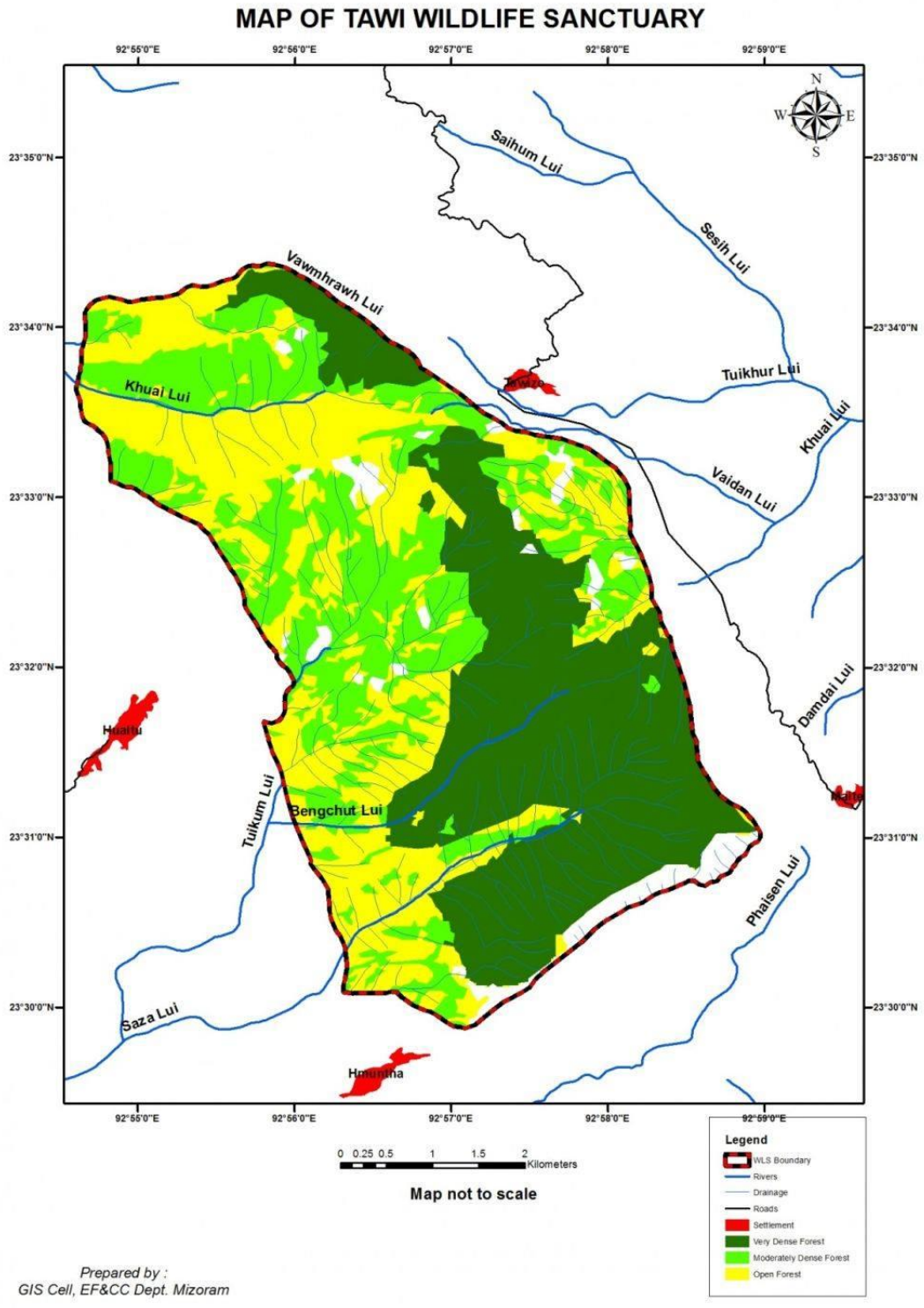


Figure 3. Map of Tawi Wildlife Sanctuary

3.5. Thorangtlang Wildlife Sanctuary

Thorangtlang Wildlife Sanctuary is situated in Lunglei district at about 245 km South of Aizawl, between $23^{o}15'$N to $23^{o}17'$N latitude and $92^{o}35'$E to $92^{o}36'$E longitude. This Sanctuary lies close to the Indo-Bangladesh border. It covers an area of about 50 km^2 with an altitude ranges from 800 m to 1380 m above msl. It receives an annual rainfall of 1700 mm to 3900 mm and the average temperature ranges from 8°C to 20°C during winter and 19°C to 29°C during summer. It was notified as a Reserve Forest in 1982 and declared as Thorang tlang Wildlife Sanctuary by the Government of Mizoram in 2002 vide Government No.B.12012/17/2001-FST dt. 23.4.2002. Its fringe villages are Thenhlum, Laisawral, Sesawm, Bunghmun, Tleu, Kawnpui 'W' and Dampui.

The Evergreen Forests and Semi-Evergreen forests of Thorangtlang Wildlife Sanctuary harbour rich variety of flora and fauna. The common floral species are *Actinodaphne macroptera, Artocarpus nitiden, Dryptes lancifolia ,Dipterocarpus turbinatu, Castonopsis tribuloides, Litsea monopetala, Ficus rigida ,Duabanga grandiflora, Garcinia cowa, Mallotus roxburghianus, Morinda angustifolia, Mesua ferrea, Mitragyna diversifolia, Schima wallichii, Sterculia villosa, Toona ciliate, Gnetum gnemon* etc. A variety of Bamboos, Canes, Orchids, Bryophytes and Lichens are also present. The fauna of the region includes Sambar, Barking deer, Serow, Goral, Tiger, Leopard, Clouded leopard, Jungle cat, Leopard cat, Common Civet, Hoolock gibbon, Rhesus macaque, Himalayan Black Bear, Wild boar, Common Indian Rat Snake, Green pit viper, Partridges, Res Jungle fowl, Kaleej Pheasant, Woodpecker, Barbet, Hornbill, Cuckoo, Parakeet, Owl, Dove, Eagle, Pitta, Leafbird, Magpie, Minivet, Warbler etc.

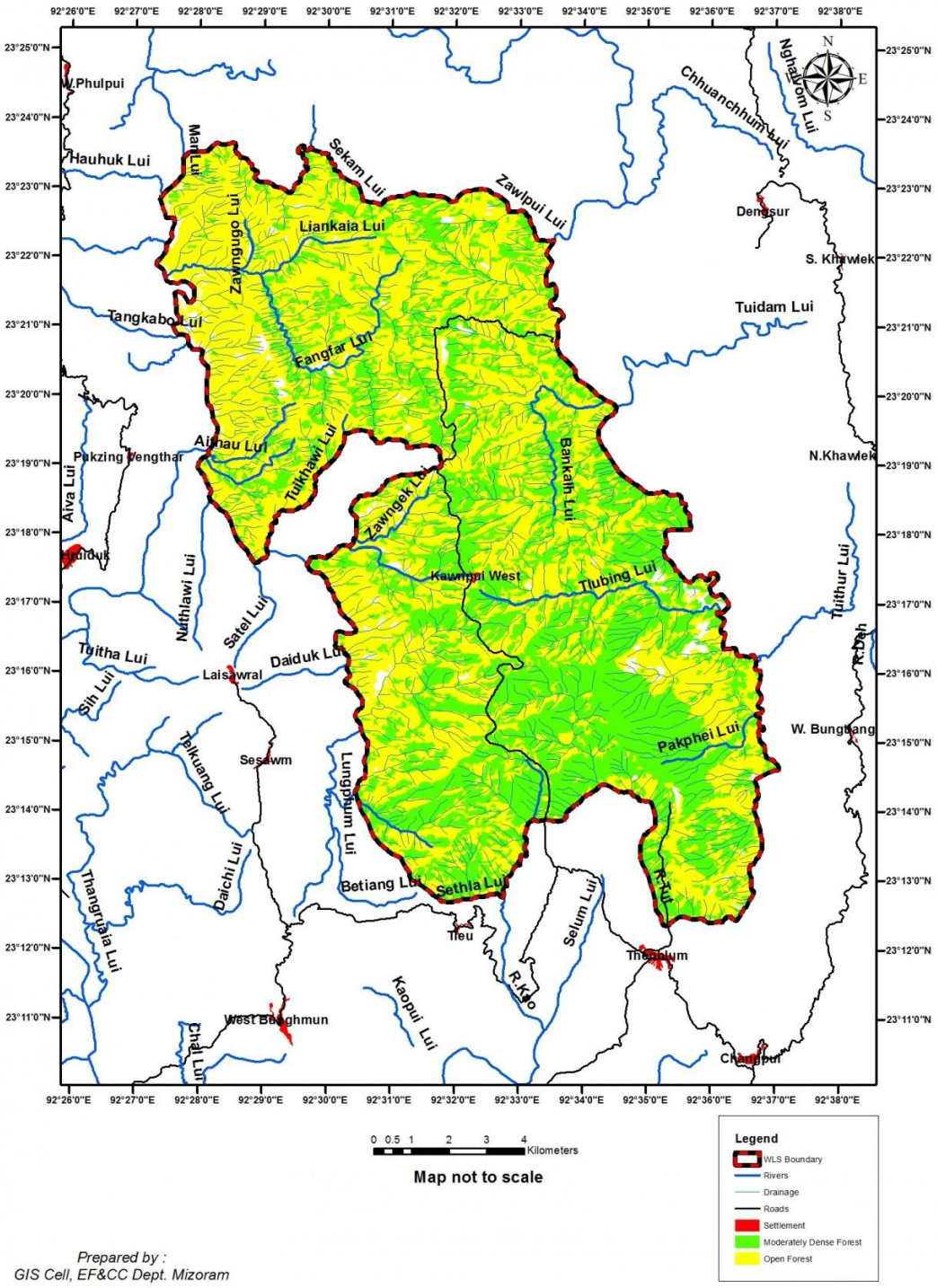


Figure 4. Map of Thorangtlang Wildlife Sanctuary

CHAPTER- IV

MATERIALS AND METHODS

4.1. Field Work and Collection of Bryophytes

Field survey and collections of Bryophytes were done in all the potential habitats within the selected sites in different seasons of the year. The collections of Bryophyte specimens were executed during May, 2014 - August, 2017. The occurrence of species was recorded along with their substrates. The plants including all the parts were scratched out along with a little substrate with the help of sharp knife. For sampling of epiphytic Bryophytes, the plants were scratched out along with the tree bark with the help of sharp knife. For collecting of epiphyllous Bryophytes, whole leaves on which the epiphylls are growing were collected. All the essential field data were noted with the help of GPS. The collected specimens of Bryophytes were placed in a handmade thick paper envelope having 10x14 cm in size with a field label data: altitude, collection number, date of collection, vegetation types, place of collection and associated habitats. The collected specimens were air-dried to avoid fungal damage.

4.2. Identification and description of the collected specimens

The identifications of collected specimens were done at Central National Herbarium, Botanical Survey of India, Kolkata; Bryological Laboratory, National Botanical Research Institute, Lucknow, BSI, Shillong and Laboratory of Ecology and Biodiversity, MZU. The collected specimens were studied carefully with microscopes, identified and described morphologically by their diagnostic characters.

The identified species were described with the help of available literatures (Yamaguchi, 1993; Evans, 1939; Schuster, 1984; Vitt, 1984; Tewari and Pant, 1994; Singh and Nath, 2007; Gangulee, 1969-1980, Bansal *et al*., 2011; Lal 2005; Chopra, 1975; Singh and Singh, 2009; Barukiyal, 2011; Barbhuiya and Singh, 2012); given accession numbers and deposited to Laboratory of Ecology and Biodiversity, Department of Botany, School of Life Science, Mizoram University, Tanhril, Mizoram.

4.3. Phytochemical Screening

Four species of Bryophytes were selected for phytochemical study, consisting of two species of moss- *Atrichum undulatum* (Hedw.) P. Beauv. and *Pogonatum neesii* (Müll. Hal.) Dozy; and two species of liverworts- *Dumortiera hirsuta* (Sw.) Nees and *Marchantia linearis* Lehm. and Lindenb. The selected specimens were collected from the study sites, washed thoroughly with sterilized water and dried at room temperature. Powdered plants were extracted with 200 ml methanol in Soxhlet apparatus for 24 hours. The crude extracts were obtained by evaporating the solvent. The crude extracts of selected species were analysed for the presence of various phytochemicals such as: alkaloids, flavonoids, tannins, phenols, terpenoids, steroids and saponins as per methods described by Harborne (1973) and Trease and Evans (1989).

4.3.1. Test for Alkaloids

Mayor's Test: To the test solution in 10 ml methanol, 6 drops of 1 % (w/v) HCl and Mayor's reagent were added.

Hager's Test: To the test solution in 10 ml methanol, 6 drops of 1 % (w/v) HCl and Hager's reagent were added. A creamish or brownish red or orange precipitate indicates the presence of alkaloids.

4.3.2. Test for Flavonoids

To a portion of the aqueous filtrate of each plant extract 5 ml of dilute ammonia solution was added followed by addition of concentrated H_2SO_4. The formation of yellow color indicated the presence of flavonoids.

4.3.3. Test for Phenols

Ferric chloride test: A drop of 1% ferric chloride solution was added to the test solution. The development of intense colour indicates the presence of phenols.

4.3.4. Test for Saponins

5 ml of distilled water was added to 1g of the crude extract, it was shaken vigorously. The formation of persistent froth indicates the presence of saponins.

4.3.5. Test for Terpenoids

Salkowski Test: To 5 ml of each extract solution mixed with 2 ml of chloroform, 3 ml concentrated H_2SO_4 was carefully added to form a layer. A reddish brown colour of the interface was formed which indicates the presence of terpenoids.

4.3.6. Test for Tannins

A few drops of 0.1% ferric chloride solution was added to 2 ml of the test solution. The formation of brownish green or blue-black colouration indicates the presence of tannins.

4.3.7. Test for Steroids

Liebermann-burchard Test: 2 ml of acetic anhydride was added to the test solution along with 2 ml of concentrated H_2SO_4. The change of colour from violet to blue or green indicates the presence of steroids.

4.4. Antioxidant Activity

Antioxidant activity of the crude extracts of selected species were estimated by the free radical scavenging activity using 1,1-Diphenyl-2-picrylhydrazyl (DPPH) assay method described by Huang *et al*.,(2005). Solution of DPPH (0.1mM) in methanol was prepared and 1 ml of this solution was added to 3 ml of methanolic extracts of selected species and standard solution prepared at different concentrations (10, 20, 40, 60, 80, 100 µg/ml). Corresponding blank sample were prepared and Butylated Hydroxy Toluene (BHT) was used as reference standard. The mixture was shaken vigorously and incubated in dark at room temperature for 30 minutes. The absorbance was measured at 517 nm against a blank using Thermo Scientific EVOLUTION 200 UV-Visible spectrophotometer. All tests were done in triplicates. The capability to scavenge the DPPH radical was calculated using the following equation:

$$\text{DPPH scavenging effect (\%)} = \frac{A_0 - A_1}{A_0} \times 100]$$

where A_0 is an absorbance of control solution at 517 nm and A_1 is the absorbance of test sample. The antioxidant potential of the test sample was expressed as IC50 value and compared with the standard. The IC50 value is the concentration (µg/ml) of the extract that scavenges the DPPH radicals by 50%.

4.5. Antibacterial activity of crude extracts of the selected species

Antibacterial activity of methanolic extracts of selected species was tested against pathogenic gram positive bacteria *Bacillus subtilis* (ATCC-11774) and gram negative bacteria *Escherichia coli* (ATCC-10536) and *Klebsiella pneumoniae* (ATCC-10031) using Agar well diffusion assay method (Murray *et al*., 1995; Olurinola, 1996). After solidification of nutrient agar, 100 µL of bacterial suspension was uniformly spread on nutrient agar medium in sterile petri-plates, wells were made with a 6 mm sterile cork borer. Different concentrations of extracts (10, 30, 50 mg/ml) were made with DMSO (Dimethyle sulfoxide) and 100 µL of each was poured in the wells. Ceftriaxone+Sulbactam were used as positive control. The plates were incubated at 37ºC for 24 hours and antibacterial activity of plant extract was observed by measuring the diameter zone of inhibition. All tests were done in triplicates and average result was recorded.

CHAPTER-V

RESULTS

5.1. Documented Bryophytes with descriptions arranged in alphabetical order of Families

A total of 151 species belonging to 98 genera and 57 families have been identified and recorded from the study sites. Of these, the mosses are represented by 102 species of 68 genera and 37 families, while Liverworts are represented by 46 species of 28 genera and 19 families. Hornworts are represented by 3 species of 2 genera and 1 family.

5.1.1. Mosses

Bartramiaceae

1. *Bartramia brevifolia* Brid.

Bryol. Univ., 2: 737. 1827.

Description: Plants in dense tufts, glaucous or brownish green. Stems 0.5-3 cm. Leaves erect to erect-spreading and somewhat flexuose when dry, spreading when moist, narrowly lanceolate, 2-5 mm; base sheathing, shoulders well developed, firm, ; margins strongly revolute, serrulate distally, teeth paired; apex subulate, ; costa excurrent, prominent in distal limb, distal abaxial surface rough; basal laminal cell walls thick toward costa, thin toward margins; distal cells 8-25x4-8 µm, prorulae high. Dioecious. Seta 0.6-1.6 cm, straight to slightly arcuate. Capsule inclined, globose to ovoid, asymmetric, 1.5-2.5 mm; operculum short-convex; peristome single or double; exostome teeth 200-350 µm, finely papillose proximally, vertically striate distally; endostome absent or, if present, basal membrane rudimentary,

segments sometimes present, less than 1/3 length of teeth, finely papillose, cilia absent. Spores 25-35 µm.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-064.

2. *Philonotis fontana* (Hedw.) Brid.

Bryol. Univ. 2: 18.1827; Gangulee, Moss. E. India, 2(4): 1114. 1974; R.S. Chopra, Taxon. Indian Moss, 252. 1975; J. Lal, Checklist Indian Moss, 102. 2005.

Description: Stems usually to 10 cm long or rarely longer, tomentose below. Leaves appressed when dry, broadly ovate; margins slightly revolute, teeth paired; costa excurrent. Median laminal cells sublinear, rectangular, hexagonal or subquadrate, smooth or mamillose at the lower end walls on the ventral surface; lower cells lax, hexagonal or rectangular, inflated, thin-walled, without mammillae. Setae 4-5 cm long, flexuose. Capsules horizontal to inclined, globose or ovoid. Exostome teeth reddish-brown; cilia of endostome elongate.

Specimens examined: Mizoram, Champhai district, MNP, 1442 m alt., Dt. 20. 02. 2018, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-063.

Brachytheciaceae

3. *Brachythecium plumosum* (Hedw.) Schimp.

Bryol. Eur., 6: 8. 1853.

Description: Plants medium-sized, pale green, somewhat glossy, in dense mats. Stems prostrate, 4 cm long, pinnately or irregularly pinnately branched, densely foliate. Stem leaves erect-spreading when dry and moist, ovate-lanceolate, concave, bi-plicate, gradually acuminate at apex; margins plane, entire below, serrulate above;

costae ending beyond mid-leaf; median leaf cells linear,thin-walled, basal cells shorter, broader; alar cells slearly differentiated, quadrate; branch leaves narrowly ovate-lanceolate, concave, slenderly acuminate at apex, often constricted at base. Dioecious. Perichaetial leaves lanceolate. Setae 2 cm long, papillose in the upper part; capsules elongate-ellipsoidal, inclined; opercula conic; peristome double; cilia long, nodulose.

Specimens examined: Mizoram, Aizawl district, TWS, 1420 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-059.

4. *Eurhynchium riparioides* (Hedw.) P.W. Richards.

Ann. Bryol., 9: 135. 1937.

Description: Bright green to brown, robust plants, glossy when dry, in tall tufts. Main stem prostrate or pendulous, irregularly branched. Branches long, erect or arched or parallel to stem. Leaves dense, terete, erectopatent both wet and dry, concave, plicate, almost orbicular, decurrent at base, acute at tip, margin denticulate almost to base. Costa covering 2/3 of leaf length. Leaf cells linear rhomboid, incrassate, vermiform on the edge, extreme basal and alar cells are rectangular, lax. Autoecious.

Specimens examined: Mizoram, Lunglei district, TTWS, 1102 m alt., Dt. 23. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-060.

5. *Homalothecium sericeum* (Hedw.) Schimp.

Bryol. Eur. 5: 93. 1851.

Description: Plants medium-sized to large, in dense or loose tufts, light green to golden or brownish yellow. Stems up to 5 cm long, moderately densely pinnate,

branches 5-7 mm, curved and secund from substrate. Stem leaves erect-appressed, homomallous, triangular-lanceolate; base short-rounded, narrowly decurrent; margins plane or often recurved at places, serrulate; apex acuminate or gradually tapered; costa up to 3/4 of leaf length; alar cells ovate; laminal cells linear; basal cells irregularly ovate. Branch leaves appressed to erect when dry, spreading when moist, narrowly lanceolate. Seta 1-2 cm, rough. Capsule erect, cylindric, straight or slightly curved, 2-3 mm; annulus separating; operculum long-conic, short-rostrate; peristome hygrocastique; exostome teeth papillose to base; endostome basal membrane moderately high, segments as long as teeth, narrow, cilia very short. Spores 15-19 µm in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-062.

6. *Rhynchostegiella menadensis* (Sande Lac.) E.B. Bartram.

Philipp. J. Sci., 68: 302. 1933.

Description: Plants slender, yellow-green, dull to glossy feathery, corticolous plants in lax mats. Main stem creeping with numerous short, pinnate, feathery, ascending branches. Leaves lax, widely spreading, narrow lanceolate, slenderly acuminate, margin faintly and irregularly dentate, decurrent at base. Costa covering about half the leaf length. Leaf cells linear elongate, slightly wider at base; alar cells rectangular above, quadrate below, distinct. Perichaetial leaves narrow acuminate, erect, spreading at top. Seta erect, smooth. Capsule inclined.

Specimens examined: Mizoram, Lunglei district, TTWS, 1112 m alt., Dt. 22. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-061.

7. *Rhynchostegium riparioides* (Hedw.) Cardot.

Bull. Soc. Bot. France, 60: 231. 1913.

Description: Plants medium-sized, stout, dark green, in loose mats. Stems prostrate, 4 cm long, loosely irregularly branched, occasionally with erect or ascending branches, sparsely foliate, sometimes naked; branches densely foliate, simple or with branchlets. Stem and branch leaves similar, broadly ovate, rounded or orbicular, broadly acute or apiculate at apex, strongly constricted ar insertion; margins plane or rarely waved, serrulate nearly throughout; costae reaching above mid-leaf, median leaf cells long rhomboidal to linear, thin-walled; apical cells shortly rhomboidal; alar cells moderately differentiated, shortly rectangular or elliptical. Autoecious. Perichaetial leaves lanceolate, costate. Setae 1 cm long, reddish brown, smooth; capsules inclined, ovoid, dark green; opercula shortly rostrate, with curved beaks; endostome segments as long as exostome teeth, perforate; cilia short, reduced.

Specimens examined: Mizoram, Lunglei district, TTWS, 1120 m alt., Dt. 23. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-054

Bruchiaceae

8. *Trematodon longicollis* Michx.

Fl. Bor.-Amer., 2: 289. 1803.

Description: Plants yellowish-green, 2 to 5 mm high; leaves erect spreading, suddenly tapering from a broad, ovate to rectangular sheathing base to a long narrow apex, margin slightly toothed at apex, entire below, 2-4 mm long; costa single, percurrent or ending before the apex; cells at lamina rectangular. Seta 2-4 cm long, pale yellow, erect, twisted when dry. Capsule inclined, curved, yellowish-brown;

neck 2-3 times as long as urn when dry, long-cylindric, strumose at base; peristome teeth reddish-brown, operculum conic rostrate, urn ovate-cylindrical, tapering into a long spongy cylindrical apophysis, calyptra cucullate; spores rounded, opaque, yellowish-brown, warty papillose, 15-22 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-094.

Bryaceae

9. *Anomobryum filiforme* var. *concinnatum* (Spruce) Loeske.

Rev. Bryol. Lichénol., 5: 200. 1933.

Description: Plant body is slender, yellow-green to gray-green, slightly shiny. Stem is about 30 mm long, single or sparsely branched. Leaves appressed when dry. When wet, they are covered with tiling and long spikes. The oval or long cotton is round and oval. The length and width are about 1.3-1.5x0.5-0.7 mm. The leaf surface is concave and the apex is sharp. With a red dot, the rim is erect, entire; the middle rib is single thick, yellowish brown, extending to the tip of the leaf. The middle part of the leaf is linear to a hexagonal diamond. With asexual buds.

Specimens examined: Mizoram, Lunglei district, TTWS, 1148 m alt., Dt. 21. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-001.

10. *Brachymenium exile* (Dozy & Molk.) Bosch & Sande Lac.

Bryol. Jav., 1: 139. 1860.

Description: Plants yellowish-green, small, loosely tufted, up to 3 mm long, stem erect, tomentose below; leaves ovate, acuminate, not much changed or contorted when dry, imbricate when moist, up to 2x0.05 mm, entire, not bordered, leaves

crowded above; costa strong, excurrent; cells rhomboid-hexagonal at upper and middle, up to 45x10 µm, lower cells quadrate, near midrib 50x15 µm; seta long, 1.3 cm high; capsule erect, apophysis narrow; spores rounded, small, 15-20 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TTWS, 1448 m alt., Dt. 21. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-002.

11. *Brachymenium nepalense* Hook. in Schwaegr.

Sp. Musc. Frond., Suppl. 2(2): 135. 1824; Gangulee, Moss. E. India, 2(4): 937. 1974.

Description: Plants robust, dark green, not gloosy, densely tufted. Stems 1-2 cm high, branched. Lower leaves small, comal leaves larger and tufted, twisted when dry, oblong-lingulate, acuminate at apex, reddish at base; margins entire and revolute below, slightly crenate and flat at tip. Costae stout, reddish, excurrent in an arista. Median laminal cells somewhat thick-walled, elongate-hexagonal, becoming rectangular at base. Leaf-margins distinctly bordered with 2-3 rows of narrower, yellowish, thick-walled cells. Setae erect or flexuous, 3-4 cm long. Capsules suberect, narrowly pyriform, with a short tapering apophysis.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 20. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-003.

12. *Bryum alpinum* Huds. ex With.

Syst. Arr. Brit. Pl. (ed. 4) 3: 824. 1801; Gangulee, Moss E. India, 2(4): 1006. 1974; A.E.D. Daniels, R. Annamalai, Tamil Nadu Biodivers., 50. 2004; J. Lal, Checklist Indian Moss, 32. 2005.

Description: Plants small, 5-10 mm long, pale green, yellowish green to yellowish brown or reddish, glossy, in tufts. Stems erect, usually branched, with rhizoids hardly present. Leaves somewhat stiff, erect or spreading when dry or moist, ovate-lanceolate, acuminate, keeled; margins recurved, entire or serrulate near apex; costae shortly excurrent; meadian leaf cells rhomboidal, thick-walled; basal cells rectangular; marginal cells gradually narrowed, borders not clearly differentiated. Dioecious. Setae 15-25 mm long; capsules pendulous, dark reddish, pyriform, 3 mm long; neck developed; peristome well developed; cilia 2-3. Spores small 12 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1516 m alt., Dt. 19. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-010.

13. *Bryum apiculatum* Schwagr.

Sp. Musc. Frond., Suppl., 1(2): 102. 1816; D.G. Long, Bot. J. Linn. Soc., 119: 15. 1995; J. Lal, Checklist Indian Moss, 32. 2005.

Description: Plants slender, densely caespitose, yellow to green. Stems 4-10 mm tall, older parts dull orange to light red-brown, often branched, typically with one or two innovations from just below perichaetia and perigonia. Leaves erecto-patent to patent, not much altered when dry; ovate-lanceolate, ovate-triangular or lanceolate, usually widest just below middle of leaf; leaf apex acuminate; margins entire or faintly denticulate only near apex. Costa moderately strong, green to brownish, percurrent to shortly excurrent. Rhizoids brown, papillose. Two types of propagules occur on stems, gemmae and bulbils. Dioecious. Capsules plentiful. Perigonia small, at stem tips; perigonial bracts much like leaves. Capsules mainly cernuous 1.0-1.6

mm, symmetrical, wide-mouthed. Mature capsules orange-brown to dark red-brown. Operculum conical, orange-brown to dull red-brown.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-004.

14. *Bryum argenteum* Hedw.

Sp. Musc. Frond., 181. 1801.

Description: Plants gregarious or in dense mats, white-green to silver-green. Stems 0.2-1 cm, strongly rounded julaceous or sometimes gemmiform. Leaves erect when moist, ovate to ovate-lanceolate, somewhat concave, 0.3-1 mm; base green; margins rarely recurved proximally or plane distally; apex broadly rounded to acute, hyaline in distal 1/4-1/2 of leaf or rarely nearly entirely green; costa not reaching apex, apiculus present, sometimes short or nearly absent, hyaline, proximal laminal cells quadrate or short-rectangular, 12-18 µm wide, distal cells short or elongate-hexagonal, walls thin or somewhat thickened. Specialized asexual reproduction by leaf axil bulbils, leafy, small. Seta brown to red-brown, 1-2 cm. Capsule red to red-brown, ovate, 2-3 mm; hypophysis differentiated, somewhat thickened. Spores 8-15 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1210 m alt., Dt. 18. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-006.

15. *Bryum cellulare* Hook.

Sp. Musc. Frond., Suppl., 31(1): 214. 1827.

Description: Plants tufted, small, light green to purplish brown, up to 1 cm long, tomentose at the base, arise from protonemal filaments, slightly glossy; leaves ovate

to oblong, tip obtuse, closely overlapping, 1 mm long, arranged in three tiers, bordered all around, slightly serrated by the elongation of the marginal cells, leaf insertion to the stem deep; costa prominent, purplish brown, percurrent or ending below apex; cells elongated, rhomboid at apex, 75-80x12-15 µm, basal subquadrangular to hexagonal, 88-92x15-20 µm; seta erect, brownish, up to 2 cm or more long; capsule erect to pendulous, globose; spores numerous, brownish, rounded, 15-20 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1248 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-005.

16. ***Bryum coronatum*** Schwägr.

Sp. Musc. Frond., Suppl., 1(2): 103. 1816.

Description Plants densely tufted, yellowish-green. Stems short, 5-10 mm long, often branched. Stem leaves imbricate, lanceolate to ovate-lanceolate, apices acuminate; margins flat, entire; costae strong, reddish at base, long-aristate, the apex often pellucid. Branch leaves triangular-lanceolate. Median laminal cells rhomboidal to hexagonal, thin-walled; cells along the margins narrow-rectangular, thin-walled, not forming border; lower cells elongate-rectangular. Setae 1-1.5 cm long, reddish-brown. Capsules pendulous, oblong, reddish-brown; the apophysis slightly wider than the urn and bulging, rounded-obtuse at base, warty when dry.

Specimens examined: Mizoram, Aizawl district, TWS, 1215 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-007.

17. *Bryum pseudotriquetrum* (Hedw.) P. Gaertn., B. Mey. & Scherb.

Oekon. Fl. Wetterau, 3(2): 102. 1802; Gangulee, Moss. E. India, 2(4): 991. 1974; J. Lal, Checklist Indian Moss, 33. 2005.

Description: Plants green above, reddish below, tomentose below; leaves crowded together, ovate to lanceolate, 1.2-2.2x0.6 mm, margin plane, faintly serrated at tip, bordered by 1-2 layers of elongated yellowish cells, base wide, often reddish; costa stout, reach far above the tip, pointed, reddish; cells at upper half hexagonal-rhomboid, 50-60x10 mm, lower broad and rectangular, 60x10-15 mm; seta arises from the base of the branches, 2.5 cm long, reddish-brown; capsule elongated, cylindrical, pendulous with a distinct tapering apophysis, 3-5 mm long; spores hyaline, 30-45 µm in diameter.

Specimens examined: Mizoram, Mamit district, DTR, 814 m alt., Dt. 20. 8. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-013.

18. *Bryum uliginosum* (Brid.) Bruch & Schimp.

Bryol. Eur., 4: 88.1839.

Description: Plants small, 10 mm high, green, yellowish green or brown, in loose or dense tufts. Stems erect, branched. Leaves loose when dry, erect-spreading when moist, 5 mm long, acuminate at apex; margins entire, not decurrent at base, bordered by several rows of linear cells, yellowish brown, 2-3 stratose; costae percurrent or shortly excurrent; leaf cells lax, thin-walled, oblong-hexagonal or shortly rhomboidal. Autoecious. Setae elongate; capsules horizontal or pendulous, elongate club-shaped to pyriform; neck as long as or shorter than urn; mouth oblique, asymmetric; exostome teeth yellowish brown; endostome segments broad.

Specimens examined: Mizoram, Champhai district, MNP, 1526 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-014.

19. *Rhodobryum giganteum* (Schwägr.) Paris.

Index Bryol., 1116. 1898; Gangulee, Moss. E. India, 2(4): 1020. 1974; R.S. Chopra, Taxon. Indian Moss, 214. 1975; M.C. Nair & Madhus., J. Econ. Taxon. Bot., 25 :573. 2001.

Description: Plants 1-3 cm high, caespitose, yellow green to dull green. Stems erect, branched or not, with a central strand; stolons creeping, subterranean. Leaves comose at apex, lax below, faintly contorted when dry, erect to erectopatent, 10-15x3-5 mm, spatulate, recurved, entire below, flat, with paired teeth at margin above, acuminate; cells thin-walled, rhomboid-hexagonal, smooth; costa single, percurrent or ending below apex. Perichaetial leaves 8x3 mm, oblong, long-acuminate, toothed at apex. Setae apical, 2-3 in each perichaetium, 2-3 cm long. Capsules reddish brown, oblong-cylindrical, horizontal to pendulous, with a short apophysis. Opercula conic, apiculate. Peristome bryoid, cilia of endostome 3, shorter than the segments, distinctly appendiculate. Spores 12-16 µm in diameter.

Specimens examined: Mizoram, Mamit district, DTR, 720 m alt., Dt. 18. 07. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-009.

20. *Rhodobryum roseum* (Hedw.) Limpr.

Laubm. Deutschl., 2(20): 445. 1892.

Description: Plants 1-3 cm tall, commonly branched by slender sub-apical innovations. Stem leaves 3-8 mm, relatively few in rosettes, 18-22; margins revolute to about mid leaf or less, apex acute; costa variable, from subpercurrent to

percurrent, with slender apiculus, to short-excurrent into a slender hairpoint on median rosette leaves, in cross section with small stereid band; distal and median laminal cells hexagonal, 25x80 µm, proximal cells longer, up to 100 µm, rectangular. Inner perichaetial leaves with costa variable, from subpercurrent to percurrent or excurrent into a short, smooth to weakly denticulate hairpoint. Spores 16-20 µm in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-011.

Cryphaeaceae

21. *Schoenobryum concavifolium* (Griff.) Gangulee.

Mosses E. India., 5: 1209. 1976.

Description: Plant yellowish-green to blackish-green, creeping, primary branches up to 2.5 cm long, secondary branches small; leaves oblong-ovate, up to 2 mm long, apex acute, margin flat, feebly serrated at tip; costa yellowish, strong, reach up to middle; cells ovate to elliptical, papillate at middle, basal elongate, 18-20x6-8 µm, upper shorter, oblique rows towards margin, marginal cells transeversely placed; capsule immersed, ovoid, calyptra conical; spores rounded to ovate, 15-25 mm diagonally. The plants are firm when dry and often have a shrub-like aspect due to the erect clustered branches.

Specimens examined: Mizoram, Lunglei district, TTWS, 1142 m alt., Dt. 21. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-074.

Daltoniaceae

22. *Cyathophorella tonkinensis* (Broth. & Paris) Broth.

Nat. Pflanzenfam. (ed. 2) 11: 278. 1925.

Description: Dark green plants, dioecious. Primary stems prostrate, rhizomatous, with tomentose rhizoids at base; Secondary stem simple, 4-5 cm long, tips caudate and densely felted with abundant brood filaments. Leaves plane; lateral leaves asymmetrical, widely spreading, smaller toward the base and tip of stems, ovate, acuminate, narrowly bordered, the border 1-2 celled wide, margin spinose-dentate, costa shortly unequally forked; cells elongate or oblong-hexagonal. Seta short, capsule erect, cylindrical, peristome teeth papillose, segments of endostome from a low basal membrane, cilia lacking. Amphigastria ovate, acuminate, costa obsolete or nearly ecostate.

Specimens examined: Mizoram, Aizawl district, TWS, 1456 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-086.

Dicranaceae

23. *Campylopodiella stenocarpa* (Wilson) P. Muell. & J.-P. Frahm.

Nova Hedwigia, 45: 290. 1987.

Description: Plants yellowish green, in loose tufts. Stems erect, 8-15 mm, radiculose proximally, erect-patent or curled when dry. Leaves 3.5-5 mm, 10-13 times longer than wide, narrowly lanceolate, gradually narrowed from an ovate base into a long acumen, entire at margins except for a few teeth at the extreme tip; costa filling 2/3 of the leaf base, 175-200 µm wide, excurrent; alar cells weakly differentiated; basal laminal cells in 15-18 rows, hyaline, thin-walled, rectangular, narrower at margins;

distal laminal cells elongate. Dioecious. Perichaetial leaves suddenly contracted from a broadly ovate base. Seta erect, 8-19 mm, sinistrorsely twisted distally. Capsule long-cylindric, 2.5x0.4 mm, yellowish or brownish with age; exothecial cells incrassate, rectangular; operculum long-rostrate, reddish brown, 1-1.2 mm; peristome teeth 16, divided almost to the base, yellowish brown, lighter at tips, striate proximally, papillose at tips, about 290 µm. Calyptra cucullate, entire at base. Spores yellowish green, 11-13 µm in diameter.

Specimens examined: Mizoram, Lunglei district, TTWS, 1049 m alt., Dt. 21. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-015.

24. *Campylopus ericoides* (Griff.) A. Jaeger.

Ber. Thätigk. St. Gallischen Naturwiss. Ges., 424. 1872.

Description: Plants small to medium-sized, 2-5 cm high, yellowish brown, somewhat shiny, in dense tufts. Stems reddish, erect, simple or rarely branched, comose foliate, radiculose at base. Leaves 5-6 mm long, somewhat flexuose when dry, erect-patent when moist, lanceolate, contracted at base, gradually narrowed to a canaliculate subula, ending in a subhyaline to occasionally hyaline hairpoint; margins inflexed in the upper 2/3, serrulate in the upper 1/3; costa pale yellowish brown, occupying 1/3 the leaf base width, shortly excurrent, with dorsal and ventral stereid bands; upper cells obliquely rectangular to rhomboidal, thick-walled, sometimes with 1 row of thin-walled, rectangular cells at the margins; basal cells yellowish, moderately long-rectangular, narrower toward the margins; alar cells forming well marked auricles, moderately inflated, hyaline or reddish brown. Dioecious. Setae 5 mm long, straight when dry, cygneous when moist, reddish brown; capsules erect,

ovoid to short-cylindric, symmetric, scabrous at base; opercula long-rostrate; annuli compound, in 2 rows of cells; peristome teeth reddish. Calyptra fringed at base. Spores 8-9 µm in diameter, yellow, smooth.

Specimens examined: Mizoram, Aizawl district, TWS, 1240 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-019.

25. *Campylopus fragilis* (Brid.) Bruch & Schimp.

Bryol. Eur., 1: 164. 1847.

Description: Plants 0.5-2 cm, yellowish green, in tufts, very densely foliate, often ending in a penicillate comal tuft, whitish tomentose. Leaves 4-5 mm, ovate-lanceolate, widest below the middle and contracted at base, narrowed into a more or less long straight, concolorous subula; alar cells hardly developed; basal laminal cells thin-walled and hyaline, very distinctly differentiated from the distal thick-walled and quadrate laminal cells; costa shortly excurrent, slightly serrate at tip, in transverse section showing very wide adaxial hyalocysts, filling half of the width of the costa, and abaxial substereids, slightly abaxially ridged. Specialized asexual reproduction by small, boomerang-shaped leaves produced in the axils of the distal leaves.

Specimens examined: Mizoram, Aizawl district, TWS, 1240 m alt., Dt. 19. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-016.

26. *Campylopus introflexus* (Hedw.) Brid.

Muscol. Recent., suppl., 4: 72. 1819.

Description: Plants 0.5-5 cm, in dense mats, yellowish to olive green, tomen-tum present or almost absent. Leaves 4-6 mm, erectopatent when wet, appressed when

dry, lanceolate, straight, with entire margins; alar cells absent or formed by thin-walled, hyaline to reddish, inflated cells; basal laminal cells hyaline, rectangular, thin-walled, extending higher at margins and forming a V-shaped area; distal laminal cells incrassate, shortly rectangular to oblique, chlorophyllose; costa excurrent in a hyaline hair tip, which is conspicuously 90° reflexed, in transverse section showing adaxial hyalocysts and abaxial stereids, shortly lamellose at back with ribs 1-2 cells high. Seta 7-12 mm, yellowish brown to brownish in age, often several sporophytes from the same plant, curved or sinuose. Capsule brown, 1.5 mm, slightly asymmetric and curved when empty. Calyptra ciliate at base. Spores 12-14 µm in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1452 m alt., Dt. 20. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-017.

27. *Campylopus richardii* Brid.

Muscol. Recent. Suppl., 4: 73. 1819.

Description: Plants medium to robust, yellowish green at tips, dark brown to black below; stems 3-6 cm long. Leaves on fertile stems appressed below, in comal tufts above, oblong-lanceolate, 3-8 mm long, apex acute, hyaline hair-pointed; margins concave below, tubulose above, entire; costa excurrent, mammillose at back, in cross section with small guide cells, dorsal stereid cells well-developed, ventral stereid cells weakly developed, consisting of only a single layer or absent, if absent guide cells ventrally exposed; upper cells obliquely rhomboidal; basal cells linear-rectangular, all incrassate-pitted; alar cells forming distinct groups of red-yellow cells. Setae 4-8 mm long, red-black, rough above;

capsules erect, symmetric, cylindrical-ellipsoid, 1.5-2.0 mm long, scabrous at base, red-black; opercula rostrate, 1 mm long. Calyptra 2 mm long, ciliate at base.

Specimens examined: Mizoram, Mamit district, DTR, 945 m alt., Dt. 19. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-018.

28. *Dicranum flagellare* Hedw.

Sp. Musc. Frond., 130. 1801.

Description: Plants in dense tufts, usually bearing 2-6 dark green, stout, terete branchlets, 1-4 mm, in the axils of the distal leaves, each flagelliform branchlet with short, ovate to lingulate, broadly acute to obtuse, ecostate or shortly and indistinctly costate leaves closely appressed to the axis, yellowish green to dark green, glossy. Stems 0.5-6 cm, densely tomentose with light brown to reddish brown rhizoids. Leaves falcate-secund to nearly straight, crisped to weakly crisped when dry, smooth, concave below, tubulose above, from a lanceolate or ovate-lanceolate base to an acuminate subula, apex acute; margins smooth to serrulate above; laminae 1-stratose; costa percurrent, smooth to rough with papilla; leaf cells smooth; alar cells 1-stratose, distinctly differentiated; proximal laminal cells elongate-rectangular; distal laminal cells short-rectangular to quadrate. Dioecious. Capsule 1.5-3 mm, straight and erect, striate when dry, yellowish brown to brown; operculum 0.5-l.6 mm. Spores 12-19 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-020.

29. *Dicranum scoparium* Hedw.

Sp. Musc. Frond., 126. 1801.

Description: Plants medium-sized to large, often robust, up to 10 cm high, dull, green to dirty green or yellowish to brownish, somewhat glossy, in dense tufts. Stems erect, simple or branched, densely tomentose below. Leaves often falcate-secund or slightly flexuose when dry, appressed or erect-spreading when moist, lanceolate, 4-10 mm long, gradually narrowed to a slender, keeled, acuminate or acute apex, sometimes to a subtubulose acumen; margins plane, strongly serrate in the upper 1/3; costa slender, subpercurrent to shortly excurrent, serrate, ridged or lamellae in 2-4 rows at back above; upper cells rhomboidal, moderately thick-walled, smooth, more or less porose; basal cells elongate, rectangular, strongly thick-walled, porose; alar cells quadrate to rounded quadrate, slightly inflated, bi- to tristratose, yellowish brown, not extending to the costa. Dioecious. Seta single, rarely double in one perichaetium, straight, 2-3 cm long, capsules cylindric, 2-3 mm long, curved,; opercula long-rostrate, 2.5-3.0 mm long, peristome teeth 0.5 mm long, papillose and pale brownish above, vertically striate and reddish brown below. Spores 16-20 µm in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1450 m alt., Dt. 20. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-021.

30. *Leucobryum aduncum* Dozy & Molk.

Pl. Jungh., 3: 319. 1854.

Description: Plants small to medium-sized, 1-2 cm high, grayish to yellowish green, in dense or compact tufts. Stems erect, branched, usually not forming conical points

at the apex. Leaves more or less in 5 rows, less than 4.5 mm long, falcate-secund, lanceolate, gradually narrowed to subtubulous tips from an ovate to elliptic base, acute at the apex, often with rhizoids, acumina channelled, filled mostly with costa, undulate and spinosely prorate on the dorsal side of the acumina; hyaline laminal cells narrowly rectangular to linear, forming borders of 1-2 rows of cells on the upper parts of leaves, 4-6 rows of cells near leaf base; in cross section, costal leucocysts 1-layered on the upper parts of leaves, 2-3-layered on the lower parts of leaves enclosing a layer of median chlorocysts throughout leaves. Dioecious.

Specimens examined: Mizoram, Lunglei district, TTWS, 940 m alt., Dt. 23. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-023.

31. *Leucobryum glaucum* (Hedw.) Ångstr.

Summa Veg. Scand., 1: 94. 1845.

Description: This perennial acrocarpous moss forms dense cushions of plants from 12 mm to 60 cm across or more. These cushions have a low dome shape; the glaucous foliage of this moss varies in color from pale grayish green to medium green. The stems are pale green, glaucous, and terete; sometimes they fork dichotomously. The leaves occur in overlapping pseudowhorls along these stems. The leaves are ascending and they clasp the stems at their bases. Individual leaves are 4-9 mm. long, lanceolate in shape, and entire along their margins; they curve upward along both sides of their broad midribs, becoming curled and semi-tubular in shape along the outer two-thirds of their length. The leaves of this moss are 4-6 cells thick. The outer cells are translucent-white, containing air bubbles when they are dry and water when they are moist. Leaf cells are square-shaped to rectangular-shaped.

Dioecious, sporophyte consists of the seta and capsule, calyptra present, peristome teeth 16 in number.

Specimens examined: Mizoram, Aizawl district, TWS, 1240 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-024.

32. *Leucobryum humillimum* Cardot.

Mem. Soc. Sci. Nat. Cherbourg., 32: 15. 1901.

Description: Plants small to medium-sized, up to 3 cm high, whitish green, in dense compact tufts. Stems erect, simple or branched; central strand present. Leaves crowded, 3-6 mm long, imbricate or straight when dry, erect-spreading when moist, broadly lanceolate to oblong-lanceolate, gradually narrowed to subtubulose apices from ovate to oblong-ovate base, distinctly mucronate to apiculate at the apex, dorsal side of leaf acumina smooth; laminal cells on the upper parts of leaves 1-2 rows of linear cells, near leaf base 4-7 rows of quadrate to rectangular cells with 2-3 rows of linear cells forming a border; in cross section, costal leucocysts in 2-4 layers on abaxial side, 1-2 layers on adaxial side, sandwiched with a layer of chlorocysts. Dioecious.

Specimens examined: Mizoram, Lunglei district, TTWS, 1140 m alt., Dt. 23. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-025.

33. *Leucobryum javense* (Brid.) Mitt.

J. Proc. Linn. Soc., Bot., Suppl., 1: 25. 1859.

Description: Plants usually robust, often more than 6 cm high, whitish green tinged with yellow or purple, in loose tufts or cushions. Stems erect, simple or branched. Leaves crowded, 10x2 mm, often falcate-secund, broadly lanceolate to narrowly

lanceolate, gradually narrowed to subtubulose apices from broadly ovate base, acute to bluntly mucronate at apex, dorsal side of leaf acumina papillosely prorate, margins bordered by 2-3 rows of linear cells on the upper parts of leaves, lamina near leaf base consisting of 4-6 rows of quadrate to rectangular cells; costal leucocysts 2-3 layers on both sides of a median layered chlorocysts. Dioecious.

Specimens examined: Mizoram, Mamit district, DTR, 840 m alt., Dt. 18. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-022.

Ditrichaceae

34. *Garckea flexuosa* (Griff.) Margad. & Nork.

J. Bryol., 7: 440. 1973; R.S. Chopra, Taxon. Indian Mosses, 41. 1975; M.C. Nair & al., Bryophyt. Wayanad., 95. 2005.

Description: Plants light green, gregarious; stem erect, very thin, radiculous only at the base; leaves narrow, basal portion broader, rectangular, elongated cells, margin smooth, 0.12 mm long, leaves at lower half distant, smaller, 1.3-1.6 mm, closely appressed when dry, upper leaves aggregated to form a coma, much larger with somewhat recurved margin, up to 2 mm long; costa thick, ending below the apex; cells prosenchymatous, long rectangular to linear, 60x10 mm, wider and yellow near the base, 40x20 mm; capsule immersed or emergent, with a very short, up to 0.5 mm long, erect seta, peristome teeth 16, inserted below the mouth of the urn, operculum rostrate from a conical base, calyptra campanulate; spores spherical, brownish, 15-18 mm diagonally.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-098.

Entodontaceae

35. *Erythrodontium julaceum* (Hook. ex Schwägr.) Paris.

Index Bryol., 436. 1896.

Description: Plants golden-greenish to brownish, robust, main stem creeping, secondary branches numerous, crowded, 4-6 cm long, branches julaceous, dense, erect; leaves broad, ovate, slightly concave, 1-1.5x0.6-0.8 mm, apex acuminate, margin smooth, faintly denticulate at tip; ecostate; cells smooth, narrow, elliptical to linear, 50-58x5-7 µm at tip, marginal and sub marginal ones ovate to quadrate, wider than the inner cells, inner cells elongate and rhomboid, 60-70x7-10 µm at base, at basal angle on both sides there are large triangular patches of transverse, ovate-rectangular cells reaching to considerable height along two margin; seta 2 cm long, twisted in the upper half; capsule cylindrical, erect, operculum conical, short rostrate; calyptra cucullate; covering more than half the capsule; peristome double, spores papillose, large, 20-30 µm diagonally.

Specimens examined: Mizoram, Lunglei district, TTWS, 1045 m alt., Dt. 20. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-087.

Erpodiaceae

36. *Erpodium mangiferae* Müll. Hal.

Linnaea, 37: 178. 1873.

Description: Plant slender, in loose or dense mats, appressed to substratum, pale green. Stems irregularly branched, green to brown, 0.1 mm in cross section, 6-celled across; cortex 1-layered; cells 8-20x6-15 µm, thin-walled; medullary ones 10-24x8-20 µm, thin-walled; branches 2-3 mm long, horizontal to ascending. Leaves

complanate, 0.6-0.8x0.3-0.45 mm, oblong-ovate, concave, entire, acute, ecostate; cells thin-walled, ovate-hexagonal with a distinct, roughly spindle-shaped, primordial utricle; apical cells 6-40x5-16 µm; median ones 32-54x12-16 µm; basal ones 55-80x17-25 µm, sometimes without a primordial utricle; marginal ones 16-28x12-24 µm. Rhizoids scattered on ventral side of stem. Sporophytes terminal on branches. Setae very short, 0.2 mm high. Perichaetial leaves smaller than vegetative ones, 0.45x0.17 mm, oblong-ovate, concave, entire, acute.

Specimens examined: Mizoram, Aizawl district, TWS, 1245 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-081.

37. *Solmsiella biseriata* (Austin) Steere.

Bryologist, 37: 100. 1935.

Description: Plants irregularly branched, usually in loose mats. Dorsal leaves asymmetric, oblong-ovate to elliptic, rounded, 0.45-0.65 mm. Ventral leaves smaller, symmetric, ligulate, rounded, 0.25-0.45 mm; laminal cells thin- to firm-walled, thickened and brown with age, 10-16x8-13 µm, oblate-hexagonal in numerous basal, marginal rows. Perichaetial leaves ovate, obtuse to rounded. Seta 0.6-0.8 mm. Capsule 0.55-0.85 mm, pale yellow; annuli a single row of quadrate cells; peristome absent; opercula conic, obliquly apiculate to rostellate. Calyptra 0.5 mm. Spores finely papillose, 21-31 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1345 m alt., Dt. 18. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-082.

Fabroniaceae

38. *Fabronia assamica* Dixon.

J. Bombay Nat. Hist. Soc., 39: 787. 1937.

Description: Minute, yellow-green glossy plants forming tufts on bark. Main stem creeping, branches erect or ascending, irregular. Leaves dense, imbricate, almost erect with tips spreading, ovate-lanceolate, leaf apex gradually narrowed into an acuminate tip; margins dentate to base. Costa single, short, faint. Leaf cells elongated rhomboid at tip becoming more elongated at extreme tip, but becoming shorter rhomboid at lamina to base, at base angle there is a row of quadrate-rectangular cells. Perichaetial bud lateral, perichaetial leaves wider. Seta smooth, erect or inclined, about 3 mm long. Capsules erect, small, urn-shaped, 1.4 mm long and 0.7 mm in diameter. Operculum short, conical, apiculate when dry.

Specimens examined: Mizoram, Lunglei district, TTWS, 1102 m alt., Dt. 23. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-088.

Fissidentaceae

39. *Fissidens bryoides* Hedw.

Sp. Musc. Frond., 153. 1801.

Description: Plant small 2.5 to 7 mm long and up to 3.5 mm broad with leaves. Leaves up to 8 pairs; oblong-lingualate, acuminate, up to 2 mm long and 0.56 mm broad, contorted when dry. Dorsal lamina narrowing down and ending at nerve base. Leaf usually equally broad from base to near apex from where it tapers down. Apical part normally symmetrical. Leaf cells smooth, transparent, chlorophyllose with rounded chloroplastids, rounded-hexagonal, 8 to 10 µm wide. Seta erect, reddish, 3.5

mm long; capsule 0.5 mm long and 0.24 mm in diameter. Operculum long-rostrate. Peristome teeth dicranate. Spores round, pellucid, smooth, 13 to 17 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-029.

40. *Fissidens taxifolius* Hedw.

Sp. Musc. Frond.,155. 1801; Gangulee, Moss. E. India, 1(2): 544. 1971.

Description: Plants 2-7 mm high, caespitose, yellow-green. Stems simple, greenish white to yellow orange, with a distinct swollen, translucent gland at leaf axils, enclosed within sheathing laminae. Leaves 7-20 pairs, erectopatent, curled, crumpled when dry, oblong-lingulate to oblong-lanceolate, serrulate at margin, apiculate; sheathing lamilae unequal; cells rounded-hexagonal to rounded-quadrate. Costa percurrent to excurrent.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-027.

41. *Fissidens virens* Thwaites & Mitt.

J. Linn. Soc., Bot., 13: 324. 1873; Gangulee, Moss. E. India, 1: 497. 1969.

Description: Plants very small, up to 1.2 mm long with 5-7 pairs of leaves; leaves crowded together, oblong, leaves equally broad at all sides, the space where the sheathing lamina ends slight constriction occurs, leaf margin crenulated by projection of cells; sheathing lamina opened, reach above the midleaf; cells rounded hexagonal, chlorophyllose, regularly arranged, each cell shows a single conical papilla on top; costa strong, ends below the apex. Stem erect, leaves linear lanceolate to lingualate from a semi-cheathing broader base, sometimes with hyaline or thickened border,

leaves mostly of two types: gemmiferous and non-gemmiferous. Seta apical; capsule erect, cylindrical to globose, short, peristorm absent or with 16 deeply inserted teeth, operculum coni-rostrate.

Specimens examined: Mizoram, Champhai district, MNP, 1556 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-026.

42. *Fissidens zollingeri* Mont.

Ann. Sci. Nat., Ser., 3(4): 114. 1845.

Description: Plant small. Leafy stems usually simple, rarely branched, 1.8-2.3 mm long, 1.4-2.5 mm wide; axillary hyaline nodules differentiated; central strand not differentiated. Leaves in 4-7 pairs, the lowest leaves much smaller than the upper leaves; middle to upper leaves oblong lanceolate, 1.2-1.5x0.2-0.3 mm, slightly acuminate at apex; base of dorsal laminae rounded to broadly wedge-shaped; margins nearly entire, limbidia along the whole margin, uniformly 1-2 cells wide on the lower half of the vaginant laminae; costa light yellow. Stout, shortly excurrent; cells of apical and dorsal laminae irregularly hexagonal, thin-walled, smooth; cells at base of vaginant laminae much larger than those of apical and dorsal laminae. Archegonia terminal on main stems of lateral branches. Setae 2-3.3 mm long, smooth; capsules erect, symmetrical; urn-shaped 0.6 mm long.

Specimens examined: Mizoram, Lunglei district, TTWS, 1110 m alt., Dt. 23. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-028.

Funariaceae

43. *Entosthodon wichurae* M. Fleisch.

Musci Buitenzorg, 2: 481. 1904.

Description: Plant yellowish green, gregarious, small, 6-8 mm long, stem reddish-brown; leaves smaller at base, upper larger forming rosette, crumbled and clinging to stem when dry, ovate-lanceolate, 1.2 mm long. Margin dentate at tip, bordered by a row of elongate cells, with raised tips; costa percurrent, cells thin, rhomboidal at apex, rectangular at base; seta apical, capsule erect to slightly inclined, globose, apophysis distinct, calyptras cucullate; spores large, rough, reddish-brown.

Specimens examined: Mizoram, Aizawl district, TWS, 1436 m alt., Dt. 19. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-050.

44. *Funaria hygrometrica* Hedw.

Sp. Musc., 172. 1801.

Description: Plants short, yellowish green, 1-3 cm long, in tufts. Stems simple or branched from the base. Leaves sparse below, crowded at tips, oblong-ovate to obovate, concave; margins entire, often involute on both sides; costa short-excurrent or percurrent; laminal cells thin-walled, upper cells subquadrate to hexagonal; basal cells elongate. Autoecious. Setae slender, light yellowish brown, 3-5 cm long, curved. Capsules pendulous, pyriform, curved, asymmetric, 2-3 mm, apophyses distinctly developed, deeply sulcate when dry. Opercula flat-convex. Annuli large, revoluble. Peristome double, exostome teeth linear-lanceolate, papillosely striate below, papillose above, strongly trabeculate; endostome segments lanceolate, nearly

as long as the exostome teeth. Calyptrae inflated-cucullate, long-rostrate. Spores globose, yellowish, slightly papillose.

Specimens examined: Mizoram, Champhai district, MNP, 1442 m alt., Dt. 20. 02. 2018, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-051.

45. *Physcomitrium pyriforme* (Hedw.) Hampe.

Linnaea, 11: 80. 1837.

Description: Plant 1.5 cm tall. Stem is either unbranched or dichotomously forked below; it is light green above and white below. A pseudo-rosette of leaves is present toward the apex of each stem; the leaves are larger in size above than below. Individual leaves are 2-5 mm. long and ovate, ovate-oblong, obovate or obovate-oblong in shape; their margins are minutely and bluntly serrated to entire. The leaves taper to acute tips and they clasp the stem at their bases, light translucent green, becoming yellowish green or brownish green with age; relatively large hyaline cells are present. A solitary midrib extends along the entire length of each leaf to its tip. Sporophyte frequently formed and peristome absent, calyptras present. Both the capsule and seta are more or less erect. The seta is 5-15 mm. long, light green to red, terete, and smooth. Capsule is 2-3 mm. long, obpyriform-rhombic or obpyriform-globoid in shape, hairless, and light green while immature. The lid of the capsule is convex with a short narrow beak in the middle; initially covered with calyptra.

Specimens examined: Mizoram, Champhai district, MNP, 1458 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-053.

46. *Physcomitrium sphaericum* (C.F. Ludw.) Fürnr.

Flora, 20: 285. 1837.

Description: Plants small, bright green, in loose tufts. Stems erect, unbranched, 3-8 mm high. Lower stem leaves smaller, upper leaves larger, obovate to oblong-obovate, acute to acuminate at apex; margins usually entire, sometimes bluntly serrulate above; costa percurrent or shortly excurrent as a short apiculus; upper and median leaf cells small, short-rectangular to pentagonal or hexagonal, basal cells larger, irregularly rectangular; marginal cells slightly elongate and narrower, forming an indistinct border. Autoecious. Setae reddish brown, 2-3 mm long; capsules subspherical, reddish brown, mouth wide, apophyses short; opercula low-conic, with a short, obtuse-apiculus; annuli small; peristome absent. Calyptrae rostrate, lobed at base. Spores spherical, blackish brown, densely and spinulosely papillose.

Specimens examined: Mizoram, Aizawl district, TWS, 1436 m alt., Dt. 19. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-052.

Hookeriaceae

47. *Hookeria acutifolia* Hook. & Grev.

Edin. J. Sci., 2: 225. 1825; Gangulee, Moss. E. India, 4:1493. 1977.

Description: Plants pale green to yellow-green, glossy, forming scattered tufts, complanate. Stems 3 cm tall, simple or branched, with central strands. Leaves heteromorphic, ovate to ovate-lanceolate; tip acute, usually showing tufts of rhizoids; margin plane, entire, with one row of rectangular cells weakly bordering the leaf. Costa absent. Leaf cells large, hyaline, thin-walled, rhomboidal, Sporophytes on short lateral shoots. Perichaetial leaves few, smaller, ovate-lanceolate. Setae erect

with hooked tip, to 2 cm long, smooth. Capsules horizontal, oblong from a narrow apophysis. Exothecial cells collenchymatous. Opercula conical-rostrate. Calyptrae conical mitriform, faintly lobed at base. Peristome double, exostome teeth oval in cross-section with two rows of scales on the outside showing a median zigzag line, lanceolate; endostome segments hyaline lanceolate on a high basal membrane, also showing a median line. Spores greenish, small, fine papillose, 10 µm in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1442 m alt., Dt. 20. 02. 2018, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-069.

48. *Hookeriopsis utacamundiana* (Mont.) Broth.

Nat. Pflanzenfam, 1(3): 942. 1907.

Description: Plants mat-forming, light green to reddish brown. Stems creeping, 3-7 cm long, 3-4 mm wide with leaves when dry, in cross section showing the outermost row of hyalodermal cells surrounding a layer of thick-walled, reddish cortical cells, a well differentiated central region of thin-walled parenchyma cells. Leaves complanate forming dorsal, ventral and lateral rows, slightly heterophyllous, flexuose when dry, concave when wet; lateral leaves ovate-oblong, asymmetrical, broadly acute to acuminate, irregularly serrate, with bifid, unicellular teeth towards the apex; costae long, double, reaching beyond mid-leaf, spinose abaxially; dorsal and ventral leaves smaller than lateral ones, more acuminate; leaf cells narrowly rhomboidal at apex, rectangular at base, thin-walled, smooth, sometimes porose. Perichaetial leaves small, ovate, acuminate, with a few marginal teeth. Setae lateral 2-3 cm long, reddish brown; capsules horizontal, 1-1.5 mm long, opercula conic-rostrate, peristome double, exostome and endostome typically hookerioid, basal

membrane high. Calyptrae mitriform. Spores spherical, 8-10 µm in diameter, papillose.

Specimens examined: Mizoram, Aizawl district, TWS, 1245 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-070.

Hylocomiaceae

49. *Macrothamnium macrocarpum* (Reinw. & Hornsch.) M. Fleisch.

Hedwigia, 44: 308. 1905.

Description: Plants yellowish-green to golden-green; main stem wiry, slender, prostrate, curved, branches ascending, leaves distant at base, above fasciculate; leaves on main stem spreading, wide based, triangular, plicate, up to 0.9x0.8 mm, margin denticulate, leaves on primary branches larger, 1-1.2x0.7-0.8 mm, cordate, narrowed below, acute on top, margin denticulate; costa double, one reaching the midleaf and other short; cells linear-rhomboid to elliptic, apical cells 20x11 µm, lower cells 65-80x8 µm; alar cells not distinct; seta erect, slender, up to 5 cm long; capsule horizontal, cylindrical, up to 1.5 mm long, peristome hypnoid with cilia. spores small, 16.0-20.0 µ in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1548 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-089.

Hypnaceae

50. *Hypnum cupressiforme* Hedw.

Sp. Musc. Frond., 291. 1801.

Description: Plants rusty green, golden green, yellow-green to pale green, medium sized to small, 2-10 cm, occasionally longer, prostrate to suberect. Stems pale to

yellowish green, brown with age, central strand poorly developed, irregularly pinnate to nearly unbranched, attached shoots often regularly pinnate; pseudoparaphyllia filamentous, 1-3-seriate at base, but ending in elongated pointed 1-seriate tip. Leaves falcate-secund, ovate to oblong-lanceolate, generally gradually curved to insertion and tapered to a slender acumen, 1.5-2x0.5-0.8 mm, margins serrulate in distal half, occasionally nearly entire, recurved to plane proximally; costa double and short to obscure; median cells 50-80x3-5 μm; basal cells shorter and wider; alar regions weakly or not excavate, made up of a well-defined triangular to quadrate area of many subquadrate cells or reduced to very few quadrate cells, the more basal cells larger, sometimes hyaline, yellowish or brownish. Dioecious; inner perichaetial leaves erect, oblong-lanceolate, serrulate distally; margins plane; costa obscure. Seta reddish brown, 1-3 cm. Capsule reddish brown, slightly inclined, cylindric and slightly curved, 1.8-2.8 mm, excluding conic to rostrate operculum, annulus 1-3-seriate; cilia of endostome usually 1-3.

Specimens examined: Mizoram, Lunglei district, TTWS, 1254 m alt., Dt. 19. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-078.

Hypopterygiaceae

51. *Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hal.

Syn. Musc. Frond., 2: 8. 1850.

Description: Plants dull green to brownish, stem creeping, densely tomentose, 2.5-3.3 cm long, secondary stem erect, dendroid, 1.2 cm long; lateral leaves 1-1.3x0.6-0.9 mm, ovate, short-acuminate, margin toothed at upper part, entire below, bordered all around by 1-2 rows of elongate hyaline cells, 40-140x6-10 μm; costa single, reach

up to midleaf; cells at middle hexagonal, 20-45x12-15 μm; amphigastria 0.8x0.6-0.8 mm, orbicular, sharply apiculate, margin entire below, distantly toothed above, bordered all around by 1-2 rows of elongate hyaline cells; costa faint, extends 1/2 of leaf length; median cells hexagonal, 20-35x13-20 μm; seta elongate, smooth; capsule inclined to horizontal, ovoid to oblong, thick necked, orange-brown, calyptra nacked, conical; spores very small, 8-10 μm diagonally.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-099.

Leskeaceae

52. *Duthiella declinata* (Mitt.) Zanten.

Blumea, 9: 559. 1959; Gangulee, Moss. E. India, 2(5): 1240. 1976.

Description: Plants yellowish-green, robust, main stem creeping, secondary stems many, ascending upwards, regularly pinnate, very small, branches of unequal length; leaves dense, stem leaf linear-lanceolate, acuminate from ovate-lanceolate base, margin sharply serrate, branch leaves with short acumen; costa single, strong, ending below tip; cells rhomboid to hexagonal, thick-walled, with one papillae except in smooth marginal cells, small at apex, basal cells smooth, alar cells quadrate, walls of basal cells thin, seta smooth, long; capsule inclined or horizontal, oblong cylindrical, calyptras cucullate; spore rounded, smooth.

Specimens examined: Mizoram, Champhai district, MNP, 1556 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-079.

53. *Duthiella wallichii* (Mitt.) Müll. Hal.

Nat. Pflanzenfam, 1(3): 1010. 733. 1908.

Description: Medium-sized to fairly robust, yellow- green plants forming mats. Shoots up to 6 cm long with ascending or procumbent secondary branches, irregularly pinnately branched. Leaves dense, erectopatent to spreading, lanceolate from a broader, ovate base, apex gradually acuminate; margins dentate to base, flat. Costa single, ending below tip. Leaf cells at tip rhomboidal-quadrate, thick-walled with single papilla at centre of lumen. Middle cells unipapillate, basal cells smooth, sub-rectangular, thin-walled. Distinct alar of rounded quadrate cells, sporophytes on side lateral shoots. Perichaetial leaves similar, but narrower. Seta erect, 2.3 cm long, smooth. Capsules horizontal somewhat curved, ovate-cylindrical, smooth. Operculum conic-apiculate. Peristome double.

Specimens examined: Mizoram, Aizawl district, TWS, 1447 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-101.

54. *Leskea gracilescens* Hedw.

Sp. Musc. Frond., 222: 56.1801.

Description: Stems and branches are straight or crooked; leaves imbricate, appressed to stem when dry but spreading when wet, ovate or ovate-lanceolate with a single faint midrib; cells with single papilla; leaf tips acute. Leaves convex along outer surface and concave along inner surface; margins revolute. Setae slender, 5-10 mm long, light yellowish brown to dull red, terete, smooth, and more or less erect. Capsules 1.5-2.5 mm long, straight-cylindrical, erect. Calyptra with long-conical beak.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-075.

Leucodontaceae

55. *Forsstroemia indica* (Mont.) Paris.

Index Bryol., 499. 1896.

Description: Plants slender, dark green. Primary stems creeping; secondary stems filiform, erect when dry, complanately branched, with attenuate or filiform branchlets. Leaves ovate, gradually acuminate, twisted, with piliform leaf apices; margins serrulate, slightly incurved below the middle; costae reaching to mid-leaf, forked above; apical cells elongate; median leaf cells shorter than apical cells. Dioecious. Inner perichaetial leaves ovate or obovate at the base, piliform, serrulate at apex. Setae 1.6-3.3mm long; capsules exserted, opercula obliquely long-rostrate; peristome teeth narrowly lanceolate, smooth, perforate; endostome. Calyptrae sparsely hairy. Spores papillose.

Specimens examined: Mizoram, Lunglei district, TTWS, 1050 m alt., Dt. 23. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-036.

56. *Leucodon julaceus* (Hedw.) Sull.

Musci Allegh., 87. 1846.

Description: Plants medium-sized, somewhat glossy. Stems short or rarely elongate, curved, rarely straight and rigidly spreading, julaceous, fragile branchlets absent from distal leaf axils. Branch leaves erect-appressed, not secund, not plicate, 1.1-1.6 mm; apex acute to short-acuminate; apical laminal cells papillose abaxially; terminal cellisodiametric, concolorous. Perichaetia common. Perigonia common. Capsule

barely to long-exserted, ovoid-cylindric, symmetric, 1.5 mm. Spores 33-40 µm in diameter.

Specimens examined: Mizoram, Lunglei district, TTWS, 1021 m alt., Dt. 20. 08. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-100.

Meteoriaceae

57. *Meteorium buchananii* (Brid.) Broth.

Nat. Pflanzenfam, 1(3): 818. 1906.

Description: Plants soft, grayish green, yellowish brown, rarely blackish when old, in loose, rarely in large, mats. Stems creeping, flexuose, pendulous, more than 10 cm long, irregularly pinnately branched; branches more or less circinate when dry, terete, distinctly julaceous. Stem leaves imbricate, broadly ovate, ovate to oblong-ovate, concave, cellulite, often not plicate, rounded and broad near the apex, abruptly constricted to a short apiculate tip, broad, sometimes auriculate at the base; margins incurved, entire to crenulate to serrulate above; costae slender, vanishing at mid-leaf; upper and median leaf cells elongate-oval to narrowly rhomboidal, branch leaves smaller and narrower. Inner perichaetial leaves oblong-lanceolate, long-acuminate at the apex. Setae 2-2.5 mm long, smooth; capsules oblong-ovoid, yellowish brown; exostome teeth lanceolate, papillose; endostome segments linear, papillose, perforate; basal membrane moderately high. Calyptra cucullate, hairy. Spores 15-20 µm in diameter, minutely papillose.

Specimens examined: Mizoram, Mamit district, DTR, 985 m alt., Dt. 19. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-057.

58. *Meteoriopsis reclinata* (Mull. Hal.) M. Fleisch.

Nat. Pflanzenfam, 1(3): 826. 1906; Bruehl, Rec. Bot. Surv. India, 13(1): 74. 1931; Gangulee, Moss. E. India, 2(5): 1354. 1976; M.C. Nair & al., Bryophyt. Wayanad, 159. 2005; J. Lal, Checklist Indian Moss, 89. 2005.

Description: Plants glossy, yellowish-green above, orange-brown to dark brown below, branches pinnate, pendant, 8-12 cm long, branches small; leaves oblong-ovate, faintly serrated all around, leaves plicate, 2-3x1.4 mm, curled backwards both in fresh and dried; costa faint, single, ending far below the apex; cells narrow elongate, cells at basal half irregularly rectangular, smooth, 2-3 small papillae, except at extreme base and tip.

Specimens examined: Mizoram, Champhai district, MNP, 1456 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-055.

59. *Meteoriopsis squarrosa* (Hook. ex Harv.) M. Fleisch.

Nat. Pflanzenfam., 1(3): 826. 1906; Gangulee, Moss. E. India, 2(5):1349. 1976; R.S. Chopra, Taxon. Indian Moss, 351. 1975.

Description: Plants yellowish-green, in dense mats, Stems creeping, secondary shoots pendulous, irregularly branched; leaves dense, squarrose with tip deflexed, 2x1.4 mm, ovate-lanceolate, folded, base semi-sheathing, cordate, quickly narrowed to sharp point; costa single, ending above midleaf; cells linear-rhomboid, 100x5-8 µm at tip, 50-60 x 5-8 µm at midleaf, near base 30-40x7-10 µm, more rhomboid with two small papillae, cells on the auricle smooth, rectangular in the alar region.

Specimens examined: Mizoram, Mamit district, DTR, 940 m alt., Dt. 21. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-056.

60. *Papillaria leuconeura* (Müll.Hal.) A. Jaeger.

Ber. Thätigk. St. Gallischen Naturwiss. Ges., 1875-76: 267.1877.

Description: Plants medium-sized, yellowish to brownish green. Branches terete, julaceus; leaves erect, densely imbricate, only slightly erectopatent when moist. Branch leaves smoothly convex, ovate-oblong to panduriform, 1.1-1.9 mm long, 0.4-0.8 mm wide, acuminate to cucullate; base cordate to broadly auriculate; margin erect or slightly undulate above mid-leaf; auricles variably denticulate; costa extending to 3/4 of the leaf length. Apical laminal cells variable, often sinuose or quadrate at the extreme apex; upper leaf cells elliptic to rhomboidal, with strong irregular wall thickening, often sinuose; median cells similar; juxtacostal cells above the base transparent, porose, more elongate, prosenchymatous; auricular cells elliptical, in divergent rows, thicker-walled than in the upper leaf; leaf margin hyaline; apparent alar cells brownish, irregularly quadrate to rectangular. Seta 2-6 mm long. Capsules ovoid, 1.6-3.5 mm long; operculum 0.9 mm long, straight or curved. Peristome: exostome teeth lanceolate, 350-450 µm long; endostome segments linear, as long as the teeth. Calyptra 3 mm long. Spores 17-25 µm in diameter.

Specimens examined: Mizoram, Mamit district, DTR, 940 m alt., Dt. 21. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-058.

Mniaceae

61. *Plagiomnium ellipticum* (Brid.) T. J. Kop.

Ann. Bot. Fenn., 8: 367. 1971.

Description: Large plants forming mats. Erect stems 2-5 cm; sterile stems up to 12 cm. Leaves green to yellow-green, crisped and contorted when dry, flat when moist, broadly elliptic, ovate, orbicular, or oblong-elliptic, 1-8 mm; margins weakly to moderately toothed distally or to 3/4 leaf length, rarely to near base, often entire on sterile stems, teeth blunt, of 1 or 2 cells; apex broadly rounded, obtuse, or occasionally truncate or retuse, usually narrowly mucronate or cuspidate, cusp bent to side, rarely toothed; costa percurrent or excurrent; medial laminal cells elongate or occasionally isodiametric, distinctly smaller near margins, often less than 1/2 size, in longitudinal and diagonal rows, collenchymatous, walls pitted, pits sometimes indistinct or absent; marginal cells short-linear or rhomboidal, sometimes linear in larger leaves, in 2-4 rows. Dioecious. Seta 1.8-4.5 cm long, yellow to reddish brown. Capsule pendent, cylindric or oblong-cylindric, 3-5 mm; operculum conic-apiculate. Spores 25-30 µm in diameter.

Specimens examined: Mizoram, Mamit district, DTR, 895 m alt., Dt. 19. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-073.

62. *Plagiomnium rostratum* (Schrad.) T. J. Kop.

Ann. Bot. Fenn., 5: 147. 1968; J. Lal, Checklist Indian Moss, 105. 2005.

Description: Plant robust, 2-4 cm long, lax green. Stems prostrate to suberect, branched, tomentose throughout or below. Leaves dark green or yellow-green, crowded at apex or distant, complanate, spreading, contorted when dry, transversely

undulate when moist, ovate-oblong, bordered, wavy, 6-10 mm; base long-decurrent; margins toothed to near base, teeth sharp, of 1 or 2 cells; apex obtuse or rounded, occasionally acute, usually cuspidate, cusp toothed; costa excurrent; medial laminal cells elongate or short-elongate, 15-40 µm, slightly smaller near margins, occasionally in longitudinal rows, rarely in diagonal rows, collenchymatous; marginal cells linear, in 2-4 rows. Specialized asexual reproduction by stolon-like stems. Dioecious. Seta 1-4, yellow-green, dark red to blackish with age, 2-4 cm. Capsule pendent, oblong-cylindric, 2.5-3 mm; operculum rostrate. Spores 30-35 µm in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1458 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-072.

63. *Plagiomnium succulentum* (Mitt.) T.J. Kop.

Ann. Bot. Fenn., 5: 147. 1968.

Description: Plant medium-sized, robust, bright green or brownish green, in loose tufts. Primary stems and infertile branches prostrate, 4 cm long, sparsely foliate, with dense rhizoids; fertile branches erect, 1.5 cm high, radiculose below, densely foliate above. Leaves crisped when dry, spreading when moist, broadly ovate or elliptical, narrowed and not decurrent at base, obtuse, apiculate at apex; margins indistinctly bordered by 1-3 rows of elongate cells, dentate with 1-2 celled teeth above mid-leaf, margins of young leaves nearly entire; costae ending just below the apex; leaf cells large, obliquely pentagonal to hexagonal or nearly rectangular, thin-walled, regularly arranged, usually oblate, enlarged and irregularly pentagonal near margins.

Dioecious. Setae often clustered, 3 cm long; capsules elongate-ovoid, horizontal to pendulous.

Specimens examined: Mizoram, Mamit district, DTR, 975 m alt., Dt. 24. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-071.

Myuriaceae

64. ***Myurium rufescens*** (Reinw. & Hornsch.) M. Fleisch.

Musci Buitenzorg, 3: 672. 1908.

Description: Dioecious. Pleurocarpous. Stems mostly sympodially branched, ascending, erect parts not or sparingly branched; branch primordia Climacium-type. Leaves mostly long-acuminate, often concave; costa absent or short and double. Lamina cells linear, smooth; alar cells well differentiated. Capsule long-exserted, erect. Peristome diplolepideous; exostome reduced; endostome rudimentary.

Specimens examined: Mizoram, Mamit district, DTR, 1042 m alt., Dt. 21. 05. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-090.

Neckeraceae

65. ***Homaliodendron flabellatum*** (Sm.) M. Fleisch.

Hedwigia, 45: 74. 1906; Gangulee, Moss. E. India, 2(5): 1426. 1976; J. Lal,

Checklist Indian Moss, 72. 2005.

Description: Plants yellowish-green, robust, main stem creeping, 2-5 cm long, branched and often with stolons, secondary stem pinnately branched; leaves lanceolate to oblong lingulate, branch leaves ovate, shortly acuminate, toothed at the extreme tip, near the base revolute on one side, longitudinaly plicate when dry, perichaetial bracts lanceolate with unicellular teeth, the lower stem leaves smaller;

costa single, ending below apex, sometimes bifurcate at apex; cells smooth, upper leaf cells polygonal, middle cells rhomboidal, 10-30x5-15 µm, basal cells elongated, 45-60x15-18 µm; seta 2-3 mm long; capsule erect to slightly inclined; spores rounded, smooth, 12-15 µm diagonally.

Specimens examined: Mizoram, Mamit district, DTR, 980 m alt., Dt. 18. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-030.

66. *Homaliodendron microdendron* (Mont.) M. Fleisch.

Hedwigia, 45: 78. 1906; Gangulee, Moss. E. India, 2(5): 1414. 1976; A.E.D. Daniels, R. Annamalai, Tamil Nadu Biodivers., 55. 2004; J. Lal, Checklist Indian Moss, 72. 2005.

Description: Plants distinctly complanate, yellowish green, strongly glossy, in large mats. Secondary stems pinnately branched, frondose, up to 10 cm long or longer, pseudoparaphyllia usually filamentous. Stem leaves broadly lingulate or spathulate, 2.5 mm long, often curved above, narrowed at the base, broadly rounded or truncate at the apex, sometimes apiculate; margins entire below, only crenulate or irregularly serrulate at the apex, often incurved on proximal side; costae single, slender, apical and upper leaf cells rounded quadrate or polygonal, thick-walled; median cells elongate-hexagonal or oblong-rhomboidal, thin-walled; basal juxtacostal cells narrowly rectangular, thick-walled, porose; branch leaves similar to stem leaves, complanately appressed. Setae slender1.5-2 mm long; capsules cylindrical; peristome double, well developed. Spores 13-17 µm in diameter, finely papillose.

Specimens examined: Mizoram, Mamit district, DTR, 950 m alt., Dt. 18. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-031.

67. *Neckera pennata* Hedw.

Sp. Musc. Frond., 200. 1801.

Description: Plants large, 5-11 cm long. Stems with branches, branches few, attenuate; paraphyllia few to absent. Stem leaves oblong-ovate, undulate, acute to broadly acute, 2-1.5 mm; margins serrulate to entire proximally, serrulate at apex; apex acute to broadly acute; ecostate or costa double, short; alar cells irregularly short-quadrate; basal laminal cells rectangular, 50x10 µm; distal medial cells oblong-linear; apical cells oblong-rhombic. Autoecious. Seta 0.1 cm. Capsule immersed.

Specimens examined: Mizoram, Aizawl district, TWS, 1258 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-032.

68. *Neckeropsis crinita* (Griff.) M. Fleisch.

Musci Buitenzorg, 3: 878. 1908.

Description: Plants yellow-green, somewhat glossy. Primary stem normal, creeping. Secondary branches rigid, erect to drooping, irregularly pinnately branched, up to 9 cm long, all branches complanate. Leaves apparently tetrastrichous, spreading horizontally, transversely crenulate when dry, more or less asymmetrical, lingulate, tip rounded, widened and auriculate at base; margin very finely crenulate, incurved in the basal auricle on one side sheathing stem. Costa single, vanishing a little below tip. Leaf cells incrassate, quadrate-hexagonal, 1 or 2 border rows distinguished by transverse or slightly elongated cells, large at middle, longer and narrower at base. Sporophyte on short lateral shoots. Perichaetial leaves longer, narrower with spreading tips; paraphyses long, filamentous, covering the capsule. Seta very short.

Capsule immersed within the paraphyses. Operculum conical, short rostrate. Calyptra mitriform, hairy. Peristome normal, neckroid. Spores papillose.

Specimens examined: Mizoram, Champhai district, MNP, 1356 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-033.

69. *Neckeropsis exserta* (Hook. ex Schwägr.) Broth.

Nat. Pflanzenfam (ed. 2) 11: 188. 1925.

Description: Plants varying in size, usually large, yellowish green, very glossy, in loose mats. Primary stems creeping, with scale-like leaves and sparse rhizoids; secondary stems up to 10 cm long or longer, complanately foliate, sparsely branched or pinnately branched, with branches 1 cm long, obtuse or attenuate at the apex, flagelliform branches often present. Leaves pseudotetrastrichous, in 8 rows, widely spreading, oblong-lingulate or broadly ovate-lingulate, asymmetric, strongly undulate, truncate or rounded, sometimes apiculate at the apex, widened at the base, somewhat sheathing or auriculate at the base; margins irregularly serrulate, sometimes entire at the apex, entire below; costae single; upper and apical cells irregularly quadrate or oval, thick-walled; median cells somewhat elongate; basal cells obliquely rhomboidal; marginal cells becoming slightly elongate and forming indistinct borders. Inner perichaetial leaves sheathing at the base, acuminate at the apex. Setae 0.7-2.5 mm long; capsules exserted, cylindrical, brown; opercula conic, with an oblique beak; peristome double; exostome teeth yellowish green, lanceolate, finely papillose, coarsely trabeculate, sometimes perforate at the apex; endostome segments yellowish green, linear, finely papillose. Calyptrae mitrate, yellow, hairy. Spores 15-20 µm in diameter, finely papillose.

Specimens examined: Mizoram, Champhai district, MNP, 1586 m alt., Dt. 20. 02. 2018, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-035.

70. *Neckeropsis semperiana* (Hampe) A. Touw.

Blumea, 11: 414. 1962.

Description: Plants large, lightly yellowish green, slightly glossy, in loose mats. Primary stems creeping; secondary stems pendulous, 2-8 cm long, sparsely irregularly branched, oval in cross section, epidermis consisting of 4-5 rows of small, thick-walled cells surrounding the large, hyaline, medullary cells; axillary hairs hyaline, 5 cells long; pseudoparaphyllia few. Leaves complanate, pseudotetrastrichous; stem and branch leaves similar, oblong to broadly lingulate, asymmetric, rounded truncate or apiculate at the apex, constricted at the base; margins irregularly crenulate at the apex, narrowly incurved on the proximal side at the base; costae single; strong, subpercurrent; upper and apical leaf cells hexagonal to polygonal or oblate-rectangular, thick-walled; median and lower cells elongate to rhomboidal, basal juxtacostal cells sublinear, evenly thick-walled. Dioecious. Inner perichaetial leaves long-lingulate, sheathing at the base, ecostate; paraphyses numerous. Setae 1 mm long; capsules shortly exserted, ovoid, 2 mm long; opercula conic, obliquely-rostrate.

Specimens examined: Mizoram, Aizawl district, TWS, 1347 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-034.

Octoblepharaceae

71. *Octoblepharum albidum* Hedw.

Sp. Musc. Frond., 50. 1801.

Description: Plants small, 5-10 mm high, glossy, glaucous-green to white; in loose or dense tufts and cushions. Stems short, sparsely branched. Leaves spreading-recurved, fleshy, fragile when dry, 4-5 mm, apiculate, older leaves sometimes with rhizoids on tips. Seta yellow, 2-5 mm. Capsule brownish, 1-1.5 mm, ovoid-cylindric, slightly asymmetric, with stomata at base; operculum 0.8 mm; peristome of 8 blunt triangular pairs of teeth, teeth smooth or faintly striate, 200 µm tall, each composed of one interior and one exterior layer of intact, empty, cell-like plates. Calyptra 1.5-1.9 mm. Spores finely papillose, 17-24 µm. Capsules mature throughout the year but most common September to April.

Specimens examined: Mizoram, Lunglei district, TTWS, 1152 m alt., Dt. 20. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-091.

Orthotrichaceae

72. *Groutiella goniorrhyncha* (Dozy & Molk.) E.B. Bartram.

Rev. Bryol. Lichénol., 23: 250. 1954.

Description: Plants brownish, dull, fairly robust, in large, dense tufts. Main stem creeping with erect secondary branches 1 to 3 cm high, tomentose. Leaves dense, erectopatent, oblong-lanceolate, apex acute apiculte, broadly acute in higher leaves, narrow acute below; lightly plicate below; margin entire below, lightly dentate at tip, flat. Costa ending at apiculus. Leaves cells with thickened walls, rounded quadrate with one large internal papilla in most of the lamina; at base the juxtacostal cells are

elongated; at extreme base the cells are large rectangular with one large tuberculate papilla each. Seta apical on branches, smooth and strong. Capsule apical, cylindrical, shrunk when dry. Operculum conic-rostrate. Peristome double. Calyptra campanulate, lobed at base.

Specimens examined: Mizoram, Champhai district, MNP, 1560 m alt., Dt. 20. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-066.

73. *Macromitrium nepalense* (Hook. & Grev.) Schwägr.

Sp. Musc. Frond., Suppl., 2(2): 134. 1827.

Description: Plants brownish-green in dense tufts, main stem up to 4 cm, produce erect secondary branches; leaves dense, 2-3x0.5 mm, curled when dry, with hook-like incurving, lanceolate, base broader, apex acute, margin entire; costa single, reach up to tip; cells thick-walled, rounded to ovate, few large papillae, middle cells rectangular, large rectangular cells at base towards inner side, papillae tubercular, margin with linear cells, at extreme base cells smooth, thin walled, larger rectangular; seta on short lateral shoots, erect; capsule erect, ovoid, up to 2.5 mm long. Calyptrae hairy, covering the entire capsule.

Specimens examined: Mizoram, Aizawl district, TWS, 1436 m alt., Dt. 19. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-068.

74. *Macromitrium sulcatum* (Hook.) Brid.

Bryol. Univ., 1: 319. 1826; Gangulee, Moss. E. India, 2(5): 1181. 1976; B.L. Chaudhary & al., Bryoph. Fl. N. Konkan, 159. 2008; J. Lal, Checklist Indian Moss, 87. 2005.

Description: Plants dark greenish to brownish, robust, in dense tufts; stem long prostrate, erect, fasciculately branched secondary shoot system; leaves dense, spirally twisted when dry, stiff, erect to spreading when moist, lanceolate to oblong-lanceolate, 0.5x0.04 mm; costa strong, ending below apex or percurrent; cells towards the apex rounded or quadrate, 4-8x3-6 µm, with irregularly rounded or ovate lumen, rich in chlorophyll, papillose, median cells 6-10x4-7 µm, basal cells elongate, 20-40x10-12 µm, sometimes rounded, hyaline, with thick walls, above basal cells elongate, surrounded by thin walled hexagonal cells, margin bordered with 5-6 smooth thin walled cells; seta erect, rough; capsule spherical to oblong-ovoid, sulcate, peristome absent; spores large of uneven size, 12-25 µm in diameter, papillose, green.

Specimens examined: Mizoram, Aizawl district, TWS, 1545 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-067.

Plagiotheciaceae

75. *Plagiothecium neckeroideum* Schimp.

Bryol. Eur., 5: 194. 1851.

Description: Plants large, green to yellowish green, strongly complanate, in dense mats. Stems prostrate, 10 cm long, 3 mm wide, irregularly branched; branches ascending, stems elliptical in cross section. Leaves dimorphic, ventral and dorsal leaves distinctly asymmetric or somewhat symmetric; lateral leaves asymmetric, ovate, concave, often undulate above, abruptly shortly acute at apex; margins plane, entire or serrulate near apex; costae double; median leaf cells linear-rhomboidal, thin-walled; apical cells shorter, basal cells broader, alar regions distinctly decurrent

on one side, hyaline, thin-walled. Brood bodies and rhizoids often present at leaf apex. Dioecious. Inner perichaetial leaves sheathing at base, ovate-lanceolate, abruptly acuminate. Setae 1.5-2 cm long, somewhat reddish; capsules nearly erect or inclined, shortly cylindrical, 2-2.5 mm long; opercula shortly conic-rostrate; annuli well developed, consisting of 2-3 rows of cells; cilia 2. Spores spherical, 12-15 µm in diameter, nearly smooth.

Specimens examined: Mizoram, Aizawl district, TWS, 1336 m alt., Dt. 19. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-080.

76. *Pseudotaxiphyllum elegans* (Brid.) Z. Iwats.

J. Hattori Bot. Lab., 63: 449. 1987.

Description: Plants in thin to dense mats, dark-to yellowish green, glossy. Stems up to 35x1.0-2.5 mm, complanate, simple or irregularly branched. Leaves semi-flaccid to rigid, close to somewhat distant, erect-spreading or sometimes secund with apices pointing toward substratum, somewhat concave, smooth, 0.3-2.0x0.2-0.7 mm, lanceolate, ovate- or oblong-lanceolate, symmetric, acuminate; margins plane, serrulate to strongly serrate distally, serrulate to entire proximally; costa strong, short and double; median cells smooth; alar cells undifferentiated or 1-3 quadrate to rectangular cells on margins. Specialized asexual reproduction present as propagula clustered in leaf axils below stem apices, 0.5-1.5 mm, yellow to green, smooth-celled, resembling the parent plant but smaller, bearing reduced leaves from apex to base of stems. Dioecious. Seta dark red, 1.0-2.5 cm. Capsule cernuous to pendulous, straight or subarcuate, 1-2 mm, oblong-ovoid to ovoid, wrinkled and contracted

below mouth when dry; operculum conic to short-rostrate, 0.4-0.7 mm. Spores 7-12 µm in diameter.

Specimens examined: Mizoram, Champhai district, MNP, 1565 m alt., Dt. 17. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-083.

Polytrichaceae

77. *Atrichum undulatum* (Hedw.) P. Beauv.

Prodr. Aethéogam., 42. 1805; A.E.D. Daniels, R. Annamalai, Tamil Nadau Biodivers., 50. 2004; J. Lal, Checklist Indian Moss, 32. 2005.

Description: Plants medium, yellowish to bright green. Stems up to 4 cm long, predominantly simple. Upper leaves crowded, crispate and incurved when dry, strongly undulate above, keeled, linear-lanceolate, apex acute, with single or aggregated teeth in irregular rows on back, ventral lamellae 4-5 on upper costa, 4-5 cells high; margins usually bordered with 2 rows of linear cells, toothed in the upper 2/3; costa percurrent, toothed on back above. Median laminal cells hexagonal to subquadrate. Often more than one seta and sporophyte on each stem. Setae 1-3, reddish-brown, 3-4 cm long. Capsules inclined, terete, slightly arcuate, reddish-brown. Peristome teeth 32, with brown striations, to 0.6 mm high. Spores rounded, finely granulose, 13-18 µm in diameter. Opercula conical-rostrate. Calyptrae cucullate, with long spines.

Specimens examined: Mizoram, Champhai district, MNP, 1410 m alt., Dt. 22. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-041.

78. *Pogonatum aloides* (Hedw.) P. Beauv.

Prodr. Aethéogam., 84. 1805.

Description: Plants short, stiff, dark green, rather triangular leaves arranged in a rosette-like tuft on short, stout, reddish stems. Individual shoots tend to emerge from a low, persistent, vividly green protonemal felt. The shoots are less than 1 cm tall and most conspicuous when crowned by male inflorescences or sporophytes. Individual leaves are 3 to 4 mm long, with blunt, multicellular marginal teeth along much of the blade. The upper surface of the leaf above the colourless sheathing base is largely covered by longitudinally orientated, parallel plates of cells. Capsules are commonly produced on a 3 to 4 mm tall reddish seta, and provide the only reliable means of identification. Capsule erect, shortly cylindrical, wall of capsule is very pale. The calyptrae are densely hairy.

Specimens examined: Mizoram, Lunglei district, TTWS, 1048 m alt., Dt. 21. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-042.

79. *Pogonatum contortum* (Menzies ex Brid.) Lesq.

Mem. Calif. Acad. Sci., 1: 27. 1868.

Description: Plants tall, rigid, stems simple, up to 7 cm long and 1.5 cm broad with leaves. Lower leaves small, scale-like. Upper leaves flexuose when dry; lamina thick, rigid, dark coloured, lanceolate from a wider, hyaline, slightly sheathing base; up to 1 cm long and 0.8 cm broad. Apex sharply acute; margin sharply toothed up to base of lamina. Costa reddish-brown, percurrent, toothed on back above. Lamellae numerous, covering most of the ventral surface of leaf, 1 to 4 cells high, cells small, parenchymatous; end cells ovoid, thin-walled and smooth. Basal leaf cells elongated,

rectangular, upper leaf cells rounded-quadrate to somewhat elongated. Seta red, up to 2.5 cm long, one in each perichaetium. Capsule slightly inclined, brown, up to 8 mm long and 2 mm in diameter, exothelial cells thick-walled and irregular on surface, columella star-shaped with 4 to 5 rays. Peristome teeth 32 with brown striations. Spores rounded, hyaline, calyptras felty covering the whole capsule.

Specimens examined: Mizoram, Champhai district, MNP, 1556 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-008.

80. *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid.

Bryol. Univ., 2: 745. 1827.

Description: Robust, coppery green plants in lax tufts. Stems simple or innovating, 5 cm or more long and about 1.8 cm wide with leaves, with pale tomenta below. Lower leaves small, scale-like. Upper leaves rigid, appressed and somewhat incurved when dry, erect-spreading; lanceolate from an ovate, yellowish, wider, slightly sheathing base; up to 9.5 mm long and 1.9 mm broad; apex sharply acute, margin sharply toothed nearly to base of lamina; costa reddish-brown, strongly toothed on back above. Lamellae numerous, covering most of the ventral face, 2 to 5 cells high; end cells thin-walled, much larger and divided to base into two flask-shaped forks. Basal leaf cells rectangular, transversely placed near shoulder; narrower towards margin. Upper leaf cells rounded-quadrate to slightly elongated. Seta up to 3 cm long, sometimes 2 or 3 from one perichaetium. Capsule erect or inclined, reddish-brown, up to 6 mm long and 2.5 mm in diameter, exothelial cells thick-walled; columella solid, 4 to 5 rayed. Peristome teeth 32 with brown striations. Spores round,

operculum broadly convex with a short beak, calyptras felty, covering the whole capsule.

Specimens examined: Mizoram, Aizawl district, TWS, 1436 m alt., Dt. 19. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-012.

81. *Pogonatum neesii* (Müll. Hal.) Dozy.

Ned. Kruidk. Arch., 4(1): 75. 1856.

Description: Brownish plants with simple unbranched stem, 1.5 cm to 4 cm long, sometimes with innovations from perichaetia. Leaves reddish-brown, oval, concave, erectopatent; incurved, appressed to stem, somewhat contorted and rigid when dry; up to 4.5 mm long and 1.5 mm broad, margin toothed. Costa reddish-brown, solid, percurrent, with multicellular teeth on back of tip. Lamellar cells incrassate, papillose, rounded-quadrate. Cells on top of sheathing base incrassate, irregular, become elongate, rectangular, pellucid towards base and near costa. Lamellae numerous, 5 to 7 cells high, end cells larger, broad, flattened or depressed at top, minutely papillose. Seta reddish-brown, erect, 2 cm long. Capsule brown, subsymmetrical, inclined, elliptic, constricted below mouth, rough on top surface, 3.5 mm long and 1.8 mm in diameter at middle. Peristome teeth 32, reddish-brown, calyptrae felty, covering the whole capsule. Dioecious.

Specimens examined: Mizoram, Champhai district, MNP, 1546 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-043.

82. *Pogonatum proliferum* (Griff.) Mitt.

J. Proc. Linn. Soc., Bot., Suppl., 2: 152. 1859.

Description: Tall plants with simple stems up to 7 cm long and 1.2 cm broad with leaves. Lower leaves small, scale-like. Upper leaves curled when dry, erectopatent when moist, thin, lanceolate from a wider, sheathing, hyaline base; up to 10 mm long and 1.2 mm broad. Apex sharply acute, margin sharply toothed up to base of lamina. Costa dark, percurrent, slightly toothed on back above. Lamellae restricted to coste, 1 to 2 cells high, cells small, thin-walled, parenchymatous, end cells smooth, elongated to ovate with rounded end. Basal leaf cells long, rectangular. Upper leaf cells irregular, thick-walled, variously shaped. Seta dark brown up to 1.8 cm long, single in a perichaetium. Capsule slightly inclined to straight, smooth, 5 mm long and 1 mm in diameter.

Specimens examined: Mizoram, Lunglei district, TTWS, 1010 m alt., Dt. 20. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-044.

Pottiaceae

83. *Barbula indica* (Hook.) Spreng.

Nomencl. Bot., 2: 72. 1824.

Description: Plants greenish-brown, up to 10 mm long; leaves ovate-oblong to spathulate with incurved margins, arranged spirally around the stem, acuminate, margin revolute, entire; costa strong, light green, shortly excurrent; upper cells small, rounded, 5-8 µm diagonally, thick-walled, basal cells somewhat widened and elongated, 25x10 µm, quadrate to rectangular, hyaline, smooth. Specialized asexual reproduction by gemmae borne on stalks in leaf axils. Perichaetial leaves obtuse to

broadly acute, strongly sheathing and convolute. Seta smooth, long, up to 1.5 cm long, yellowish orange; capsule erect, yellowish orange, cylindrical, calyptra beaked; spores rounded, 10-12 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-085.

84. *Hyophila involuta* (Hook.) A. Jaeger.

Ber. Thätigk. St. Gallischen Naturwiss. Ges., 1871–72: 354.1873.

Description: Plants in loose or dense, dark green to red-brown or blackish tufts, dull or occasionally with a metallic sheen. Stem densely foliate, 5-10 mm, central strand strong. Leaves concave when moist, to 1.5-2.5 mm, oblong-spatulate to obovate, occasionally with multicellular teeth, rounded to rounded obtuse at the apex, sometimes apiculate; costa stout, prominent abaxially, smooth on the abaxial surface to occasionally roughened at the apex; laminal cells near insertion short-rectangular, firm-walled, pale and brownish or hyaline, cells 8-12 µm wide, in longitudinal and oblique rows, thin to thick-walled, bulging-mammillose on the adaxial surface, plane on the abaxial. Dioecious. Seta 6-7 mm, reddish to yellow-brown with age. Capsule erect, 1.5-3 mm, narrowly cylindric from an indistinct neck, annulus well differentiated, red-brown, of vesiculose cells, persistent or deciduous; operculum erect, conic-rostrate. Calyptra cucullate. Spores dirty brown, pellucid, spherical, 8.5-11.5 µ in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1545 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-084.

85. *Pohlia cruda* (Hedw.) Lindb.

Musci. Scand., 18. 1879.

Description: Plants medium-sized to large, green, whitish, or sometimes bluishtinged, shiny. Stems 0.5-2.5 cm long. Leaves erect to spreading, lanceolate to elliptic, 0.8-2 mm; margins serrulate to serrate; costa subpercurrent; distal medial laminal cells linear-rhomboidal, vermicular, 70-140 µm, walls thin. Perigonial leaves in dioecious plants linear- or long-lanceolate from ovate base; perichaetial leaves strongly or rarely weakly differentiated, linear-lanceolate. Seta orange to orange-brown. Capsule inclined, stramineous to orange-brown, long-and slender-pyriform, neck 1/2 urn length; exothecial cells elongate-rectangular, walls straight; stomata superficial; annulus present; operculum conic; exostome teeth yellow-brown to red-brown, acute-triangular; endostome hyaline, basal membrane 1/2 exostome length, segments broadly keeled, broadly perforate, cilia short to long. Spores 18-26 µm in diameter, coarsely papillose.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-065.

Pterobryaceae

86. *Pterobryopsis acuminata* (Hook.) M. Fleisch.

Hedwigia, 45: 59. 1905.

Description: Plants yellowish-green, primary stem creeping, up to 5 cm long, blackish; secondary shoot rigid, 10-15x3-5 mm; leaves dense, imbricate, ovate-cordate, tip apiculate, plicate, 2x1 mm, margin flat; costa single, reach above midleaf, flexuose above; cells thick-walled, elongate, walls porose at base, stem

attached cells coloured, alar cells deep reddish brown, rectangular, 25-48x18-20 µm, middle cells 120-130x3-5 µm, upper cells 120-125x5 µm, shorter at base margin.

Specimens examined: Mizoram, Mamit district, DTR, 895 m alt., Dt. 19. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-092.

Pterigynandraceae

87. *Trachyphyllum inflexum* (Harv.) A. Gepp.

Cat. Afr. Pl., 2(2): 299. 1901.

Description: Plants yellowish-green, slender, creeping in extensive thin mat, giving rise to short, erect or ascending julaceous branches; stem leaves cordate, ecostate; branch leaves dense, concave, cordate-ovate, short apiculate, margin smooth; costa short, forked or in some indistinct; cells elongated to rhomboid, papillose at tip and lamina, basal median cells ovate-rectangular, basal angle cells transeversely elongated, chlorophyllose, 8-12 µm diagonally, at extreme base angle few larger quadrate cells, 14x14 µm, smooth, upper cells elongated; mostly remain as sterile.

Specimens examined: Mizoram, Champhai district, MNP, 1540 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-095.

Racopilaceae

88. *Racopilum cuspidigerum* (Schwägr.) Ångström.

Ofvers. Forh. Kongl Svenska Vetensk. -Akad., 29(4): 10. 1872; Gangulee, Moss. E. India, 2(5): 1200. 1976; M.C. Nair & al., Bryophyt. Wayanad, 143. 2005.

Description: Plants greenish, glossy, creeping, 2-6x0.5-0.7 mm, highly branched, branches pinnate, tomentose throughout; leaves two types, lateral and amphigastrial, lateral leaves oblong-ovate, 1-1.5 mm long, amphigastria small, 0.7-1 mm long,

margin strongly serrated at upper half in both the leaves; costa prominent, percurrent; cells rounded-hexagonal, chlorophyllose, marginal leaf cells hyaline; seta long, erect, capsule horizontal to inclined, calyptra cucullate; spores 10-15 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1545 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-093.

Rhizogoniaceae

89. *Pyrrhobryum spiniforme* (Hedw.) Mitt.

J. Linn. Soc., Bot., 10: 174. 1868; M.C. Nair & al., Bryophyt. Wayanad, 133. 2005.

Description: Plants robust, 2-4 cm high, densely caespitose, brown-green. Stems erect, branched from base, tomentose below, brown. Leaves lax, evenly spread out, erect spreading, flexuose, carinate, linear, flat, with paired spines at margin, incurved at apex when dry, gradually acuminate, cells thick-walled, rounded-quadrate to elongate, smooth; costa single, short excurrent. Setae 4-5 cm high, flexuose, brown. Capsule ellipsoid-cylindric, inclined to horizontal, faintly furrowed when dry, brown. Peristome teeth two rowed; exostome hyalinepapilose at apex; endostome segments pale yellow or hyaline, lightly papillose. Spores 17-28 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1445 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-038.

90. *Rhizogonium spiniforme* (Hedw.) Bruch.

Flora, 29: 134. 1846.

Description: Plants brownish, dense tufts, tomentose below. Stem 3.5 cm long, flexuose, generally branched from base. Leaves laxly arranged on stem,

erectospreading, flexuose with incurved tips when dry; almost equally placed on stem, lower leaves smaller, upper leaves larger, linear lanceolate, gradually acuminate, carinate-concave, up to 7 mm long and 2 mm wide at base; margin thickened, soinose-serrate with paired teeth from near base. Costa strong, short excurrent in a sharply pointed tip, toothed on back above. Leaf cells incrassate, smooth, oval or rounded quadrate-hexagonal. Innermost perichaetial leaves small, awl-shaped, lower margin entire, upper dentate. Seta brown, slender, erect-flexuose, lateral from base. Capsule horizontal or inclined, ovate-cylindrical, lightly furrowed when dry. Exothelial cells prosenchymatous, thick-walled to rectangular. Annulus broad. Operculum obliquely conic-rostrate. Peristome large; outer peristome yellowish brown, teeth narrow lanceolate, papillose hyaline at apex; cilia 1 to 3. Spores yellowish, finely papillose. Autoecious.

Specimens examined: Mizoram, Champhai district, MNP, 1556 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-102.

Sematophyllaceae

91. *Radulina hamata* (Dozy & Molk.) W.R. Buck & B.C. Tan.

Acta Bryol. Asiat., 1: 10. 1989.

Description: Plants greyish green or brownish yellow, slightly glossy, in mats. Stems prostrate, often branched; branches 2-4 mm long. Leaves narrowly lanceolate, curved, gradually forming a long acuminate apex from concave, ovate-lanceolate base, 1.5-2.0 mm long, less than 0.5 mm wide; margins plane, clearly serrulate above; leaf cells linear, thin to thick-walled, slightly pitted at base, with single row of numerous papillae over cell lumen; alar cells 2-3, large, thin-walled

and hyaline. Inner perichaetial leaves abruptly long acuminate, serrate. Setae 1.0-1.7 cm long, papillose above, smooth below; capsules small, rounded ovoid, horizontally curved; opercula long-rostrate, beaks longer than capsules.

Specimens examined: Mizoram, Mamit district, DTR, 980 m alt., Dt. 18. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-039.

92. *Sematophyllum subhumile* (Müll. Hal.) M. Fleisch.

Musci Buitenzorg, 4: 1264. 1923; Gangulee, Moss. E. India, 3(8): 1884. 1980; J. Lal, Checklist Indian Moss, 123. 2005.

Description: Plants yellowish-brown to green, glossy, medium-sized plants forming tufts on tree base; main stem creeping, branching irregularly, secondary branches pinnate, sub-erect; leaves not dense, erectopatent, concave, ovate lanceolate from ovate base, 1.3x0.4 mm, margin crenulate at tip, often revolute on both sides at middle of leaf; leaf cells narrow, elongate, rhomboid, 60x5 mm, cell walls irregularly thickened, alar differentiated, hyaline, broadly elliptical to oblong; seta erect flexuose, slender, 1 cm high.

Specimens examined: Mizoram, Mamit district, DTR, 980 m alt., Dt. 18. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-037.

93. *Wijkia tanytricha* (Mont.) H.A. Crum.

Bryologist, 74: 174. 1971.

Description: Robust, yellow-green, glossy, large and spreading plants forming tufts. Main stem creeping, pinnately and bipinnately branched. Stem leaves lax, larger, wider, oblong-ovate, plicate, narrowed into a long, filiform subula. Margins dentate at shoulder, smooth at subula. Leaf cells narrow linear, alar differentiated, hyaline,

inflated. Sporophytes on main branches, seta slender, erect or curved, 3 cm long. Capsule inclined, ovate-cylindrical. Operculum conic, long rostrate. Annulus present. Persistome normal, with 1 to 2 cilia.

Specimens examined: Mizoram, Champhai district, MNP, 1536 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-040.

Splachnaceae

94. *Tayloria hornschuchii* (Grev. & Arn.) Broth.

Nat. Pflanzenfam, 1(3): 502. 1903.

Description: Plants 3-7 cm, in moderately dense tufts, brown proximally, yellow-green distally. Stems unbranched, or 6 or fewer subterminal innovations. Leaves crowded at stem and branch apices, stiffly erect-imbricate when dry, lingulate, 1-2.5x0.7-1.2 mm; margins plane or slightly revolute proximally, entire; apex obtuse; costa ending 3 or 4 cells before apex. Specialized asexual reproduction by brood bodies usually in proximal leaf axils. Sexual condition dioecious. Capsule oblong to cylindric, quadrate mid capsule, 1x1 mm; hypophysis stramineous to dark red-brown when mature, 1.5 mm; columella exserted; operculum systylius, flat, apex obtuse but usually elongate; peristome inserted at mouth; exostome teeth 16, partially split into 32, erect to reflexed when dry, red to red-brown, truncate to obtuse. Spores 30-40 µm, papillose.

Specimens examined: Mizoram, Aizawl district, TWS, 1545 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-096.

Stereophyllaceae

95. *Stereophyllum anceps* (Bosch & Sande Lac.) Broth.

Nat. Pflanzenfam, 1(3): 898. 1907.

Description: Stem prostrate, irregularly branched, main stem 8-10 cm long, often glossy in appearance. Leaves crowed, lateral leaves not markedly asymmetrical, complanate, ovate, concave; apex acuminate; costa homogenous, single, strong, reaching midleaf; margin plane, smooth, lower part of the leaf margin inflexed on one side. Lamina cells rhombic to linear, 50-55.0x11-14.5 μ, basal lamina cells shorter, smooth; alar cells generally numerous, quadrate, hyaline, sometimes opaque. Seta short, thin, red colour; capsule sub-erect, faintly gibbose; peristome teeth perfect, generally connate at base; operculum apiculate, conic rostrate; calyptra cucullate; spores small, round to elliptic, 10-12 μ in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1545 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-097.

Thuidiaceae

96. *Pelekium bifarium* (Bosch & Sande Lac.) M. Fleisch.

Musci Buitenzorg, 4: 1513. 1923.

Description: Plants slender, green to yellowish green, brownish at base, in small lax patches. Stems procumbent, up to 5 cm long, regularly bipinnately branched; central strand present; paraphyllia densely covered on stems, usually not on branches. Stem leaves triangularly ovate, concave, acuminate to a piliform apex, appressed when dry, erect-spreading when moist; margins entire; costa percurrent, hyaline above, smooth; median leaf cells rhomboidal to oblong, thick-walled; unipapillose; branch

leaves arranged in 2 rows, triangular to oblong-ovate at base, acuminate towards apex, 1 mm long, margins serrate; costa slender, hyaline, multipapillose.

Specimens examined: Mizoram, Mamit district, DTR, 990 m alt., Dt. 19. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-045.

97. *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk.

Bryol. Jav., 2: 115. 1865; Gangulee, Moss. E. India, 3(7): 1646. 1978; J. Lal, Checklist Indian Moss, 132. 2005.

Description: Plants robust, up to or more than 10 cm long, light green to dark green, yellowish brown when old, often in large, interwoven patches. Stems creeping, usually regularly bipinnately branched; branches about 1.5 cm long; central strand differentiated; paraphyllia dense on stems and branches, foliose or filamentous, apical cells multipapillose. Stem leaves loosely appressed when dry, erect-patent when moist, suddenly narrowed from a triangularly ovate base to a lanceolate to piliferous apex, usually 6-10 cells long; margins mostly revolute or slightly rarely plane, serrulate above; costa extending to the lanceolate apex, with papillae or paraphyllia on back; median leaf cells oval-rhomboidal to elliptic, branch leaves concave, ovate lanceolate, margins entire. Setae yellowish brown to reddish brown, about 2 cm long, capsules cylindrical; peristome double; exostome teeth broadly lanceolate, reddish brown, papillose above; endostome segments as long as the exostome teeth, finely papillose; cilia 2-3. Spores 20 µm in diameter, finely papillose.

Specimens examined: Mizoram, Champhai district, MNP, 1536 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-049.

98. *Thuidium delicatulum* (Hedw.) Schimp.

Bryol. Eur., 5: 164. 1852.

Description: This pleurocarpous perennial moss forms a loose mat of evergreen compound leaves that are green to yellowish green and either double-pinnate or triple-pinnate. The central stems of these leaves are up to 8.5 cm in length; they are densely covered with narrow scale-like leaves up to 0.5 mm in length that are long-ciliate along their middle to lower margins. The larger stem leaves are about 1 mm in length, broadly ovate to triangular-ovate in shape, smooth and revolute along their margins, and convex on their outer sides. The midribs of these leaves extend nearly to their tips. Several leafy primary branches radiate from the central stem of the compound leaf, becoming shorter as they approach the tip of the central stem. When dry the leaves are more appressed and contracted against the central stem or branches.

Specimens examined: Mizoram, Champhai district, MNP, 1445 m alt., Dt. 21. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-047.

99. *Thuidium pristocalyx* (Mull. Hal.) A. Jaeger.

Ber. Thatigk. St. Gallischen Naturwiss. Ges., 1876-77: 257. 1878.

Description: Plants yellowish green, main stem creeping, thick, highly tomentose, variously branched, branching pinnate to bipinnate or tripinnate; leaves at stem large, up to 1x0.5 mm, leaves arranged in three tiers, ovate-acuminate, branch leaves ovate-acuminate, margin crenulated. Leaf back toothed; costa thin, faint, reach up to midleaf, in stem leaf costa reach up to tip; cells not pegged, almost rounded at tip, basal cells rounded to elongate-hexagonal.

Specimens examined: Mizoram, Champhai district, MNP, 1536 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-046.

100. *Thuidium tamariscinum* (Hedw.) Schimp.

Bryol. Eur., 5: 163. 1852.

Description: Plants large, up to 15 cm long, yellowish green to brownish green, in densely interwoven mats. Stems procumbent, regularly bipinnately to tripinnately branched; branch about 1 cm long; central strand present; paraphyllia numerous, foliose or filamentous. Stem leaves appressed when dry, erecto-patent when moist, widely triangular to triangularly ovate, gradually tapering into a short acumen, slightly plicate, margins serrulate; costa stout, vanishing at upper portion of leaf, often papillose on the back; leaf cells rhomboidal to oblong; median leaf cells 6-20 µm long, unipapillose; branch leaves ovate to widely ovate, concave shortly acute, costa vanishing below leaf apex. Dioecious. Perichaetial leaves larger, sheathing at base, suddenly narrowed to a long reflexuose apex, slightly ciliate at shoulder, serrate above, costa excurrent. Setae slender, reddish brown.up to 2 cm long, smooth; capsules cylindrical, slightly asymmetrical, about 3 mm long, horizontal, dark reddish brown; opercula conical; exostome reddish brown, glossly papillose above; endostome segments as long as the teeth, finely papillose, cilia 2-3, finely papillose. Spores 20 µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1447 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-048.

Trachypodaceae

101. *Trachypodopsis serrulata* (P. Beauv.) M. Fleisch.

Hedwigia, 45: 67. 1905; Gangulee, Moss. Eastern India, 2(5):1234. 1976

Description: Plants dark greenish, robust, in dense mats; secondary stem ascending or hanging, up to 10 cm or more long, pinnately branched; leaves erect spreading when moist, appressed to stem when dry, plicate, lanceolate, acuminate, margin serrulate, base auricled; costa single, faint or strong ending far below apex; cells thick-walled, rhomboid to linear, 35-40x5-8 µm, smooth at apex, basal cells rhomboid with a single papilla at centre, 15x5 µm, juxtacostal cells broader rectangular, alar cells quadrate-rhomboid, 10x6 µm.

Specimens examined: Mizoram, Aizawl district, TWS, 1545 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-076.

102. *Trachypus bicolor* Reinw. & Hornsch.

Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur., 14(2): 708. 1829.

Description: Plants yellowish-green to dark greenish, robust, in dense to loose mats; stem highly branched, secondary stem ascending or hanging, up to 10 cm or more long, pinnately branched; leaves erect spreading when moist, appressed to stem when dry, plicate, lanceolate, acuminate, margin serrulate, base auricled; costa single, faint or strong ending far below apex; cells thick-walled, rhomboid to linear, 35-40x5-8 µm, smooth at apex, basal cells rhomboid with a single papilla at centre, 15-20x5-9 µm, costal cells broader rectangular, alar cells quadrate-rhomboid, 10-12x6-8 µm. Seta up to 2 cm long; capsule erect, globose-ovoid, small-necked, dark brown, peristome teeth white; spores large, brown, 17.5-25.5µm in diameter.

Specimens examined: Mizoram, Aizawl district, TWS, 1545 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-077.

5.1.2. Liverworts

Aneuraceae

1. *Aneura pinguis* (L.) Dumort.

Comm. Bot., 115. 1822; A.E.D. Daniels, R. Annamalai, Tamil Nadau Biodivers., 59. 2004.

Description: Thallus 3-6 cm long and 0.2-0.8 cm wide, pale green, yellowish green to dark green, with greasy lustre, plano-convex to biconvex in section; wings 2-4-stratose close to the margin; margin obtuse to acute, flat or nearly so, bordered by 1-2 unistratose rows of cells; epidermal cells quadrangular in section, isodiametric, with firm walls; midrib 10-15 cells thick, gradually tapered towards margin. Thalli ascending, prostrate or procumbent, fleshy, rigid, irregularly branched; margin plane, undulate or sinuose. Oil bodies more than 6, in epidermal cells, ephemeral, finely granulose. Rhizoids hyaline, present in the middle of the ventral side of thallus. Antheridia and archegonia on small, lateral branches. Capsule ellipsoidal. Dioecious.

Specimens examined: Mizoram, Aizawl district, TWS, 1233 m alt., Dt. 15. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-130.

2. *Riccardia chamedryfolia* (With.) Grolle.

Trans. Brit. Bryol. Soc., 5: 7720. 1969.

Description: Plants to 3-4 cm long, pale green or yellowish. Lobes 2 mm wide; margin in male branches erect but not incurved. Thalli fragile, pinnate, palmate or irregularly branched, with emarginate or truncate apex; lobe margins usually unistratose, 1-3 cells wide; midrib poorly differentiated from wings. Oil bodies in epidermal cells 1-2, usually ephemeral, or lacking. Rhizoids on the ventral side and also very often at margin of thallus, hyaline, light brown. Gemmae often present on the dorsal side, near thallus apex, 2-celled. Antheridia and archegonia on small, lateral branches; archegonia and sporophytes surrounded by clavate involucre. Capsule ellipsoidal. Autoecious or dioecious. Thalli pinnate, prostrate; 1-4 oil bodies in internal cells, 1 large oil body in epidermal and marginal cells.

Specimens examined: Mizoram, Champhai district, MNP, 1422 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-131.

Aytoniaceae

3. *Asterella angusta* (Stephani) Pandé, K.P. Srivast. & Sultan Khan.

J. Hattori Bot. Lab., 11: 8. 1954.

Description: Thalli prostrste, light green, forming irregular rosettes or overlapping in dense green patches.Thallus 1-3 times dichotomously branched, lobes linear or linear oblong, dorsal surface flat, with wavy margins. Ventral scales in two rows, violet, usually triangular or lunate, one cell thick with long lanceolate appendages; rhizoids tuberculate and smooth-walled. Surface cells polygonal; pores simple, large, bounded by 2 to 3 series of 6 cells each, air chamber 1- 2 layered in midrib and many

layered in wings. Antheridia in raised cushions on dorsal surface of the thallus; receptacles studded with small red papillae, projecting from the surface of the thallus; each receptacle with 15 to 20 antheridia. Female receptacles hemispherical or disci-form, stalked, terminal, usually four lobed, sometimes 2, 3 or 8 lobed. Each involucre has a single archegonium; perianth ovate. Sporogonium with bulbous foot, short seta and spherical capsule. Spores dark brown, elaters yellow, simple. Dioecious.

Specimens examined: Mizoram, Champhai district, MNP, 1417 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-103.

4. *Asterella khasiana* (Griff.) Grolle.

Khumbu Himal., 1(4): 267. 1966; D.G. Long, Bryophyt. Biblioth., 63: 167. 2006.

Description: Thallus bright or yellowish green, medium-sized; dorsal surface of thallus reticulate and with simple pores; epidermal cells without trigones; under surface with small scales; thallus margin delicate. Air chambers usually 1 layer, without photosynthesis filaments. Monoicous. Androecia on main thallus just behind base of carpocephalum stalk. Carpocephalum flattened, 3-4 mm in diameter, strongly papillose above, slightly lobed at margin, with a small group of archegonia underneath, surrounded by a cup-shaped involucre. Sporophyte with a very short seta; capsule ovoid, 0.5 mm long; pseudoperianth lanceolate. Spore yellowish-brown, 75-90 µm in diameter; dorsal face regularly areolate, proximal face differs from distal side, irregularly reticulate, triradiate mark strongly distinct. Elaters dark-brown, bispiral thickening, 200-230 µm in length.

Specimens examined: Mizoram, Aizawl district, TWS, 1302 m alt., Dt. 18. 08. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-104.

5. *Plagiochasma appendiculatum* Lehm. & Lindenb.

Nov. Stirp. Pug., 4: 14 .1832.

Description: Plants 1-2 cm long, simple or furcate, ventrally branched; lobes flat, fragile, with retuse apex, 4-8 mm wide; light green to yellowish green, with light brown to reddish borders. Pores prominent, surrounded by 2-3 rings of concentric cells. Base of air chambers in mid thallus 3-4 cells wide. Air chambers low, in 2-3 irregular, vertical layers, without chlorophyllose filaments. Ventral scales in one row on either side of midrib, large, pink to purplish, with metallic sheen, with terminal appendages basally constricted and usually discoloured, projecting beyond margins at apex of young lobes. Male receptacles reniform, sessile, with numerous antheridia, surrounded by small, lanceolate scales, in mid thallus. Female receptacles in mid thallus, usually asymmetrical; stalk solid, 4-7 mm long, with filiform scales at base and apex.

Specimens examined: Mizoram, Mamit district, DTR, 821 m alt., Dt. 21. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-106.

6. *Reboulia hemisphaerica* (L.) Raddi.

Opusc. Sci., 2(6): 357. 1818.

Description: Thallus yellowish-green, creeping, primary branches up to 2.5 cm long, secondary branches small; thallus margin purple, dense patches of overlapping individuals, 10-30 mm long and 3-8 mm broad, lobes oblong, emarginate or bilobed at apex, margin ascending; dorsal epidermal cells 4-6 angled, walls slightly

thickened, pores a little elevated with 3-5 concentric rings of 6-8 cells each; radial walls and trigones thickened; scales purple, in one row on either side of the midrib, appendages two, linear; midrib thick, gradually passing into the lamina ending in one cell thick margin; male receptacle not seen; female receptacles hemispherical, 4-lobed, about 4 mm long; capsule spherical; spores brown, spherical, reticulate with a broad wing; elaters 2-3 spiraled.

Specimens examined: Mizoram, Aizawl district, TWS, 1296 m alt., Dt. 18. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-105.

Calypogeiaceae

7. *Calypogeia arguta* Nees & Mont. ex Nees.

Naturgesch. Eur. Leberm., 3: 24. 1838.

Description: Plants small, light green or bluish. Stem prostrate, often with erect propaguliferous branches. Rhizoids abundant at base of underleaves. Leaves obliquely inserted, incubous, more or less ovate, flat, simple with rounded or bidentate apex or bilobed; ventral margin more or less decurrent; cells thin-walled, trigones small or lacking, 2-3 oil bodies, granulose, colourless or blue. Underleaves wider than stem, bilobed, retuse, emarginate or rounded at apex, 2-14 cells deep from sinus to rhizoidal area. Gemmae 1-2-celled, greenish, grouped at apex of attenuate stems. Male inflorescence spiciform, rare, small. Female bracts on the ventral side of stem; perianth lacking. Marsupium subterranean, dark brown, covered by rhizoids. Leaves bilobed, lobes divergent, sinus rounded; underleaves deeply bilobed, lobed bifid, acute, 1-2 cells deep from sinus to rhizoidal area. Leaves with papillose cuticle.

Specimens examined: Mizoram, Aizawl district, TWS, 1245 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-143.

Cephaloziellaceae

8. *Cephaloziella divaricata* (Sm.) Warnst.

Krypt.-Fl. Brandenburg, Leber- & Torfm., 3: 320. 1902.

Description: Plants small, filiform. Stem usually procumbent, laterally or ventrally branched. Leaves distant to imbricate, patent or erect, usually channeled, lobes acute or obtuse, transversely inserted, rarely obliquely inserted, succubous, bilobed; margin entire to dentate or spinose; sinus usually recurved; cuticle smooth, papillose or with projections on the dorsal side. Underleaves bilobed, subulate or lacking. Gemmae common, on lobe apex of upper leaves, usually 2-celled, ellipsoidal or angulate. Perianth mouth crenulate or spinose, with thick-walled cells. Dioecious.

Specimens examined: Mizoram, Mamit district, DTR, 915 m alt., Dt. 15. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-145.

Fossombroniaceae

9. *Fossombronia himalayensis* Kashyap.

New Phytol., 14: 4. 1915.

Description: Plants green, up to 7 mm long. Stem prostrate, dichotomously branched, often with apical tubers, dorsally flattened, ventrally convex with simple vinous purple rhizoids; internal cells parenchymatous, thin walled. Leaves simple, quadrate, succubous, obliquely inserted on the stem in two lateral rows, irregularly lobed, wavy at the margins, unistratose, cells thin walled. Monoicous, antheridia

yellowish, globose and shortly stalked, scattered dorsally on the stem usually near the insertion of leaves, male bracts larger than leaves with 3-4 stalked anthredia. Archegonia lie dorsal on the stem, solitary, near the base of the leaves. Capsule spherical, dark brown, exserted with a short seta, dehiscence irregular, capsule wall bistratose. Spores dark brown, 36-45 µm in diameter. Elaters usually 2-4 spiraled, spirals pale yellow or less pigmented and loosely twisted.

Specimens examined: Mizoram, Champhai district, MNP, 1450 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-133.

10. *Fossombronia indica* Steph.

Sp. Hepat., 6: 73. 1917; Bapna & Kachroo, Hepatic. India, 2: 339. 2000.

Description: Plants yellowish-green, delicate, prostrate, dichotomously branched, upto 1 cm long, rhizoids pinkish, smooth, arises in bunches from the ventral surface, leaves ovate, succubous, overlapping, as long as wide, 0.5-1.2x1 mm, cells thin-walled with numerous chloroplasts. Margin wavy, with single mucilage papilla, oil bodies 10-20 per cell, globose or ovate, faintly granular, bluish-green, dispersed in the cells.

Specimens examined: Mizoram, Azaiwl district, TWS, 1220 m alt., Dt. 05. 06. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-111.

11. *Fossombronia pusila* (L.) Dumort.

Recueil Observ. Jungerm., 11. 1835.

Description: Plants about 1 cm long forming more or less dense light green rosettes or mats. Stem prostrate. Stem usually apically thickened. Rhizoids on the midrib. Wings deeply divided into crisped lobes, obliquely inserted, arranged in 2 rows along

the midrib, as wide as long; margin sinuose, undulate or dentate, seemingly continuously ruffled. Sporophyte surrounded by a pseudoperianth. Spores 45-62 µm in diameter; lamellae often joining to form several alveoli in the centre of the distal face; elaters 3-spiraled, frequent. Monoicous.

Specimens examined: Mizoram, Champhai district, MNP, 1415 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-132.

Jubulaceae

12. *Frullania acutiloba* Mitt.

J. Proc. Linn. Soc., 5: 120. 1861.

Description: Plants pale to deep green, 10-35 mm long, irregularly branched, leaf lobe ovate to cordate, imbricate, oblique to widely spreading, concave, apex incurved, basal appendages rounded to quadrate; lobules lanceolate to galeate, large with piliferous beak, up to 0.4 mm long, apical portion of rostrum with a row of 3-4 cells, acute to acuminate, rotundate, touching the base of underleaves, mouth wide, truncate, underleaves large, 0.8-1.2 mm long, sinus transversely inserted, margin entire, some leaves possess 1 or 2 teeth; dioecious, female inflorescence terminal on stem or main branches, perichaetial leaves entire, bracteoles often bear 1 or 2 teeth along margin; perianth exerted, 3-keeled sharp, toothed with irregular spinous out growths.

Specimens examined: Mizoram, Mamit district, DTR, 715 m alt., Dt. 23. 07. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-114.

13. *Frullania dilatata* (L.) Dumort.

Recueil Observ. Jungerm., 13. 1835.

Description: Plants to 4 cm long and to 1.5 mm wide, usually dark brown or reddish brown. Leaf cells more or less thick-walled, with large trigones. Perianth tuberculate in all its surface. Stem irregularly branched. Rhizoids fascicled from underleaf base. Leaves imbricate, bilobed, conduplicate, keel short or vestigial, incubous; dorsal lobe orbicular or ovate; ventral lobe smaller, involute, helmet-shaped or sac-shaped, sometimes evolute; leaf cells more or less thick-walled, sometimes with trigones, usually with ocelli arranged in 1-2 rows, spreading or in small groups in mid-leaf. Underleaves bilobed. Male inflorescences spiciform, on short branches, with imbricate bracts. Female inflorescences at the end of branches, with 2-5 pairs of bilobed, flat bracts. Perianth obovoid, with lateral and one or more ventral keels, abruptly narrowed in a beak. Dioecious. Stylus lanceolate, 4-8 cells wide at base, uniseriate or biseriate above; perianth trigonous, with 1 ventral keel.

Specimens examined: Mizoram, Champhai district, MNP, 1422 m alt., Dt. 20. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-115.

14. *Frullania ericoides* (Nees ex Mart.) Mont.

Ann. Sci. Nat., Bot., sér. 2, 12: 51. 1839; S.K. Sing & D.K. Sing, Hepat. Anthocerot. Gt. Himal. Natl. Pk., 203. 2009.

Description: Plants dioecious, 3-4 cm long, dark green to brown. Leaves squarrose, ovate to cordate, concave, obtuse; cells irregularly rounded, with indistinct trigones and distinct intermediate nodular thickenings; oil bodies 3-5 per cells, ovoid, segmented, bluish green; lobules explanate to galeate, rounded at vertex, truncate at

mouth. Underleaves imbricate to distant, transversely to obliquely inserted, triangular to ovate, acuminate to acute. Female inflorescences terminal on stem or leading branches; bracts and bracteoles concave, asymmetrically 2-lobed, 1 or 2-toothed. Perianth terminal or axillary, obovate, 3-keeled; keels sharp, angular, irregularly toothed, sagittate in cross section. Capsules globose, 4-valved; walls distinctly thickened at corners. Spores globose, with scattered patches of papillae, green. Elaters 1-spiraled, chocolate-brown, ovate. Peristome normal.

Specimens examined: Mizoram, Champhai district, MNP, 1410 m alt., Dt. 17. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-113.

15. *Frullania retusa* Mitt.

J. Proc. Linn. Soc., Bot., 5: 119. 1861; Steph., Sp. Hepat., 4: 448. 1910.

Description: Plants greenish brown; shoots 1.5-2.5 cm long, 1.4-1.6 mm wide, irregularly pinnately branched; stem in cross section more or less orbicular, 7-8 celled across diameter, cells polygonal, thick-walled. Leaves imbricate, spreading; leaf lobes ovate-orbicular to ellipsoidal. Rounded or rotundate at apex, margin entire, leaf cells with medium to large nodulose trigones and intermediate thickenings; leaf lobules erect, parallel to stem, cucullate, incurved at openings, with prominent beak at apex, stylus 6 cells long, uniseriate. Underleaves large, flat, appressed to stem, reniform, orbicular, rotundate or retuse at apex, transversely inserted, margins entire. Rhizoids hyaline. Dioecious.

Specimens examined: Mizoram, Champhai district, MNP, 1415 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-112.

16. *Frullania tamarisci* (L.) Dumort.

Recueil Observ. Jungerm., 13. 1835; Steph., Sp. Hepat., 4: 562. 1911; V. Nath & A.K. Asthana, J. Hattori Bot. Lab., 85: 68. 1998; A.P. Sing & V. Nath, Hepatic. Khasi Jaintia Hills, 190. 2007.

Description: Plants polymorphic, 10 cm long and 1 mm wide, reddish brown. Stem irregularly branched or 1-3-pinnately branched; leaves persistent, imbricate, bilobed, conduplicate, keel short or vestigial, incubous; dorsal lobe acute or apiculate with recurved apex; ocelli in uniseriate row or scattered; underleaves with recurved margins, usually with auricles. Stylus 1-2-seriate, forming a disc at base. Rhizoids fascicled from underleaf base. Ventral lobe smaller, involute, helmet-shaped or sac-shaped, sometimes evolute; leaf cells more or less thick-walled, sometimes with trigones. Stylus present between ventral lobe and stem. Underleaves bilobed. Male inflorescences spiciform, on short branches, with imbricate bracts. Female inflorescences at the end of branches, with 2-5 pairs of bilobed, flat bracts. Perianth obovoid, with lateral and one or more ventral keels, abruptly narrowed in a beak. Dioecious.

Specimens examined: Mizoram, Champhai district, MNP, 1442 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-116.

17. *Jubula complanata* (L.) Corda.

Deutschl. Fl., Abt. II, Cryptog., 26-27: 152. 1835.

Description: Plants 1 to 2 cm long, dark green. Stem irregularly pinnately branched. Leaves imbricate, longitudinally inserted, incubous, bilobed almost to base, conduplicate, dorsal lobe ovate; margin spinosely toothed or ciliate, ventral lobe much smaller than underleaves, helmet-shaped or ovate-lanceolate,

sometimes recurved, with or without a long distal cilium; cells of dorsal lobe thin-walled, without trigones. Underleaves bilobed, acute with entire to spinose-dentate or ciliate margin. Male inflorescences on short branches. Female bracts with lanceolate, dentate ciliate lobes. Perianth truncate-obovate, up to 2.2 mm long. Autoecious or dioecious.

Specimens examined: Mizoram, Champhai district, MNP, 1418 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-117.

Jungermanniaceae

18. *Jungermannia appressifolia* Mitt.

J. Proc. Linn. Soc., Bot., 5: 91. 1860; Amak., J. Hattori Bot. Lab., 30: 187. 1967.

Description: Plants yellowish green when young, dark brown to blackish green when mature, up to 3 cm long, in tufts. Stem erect, branches few at the tip, innovating; rhizoids throughout the stem, numerous below, purple; leaves imbricate, rotundate, sinuately inserted, decurrent on both sides, obliquely spreading, when dried laterally appressed to the stem. Leaf cells thin-walled, cuticle smooth; perianth pyriform when young; female bracts one pair, similar to the stem leaves. Dioecious.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-134.

19. *Jungermannia macrocarpa* Steph.

Sp. Hepat., 6: 87. 1917.

Description: Plants light yellowish brown, often tinged with red, up to 1 cm long and 1.5 mm wide, flaccid; stem fleshy, simple, erect, rarely with small lateral

branches; rhizoids numerous, purple; leaves imbricate, widely inserted, more or less concave, leaf insertion wide and oblique; leaf cells thin-walled, trigones distinct.

Specimens examined: Mizoram, Aizawl district, TWS, 1242 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-135.

Lejeuneaceae

20. *Lejeunea cavifolia* (Ehrh.) Lindb.

Acta Soc. Sci. Fenn., 10: 43. 1871; Chopra, Census Indian Hepat., J. Indian Bot. Soc., 22: 251. 1943; A.P. Sing & Nath, Hepat Khasi Jaintia hills, 268. 2007.

Description: Plants 3 cm long, 0.4-1.5 mm wide, green to yellowish. Leaves usually imbricate, 0.45-0.7 mm long; ventral lobe with elongated hyaline papilla. Underleaves bilobed, with straight or connivent lobes, 2-4 times wider than stem. Perianth with smooth keels and with subperianthal innovations. Rhizoids fascicled from the underleaves base. Leaves incubous, bilobed, conduplicate; cuticle smooth or slightly papillose. Male inflorescence usually on short branches. Female inflorescence on stem or on short branches, perianth beaked, with 1-5 crenulate or smooth keels or keels absent. Autoecious. Dorsal lobe of leaves elliptical, suborbicular, subquadrate, obovate or ovate; leaves distant or imbricate; oil bodies simple or granulose, numerous or scarce, persistent or not. Underleaves usually contiguous in mature stems; oil bodies numerous, simple, glistening and persistent.

Specimens examined: Mizoram, Champhai district, MNP, 1418 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-122.

21. *Lejeunea flava* (Sw.) Nees.

Naturgesch. Eur. Leberm., 3: 277. 1838; S.K. Singh & D.K Singh, Geophytology, 32: 115. 2004.

Description: Plants yellowish green to dull green; shoots 1-2 mm long and 0.7-1.2 mm wide, irregularly pinnately branched; stem in cross section orbicular to ellipsoid. Cortical cells large, subquadrate, medullary cells pentagonal to hexagonal, smaller than cortical cells, thick-walled. Leaves imbricate, widely spreading, leaf lobes ovate, margins entire, rounded at apex; marginal leaf cells quadrate to polygonal, median leaf cells polygonal; basal leaf cells slightly elongated, polygonal with small triradiate trigones. Leaf lobules inflated, oblong-ovate. Underleaves ovate to orbicular, entire at margins, lobes acute to obtuse, sinus narrow acute. Monoecious.

Specimens examined: Mizoram, Lunglei district, TTWS, 1228 m alt., Dt. 21. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-124.

22. *Lopholejeunea abortiva* (Mitt.) Stephani.

Sp. Hepat., 5: 70. 1912.

Description: Plants small light green to yellowish green, 5-15 mm long, leaves widely spreading, lobe ovate, margins entire, apex rounded, cells with inconspicuous trigones and intermediate nodular thickenings. Lobule ovate, distinctly saccate, with inconspicuous tooth; underleaves wider than length, margins entire. Female inflorescence terminal on short or elongated branch, bracts ovate, margins entire, apex rounded, Bracteole longer than width, margin entire and revolute; perianth obovate, 5-keeled, keels with small dentitions. Dioecious.

Specimens examined: Mizoram, Mamit district, DTR, 678 m alt., Dt. 15. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-151.

23. *Lopholejeunea indica* Udar & U.S. Awasthi.

Bull. Bot. Surv. India, 25: 174. f. 1-40. 1983.

Description: Plants monoecious, 5-10 mm long, greenish brown in colour, leaves widely spreading, lobe ovate, margin entire, apex rounded, cells thick-walled, with radiate trigones and intermediate nodular thickenings, lobule ovate 1/3 of the lobe length, with inconspicuous teeth; underleaves slightly wider than length, margin entire, bracts hypostatic, lobe ovate, margin entire, apex obtuse or rounded, lobule ovate-oblong, margin entire, apex obtuse, bracteole almost orbicular, margin entire; female inflorescence terminal, on short lateral branch, lacking in subfloral innovation, bract lobe obovate-oblong, margin dentate or entire, apex acute, sometimes rounded, lobules almost rectangular, 1/2 or slightly more than 1/2 of the lobe length, sometimes extended beyond the keel, with 1-6 teeth, bracteole orbicular, margin dentate, slightly revolute, perianth obovate, 4-keeled, keels dentate.

Specimens examined: Mizoram, Lunglei district, TTWS, 1228 m alt., Dt. 21. 08. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-125.

24. *Ptychanthus striatus* (Lehm. & Lindenb.) Nees.

Naturgesch. Eur. Leberm., 3: 212.1838; Kashyap, Liverw. W. Himal., 2: 25. 1932;

S. K. Singh & D.K. Singh, Cryptog. Bryol., 28: 257. 2007.

Description: Plants brownish green to dark green, stem 3-10 cm long, regularly pinnate or bipinnate. Leaves imbricate, spreading usually widely. Lobe oblong-ovate, about 1.5 mm long, margin irregularly dentate towards apex, apex acute to

acuminate, dorsal margin slightly arched and forming a cordate base, lobule small, oblong-ovate, rectangular, slightly inflated, usually with 1 blunt tooth, hyaline papilla on the inner surface of the tooth. Underleaves contiguous to imbricate, 3-5 times as wide as the stem, apex rounded or emarginate, irregularly dentate, base usually auriculate. Lobe cells thick-walled, trigones large, cordate, intermediate thickenings frequent. Oil bodies usually 10 per leaf-lobe cell, oblong to ovoid. Autoecious, gynoecia on short or long branches, with a thecal innovation, perianth obovate, inflated, with 10 entire keels, bract lobe oblongovate, as large as the leaf. Androecia on long branches, usually intercalary, bracts in 5-12 pairs, imbricate.

Specimens examined: Mizoram, Lunglei district, TTWS, 1280 m alt., Dt. 25. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-123.

25. *Trocholejeunea sandvicensis* Mizut.

Misc. Bryol. Lichenol., 2: 169. 1962; S.K. Singh & D.K. Singh, Cryptog. Bryol., 28: 258. 2007.

Description: Plants olive green to olive brown; shoots irregularly branched; stem in cross section orbicular, cortical cells subquadrate to polygonal, thin-walled; medullary cells slightly smaller than cortical cells, polygonal, thin-walled. Leaves closely imbricate, widely spreading; leaf lobes squarrose when moist, ovate, rounded at apex, entire at margins; marginal leaf cells towards apex subquadrate, median leaf cells hexagonal to polygonal, basal leaf cells polygonal, with triradiate to subnodulose trigones and intermediate thickenings; cuticle smooth; leaf lobules about half of lobe length, inflated, suborbicular or ovate. Free margins with 3-4 small teeth, keel sinuate. Underleaves closely imbricate, obliquely to widely spreading

when moist, reniform, narrowly recurved or flat at margins, sinuately inserted. Rhizoids few, pale brown. Monoecious.

Specimens examined: Mizoram, Champhai district, MNP, 1418 m alt., Dt. 18. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-126.

Lepidoziaceae

26. *Bazzania tridens* (Reinw., Blume & Nees) Trevis.

Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat., 4: 415. 1877; A. P. Singh & V. Nath, Hepatic. Khasi Jaintia Hills, 33. 2007.

Description: Plants 5-15 mm long, prostrate, forming interwoven mats, brown. Stems pinnately branched, 7-9 celled across; cells thick-walled; cortical cells and medullary cells thin-walled; flagella 4-10 mm long. Leaves imbricate, subopposite, widely spreading, oblong-ovate, weakly incurved ventrally and mildly verrucose, narrower towards apex, with 3 apical teeth and inconspicuous; bulging trigones on walls; oil bodies 2-6 per cell, elongate, segmented. Underleaves distant to approximate, patent or reflexed, quadrate to subquadrate, connate with leaves at base, irregularly toothed at apex. Perianth fusiform. Capsules ovoid to short cylindric.

Specimens examined: Mizoram, Lunglei district, TTWS, 1128 m alt., Dt. 21. 08. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-140.

Lophocoleaceae

27. *Lophocolea bidentata* (L.) Dumort.

Recueil Observ. Jungerm., 17. 1835.

Description: A translucent, pale green in colour with shoots 2 to 4 mm wide sometimes stretching to several centimeters in length. The conspicuously bilobed

leaves are 2 mm in length with the lobes drawn out to a long, narrow point. The underleaves are also bilobed, with an additional lateral tooth on each side. The plant is strongly aromatic, and often fertile, with toothed perianths.

Specimens examined: Mizoram, Mamit district, DTR, 915 m alt., Dt. 15. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-147.

Marchantiaceae

28. *Dumortiera hirsuta* (Sw.) Nees. in Mart.

Fl. Bras., 1: 307. 1833; Mitt., J. Proc. Linn. Soc. Bot., 5: 125. 1861; Bapna & Kachroo, Hepatic. India, 2: 440. 2000; A.P. Singh & V. Nath, Hepatic. Khasi Jaintia Hills, 325. 2007.

Description: The large dark green thalli are up to 12 cm long and 2 cm wide and these may form large mats or become pendent on steep substrata. The thalli are dull when dry, almost flat above, with a pattern of fine ridges. There are no conspicuous air chambers or pores on the upperside of the thallus but its margins have a fringe of tiny hairs. The plants form long-lived perennial patches. Dioecious or autoecious. Reproductive structures occur near the thallus tip. The male receptacle is up to 5 mm in diameter with a stalk about 1 mm high, the female receptacle up to 9 mm diameter on a stalk up to 50 mm tall. Sporophytes only occur occasionally ripening from May to September, with up to nine capsules on each receptacle.

Specimens examined: Mizoram, Mamit district, DTR, 685 m alt., Dt. 18. 05. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-139.

29. *Marchantia emerginata* Reinw., Blume & Nees.

Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur., 12: 192. 1825.

Description: Thallus with distint mid-dorsal line, oblong-ovate, apiculate appendages of ventral scales with 2-3 cells uniseriate towards apex, margins strongly toothed, teeth 1-3 cells long, stalk of antheridiophore with 2-4 furrows, receptacle 7-9 lobed. Ventral scale margin with 1-2 cells long or angular, stalk of male and female antheridiophores with two rhizoidal furrows and female receptacle with 5-9 lobed.

Specimens examined: Mizoram, Aizawl district, TWS, 1245 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-120.

30. *Marchantia linearis* Lehm. & Lindenb.

Nov. Stirp. Pug., 4: 8. 1832.

Description: Thallus light green to green, dichotomously branched, lobes linear, 30-60 mm long, 2-3.5 mm wide, apex notched, margin entire to slightly wavy, hyaline or purplish, mid-dorsal line distict, blackish. Midrib ventrally convex, upper surface areolate, epidermal pores barrel-shaped, circular-oval, surrounded by 5-6 concentric rings of cells of 5-6 cells each, 2-3 rings of cells above the epidermis level and 2-3 rings of cells projecting below into the air chamber, inner opening bordered by cells with more or less convex inner walls, epidermal cells subquadrate-rectangular or hexagonal, thin-walled, air chamber in single layer, occupied by assimilatory filaments, storage tissue with parenchymatous cells. Ventral scale purplish, arranged in four rows, 2 on either side of the midrib, broadly ovate, oil cells scattered, appendaged. Rhizoids both smooth-walled and tuberculate. Cupules with 1-2 cells long cilia.

Specimens examined: Mizoram, Aizawl district, TWS, 1245 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-121.

31. *Marchantia paleacea* Bertol.

Opusc. Sci., 1: 242. 1817; Bischl., Bryophyt. Biblioth., 38: 91. 1989.

Description: Thallus green, thick, without distint midrib, appendaged, cupules ciliated, deeply lobed, repeatedly dichotomously branched. Dioecious. The stalk of male receptacle is with two rhizoidal furrows and without air chambers, disc slightly convex or flat shallowly 6-8 lobed, stalk of female receptacle with air chambers, deeply 7-9 lobed disc. Apex of the lobes truncate, expanded, convex in proximal part, thin and flat distally.

Specimens examined: Mizoram, Aizawl district, TWS, 1215 m alt., Dt. 21. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-118.

32. *Marchantia papillata* Raddi.

Critt. Bras., 20. 1822.

Description: Dark median streak on dorsal surface of thalli, barrel-shaped epidermal pores, each surrounded by 5-8 concentric rings of 4-5 cells each, ventral scales arranged in four rows, broadly ovate, appendages ovate, subrotund or oblong, 9-12 cells wide in the middle, apex acute in older ones, margin coarsely toothed, teeth 1 cell long and wide. The female receptacle as like as male receptacles with 2 rhizoidal furrows and 1 narrow band of air chamber, disc hemispherical, head-base swollen, 6-9 lobed, lobes at apex emarginated, incurved when young.

Specimens examined: Mizoram, Lunglei district, TTWS, 1088 m alt., Dt. 22. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-119.

Metzgeriaceae

33. *Metzgeria conjugata* Linbd.

Acta Soc. Sci. Fenn., 10: 495. 1875.

Description: Thalli 1.4-2.5 cm long and 0.8-1.6 mm wide, weakly convex, sometimes recurved at margins, with simple hairs on ventral side. Thalli prostrate, furcate, usually with ventral branches arising from midrib, rarely from margins; wings unistratose, translucent, commonly with scarce, short, hyaline, unicellular hairs on ventral side and at margins, or lacking; midrib narrow. Antheridia on small branches on ventral side of midrib, inside a globose sac. Archegonia on small branches on ventral side of midrib, hidden under a thallus flap. Marginal hairs in pairs; plants autoecious.

Specimens examined: Mizoram, Aizawl district, TWS, 1255 m alt., Dt. 20. 08. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-138.

Pallaviciniaceae

34. *Pallavicinia lyellii* (Hook.) Gray.

Nat. Arr. Brit. Pl., 1: 685. 1821; Carruth., J. Bot., 3: 302. 1865; R.S. Chopra, J. Indian Bot. Soc., 22: 240. 1943; Bapna & Kachroo, Hepatic. India, 2: 349. 2000.

Description: Thalli 1-3 cm long, delicate, simple or furcate; lobes 1.5-4 mm wide; wings plane, undulate or crisped, unistratose except at base; midrib strong, pale green, 10-14 cells thick, with a central strand of narrow, elongated cells and dark walls; margin entire or papillose. Rhizoids on the midrib, pale brown. Antheridia in 2 rows on each side of midrib, pale orange when mature, covered by small lamellae with laciniate or dentate-laciniate margins. Archegonia in small

groups on the dorsal side of midrib, surrounded by an involucre of lamellae with laciniate margins, fused at base; perianth cylindrical, 3-5 mm long, constricted and ciliate at mouth. Capsule cylindrical to ellipsoidal; spores 22-26 µm, with the distal surface reticulate. Dioecious

Specimens examined: Mizoram, Aizawl district, TWS, 1210 m alt., Dt. 15. 08. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-141.

Pelliaceae

35. *Pellia epiphylla* (L.) Corda.

Naturalientausch, 12: 654. 1829.

Description: Thalli furcate, 1 cm wide, with retuse apex and mucilaginous hairs in the upper part of ventral side or on both sides; wings undulate at margins, 1-3 cells thick; midrib 6-15 cells thick, poorly distinct on the dorsal side. Rhizoids abundant on the midrib ventral side. Antheridia almost immersed in mid dorsal side, in 2-3 irregular rows. Archegonia grouped at thallus apex, surrounded by an involucre, without perianth. Capsule globose. Involucre horizontal, reduced to a small, convex scale, with almost entire margin; thallus 10-15 cells thick in the middle. Plants scarcely aromatic, dark green. Lobes plane; midrib dark green, sometimes reddish.

Specimens examined: Mizoram, Mamit district, DTR, 915 m alt., Dt. 15. 05. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-142.

Plagiochilaceae

36. *Plagiochila asplenioides* (L.) Dumort.

Recueil Observ. Jungerm., 14. 1835.

Description: Plants 10 cm long and 0.5-0.9 cm wide, light green or yellowish without flagelliform branches; leaves 3-4x2.5-4.2 mm; cells with small trigones or trigones lacking. Leaves nearly imbricate, translucent; cells thin-walled, median cells with 3-4 oil bodies. Stem procumbent or ascending. Rhizoids scarce or lacking. Leaves alternate, strongly obliquely to longitudinally inserted, succubous, asymmetrical, persistent or caducous, convex, with rounded or truncate apex, rarely bilobed, with the dorsal margin decurrent or not; margin usually dentate or entire, plane or recurved. Underleaves small or lacking, caducous, visible in the upper part of some stems. Plants rarely fertile, vegetative propagation by means of caducous leaves. Perianth large, laterally compressed. Dioecious.

Specimens examined: Mizoram, Lunglei district, TTWS, 1228 m alt., Dt. 21. 08. 2016, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-127.

37. *Plagiochila chinensis* Steph.

Mem. Soc. Sci. Nat. Cherbourg, 29: 223. 1894.

Description: Plants greenish-brown, 2-3 cm long, sparingly branched, branches exclusively lateral intercalary, rhizoids scanty on basal part of shoot; leaves oblong ovate, up to 1.5x1 mm, dorsal margin recurved, base long decurrent, apex subtrunccate, 15-25 teeth per leaf, 3-7 cells long, 1-2 cells with at base; terminal cells of leaves elongated, trigones distinct, small; underleaves vestigial, paraphyllia

absent; androecia terminal as well as intercalary, gynoecia terminal on main shoot, bracts broadly ovate, perianth long, irregularly toothed.

Specimens examined: Mizoram, Champhai district, MNP, 1405 m alt., Dt. 17. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-128.

38. *Plagiochila fruticosa* Mitt.

J. Proc. Linn. Soc., Bot., 5: 94. 1861.

Description: Plants greenish brown, glossy, 3-10 cm long and 2.1-2.6 mm wide, rhizome long creeping; leaves ovate to rectangular, stem leaves1-1.2x0.5 mm, dorsal margin slightly recurved, base long, decurrent, 6-8 teeth per leaf, 4-6 cells long, 4-6 cells wide at base; trigones small; underleaves vestigial, paraphyllia absent; androecia intercalary, gynoecia terminal on branches, bracts irregularly toothed, perianth triangular, companulate, highly dentate.

Specimens examined: Mizoram, Champhai district, MNP, 1415 m alt., Dt. 22. 02. 2018, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-129.

Porellaceae

39. *Porella campylophylla* (Lehm. & Lindenb) Trevis.

Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat., 4: 408. 1877; Kachroo, J. Sci. Univ. Kashmir, 1: 156. 1973; M.C. Nair & al., Bryophyt. Wayanad, 61. 2005.

Description: Plants yellowish-green, 5-7 cm long, irregularly branched; leaf lobes widely spreading, widest at base, 2-2.2x1.2-1.5 mm, ovate to oblong-ovate, apex acuminated, 3-4 teeth at apex, with a prominent terminal tooth, dorsal margin arched towards the base; submarginal and median cells 10-20 mm, basal cells rounded-

elongate, 20-25 mm, trigones small; leaf lobules elongated to lanceolate, entire, acuminate, 1x0.1-0.2 mm; underleaves broad at base, tip with two spines at margin.

Specimens examined: Mizoram, Lunglei district, TTWS, 1020 m alt., Dt. 20. 05. 2015, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-144.

Radulaceae

40. *Radula javanica* Gottsche.

Syn. Hepat., 257. 1845.

Description: Plants pale yellowish-green, main stem 1-5 cm long, irregularly branched, branches small, bearing few rhizoids; leaves imbricate, ovate with rounded apex, slightly concave, margin smooth, postical lobe infolded towards the leaf, less than half the size of the broadly rounded antical lobe; lobules quadrate with a pointed apex; cells rounded hexagonal, thin-walled, trigones absent; underleaves absent.

Specimens examined: Mizoram, Champhai district, MNP, 1415 m alt., Dt. 19. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-146.

Ricciaceae

41. *Riccia discolor* Lehm. and Lindenb.

Nov. Stirp. Pug., 4: 1. 1832.

Description: Thallus dioecious, overlapping, bluish green 1-2 forked with median groove along whole thallus, lobes oblong. Female thallus larger than male. 4-15 mm long; 2-8 mm broad. Male thallus 2-8 mm long; 2.5 mm broad. Air space narrow, epidermal cells oval, pappilate. Ventral scale small, semilunar, purple beyond the thallus margin. Rhizoids both simple and tuberculate. Archegonia on median furrow,

protruding out from thallus. Capsule in 1-2 rows. Spores brown 80-120 µm in diameter, reticulate, 6-10 areoles on outer surface, triradiate mark inconspicuous.

Specimens examined: Mizoram, Aizawl district, TWS, 1215 m alt., Dt. 19. 05. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-110.

42. *Riccia fluitans* L.

Sp. Pl., 1139. 1753; Kachroo & al., J. Indian Bot. Soc., 56: 79. 1977.

Description: Thallus yellowish-green, narrow, thin, 1-5 cm long and 0.5-2 mm wide, dichotomously branched, terrestrial thallus is much broader, rhizoids pegged, ventral scales rudimentary; both lacking in the free-floating form; thallus segments broadly channeled in free-floating form, spongy, large air chambers occur throughout thallus.

Specimens examined: Mizoram, Aizawl district, TWS, 1350 m alt., Dt. 23. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-107.

43. *Riccia glauca* L.

Sp. Pl., 1139. 1753; K. Mull., Rabenh. Krypt. Fl., 183. f. 97. 123. 1907; Hatt., Nat. Sci. Mus. Tokyo, 14: 142. 1943; Kachroo, J. Univ.Gauhati, 5: 131. f. 6A-B. 1954.

Description: Thallus monoecious, usually in rosette, glaucous green, up to 10 mm long and 2-3 mm broad, mid dorsal groove prominent, apex emarginated, epidermal cell 5-7 angled, rounded, air space in longitudinal row, separating walls usually one cell thick densely chlorophyllose. Scale prominent along the margin. Rhizoids both simple and tuberculate, hyaline. Antheridia and archegonia in usually regular rows immersed along median groove on dorsal side of thallus, with emergent necks. Capsule irregularly dehiscing, globose, immersed in thallus or slightly bulging dorsally or ventrally. Spores dark brown, 75-100 µm in diameter.

Specimens examined: Mizoram, Azawl district, TWS, 1218 m alt., Dt. 20. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-108.

44. *Riccia huebeneriana* Linbend.

Nov. Actorum Acad. Caes. Leop.-Carol. German. Nat. Cur., 18: 504. 1836.

Description: Thalli 3-30 mm long, furcate, fleshy, with or without wings, on the dorsal side flat or with convex flanks, with a narrow or wide and flat median groove or median groove lacking, glabrous or with cilia or papillae on the dorsal side and at margins, usually more abundant in the apical part of lobes; margin acute or rounded. Lobes with median groove visible at apex, reaching the base in dry plants. Rhizoids hyaline. Antheridia and archegonia in usually regular rows immersed along median groove on dorsal side of thallus, with emergent necks. Capsules prominent on the ventral side, not or only slightly visible on the dorsal side. Spores yellowish to brownish or black, 55-75 µm in diameter; wing irregularly lobed, finely papillose, usually more than 3-6 µm wide; distal face with 6-8 complete alveoli; proximal face with incomplete alveoli. Monoicous.

Specimens examined: Mizoram, Aizawl district, TWS, 1255 m alt., Dt. 23. 08. 2018, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-109.

Targioniaceae

45. *Cyathodium cavernarum* Kunze in Lehm.

Nov. Stirp. Pug., 6: 18. 1834.

Description: Thallus yellowish-green to light greenish or fluorescent green, thin, delicate, 4-10x4-5 mm, often dichotomously branched; dorsal epidermal cells thin-walled, chlorophyllose; air chambers in single row, partition between air chambers 1-

2 cells high with chloroplasts, pores on dorsal surface with 3-4 concentric rings of 4-6 cells; rhizoids smooth-walled, scales minute in two rows.

Specimens examined: Mizoram, Aizawl district, TWS, 1310 m alt., Dt. 22. 08. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-136.

46. *Targionia hypophylla* L.

Sp. Pl., 1136. 1753.

Description: A small bluish-green liverwort which is purple beneath. The reproductive structures are contained in a purple mussel-shaped enclosure under the apex of the thallus. Autoecious or dioecious. Thallus greenish, simple, rarely dichotomously divided, 5-10x2-4 mm, margin entire, areolae indistinct, epidermal cells 5-6 angled, walls slightly thickened, angles much thickened; air chambers distinct, containing green filaments, terminal cells of the filaments under the pore hyaline with very few chloroplasts, pores simple, conspicuous, slightly elevated, with 4 concentric rings of 6 cells each; ventral surface purple, scales broadly triangular, long subulate at apex; involucre purple, subglobose, keeled; sporogonia single; capsule spherical; spores 42-55 µm in diameter, dark brown; elaters bispiraled, 80-200x7-10 µm.

Specimens examined: Mizoram, Champhai district, MNP, 1398 m alt., Dt. 17. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-137.

5.1.3. Hornworts

Anthocerotaceae

1. *Anthoceros angustus* Steph.

Sp. Hep., 5: 1001. 1916.

Description: Thallus light greenish, growing in dense cushions arranged as rosettes, up to 12 mm long, 1.5-4 mm wide, dorsal surface smooth, bears gemmae at apical margin. Epidermal cells usually contain two chloroplasts with its associated pyrenoids, a distinguishing character from other species of the genus, mucilage cavities large, separated each other by one cell thick partition; androecia arranged linearly along median lines. Spores light brown, 31-40 µm in diameter, with spinulate blunt projections; pseudoelaters light brown, thin-walled, sometimes branched.

Specimens examined: Mizoram, Aizawl district, TWS, 1315 m alt., Dt. 18. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-148.

2. *Anthoceros erectus* Kashyap.

New Phytol., 14: 9. 1915.

Description: Plants dioecious. Male thalli up to 4 mm long, raised on a cylindrical stalk fanning at apex. Androecial chambers scattered, raised like humps on dorsal surface of thallus with 20-35 antheridia per androecial chamber in a bunch; antheridial body up to 168 µm long, cells of antheridial jacket in 4 tiers, stalk usually quadriseriate. Female thalli fanning above from a narrow base up to 6 mm long, wide at apex with lobed and dissected margin. Epidermal cells are reniform forms with

their radial and end walls uniformly thickened. Spores dark, reticulate, 40-60 µm in diameter. Elaters light brown, thin-walled, 4-celled, sometimes branched.

Specimens examined: Mizoram, Champhai district, MNP, 1410 m alt., Dt. 17. 08. 2017, Lalhriatpuia, Accession Number: MZU/Bot/Bryo-149.

3. *Phaeoceros laevis* (L.) Prosk.

Bull. Torrey Bot. Club, 78: 347. 1951; S.K. Singh & D.K. Singh, Hepat Anthocerot. Gt. Himal. Natl. Pk., 415. 2009.

Description: Thallus dioecious, greenish yellow, male thallus up to 6 mm or more, wide at apex, deeply lobed; female thallus fan shaped, expansive, long and branched, deeply lobed with smooth-wavy margin, up to 18 mm long and 16 mm wide at apex, cells 4-8 layers in the middle region, upper epidermal layer with single globose chloroplast per cell; spores yellowish green, 35-55 µm in diameter, usually densely impregnated with minute papillae; pseudoelaters light yellowish, thin-walled, short, sometimes branched.

Specimens examined: Mizoram, Aizawl district, TWS, 1310 m alt., Dt. 18. 11. 2014, Lalhriatpuia, Accession Number: MZU/Bot/ Bryo-150.

Photo Plate 1:

a. *Anthoceros erectus* Kashyap

b. *Anthoceros angustus* Stephani

c. *Phaeoceros laevis* (L.) Prosk.

d. *Asterella angusta* (Stephani) Pandé, K.P. Srivast. & Sultan Khan

e. *Asterella khasiana* (Griff.) Grolle

f. *Targionia hypophylla* L.

Photo Plate 2:

a. *Dumortiera hirsuta* (Sw.) Nees

b. *Bazzania tridens* (Reinw., Blume & Nees) Trevis.

c. *Cephaloziella divaricata* (Sm.) Warnst.

d. *Ptychanthus striatus* (Lehm. & Lindenb.) Nees

e. *Fossombronia pusilla* (L.) Dumort.

f. *Lejeunea cavifolia* (Ehrh.) Lindb.

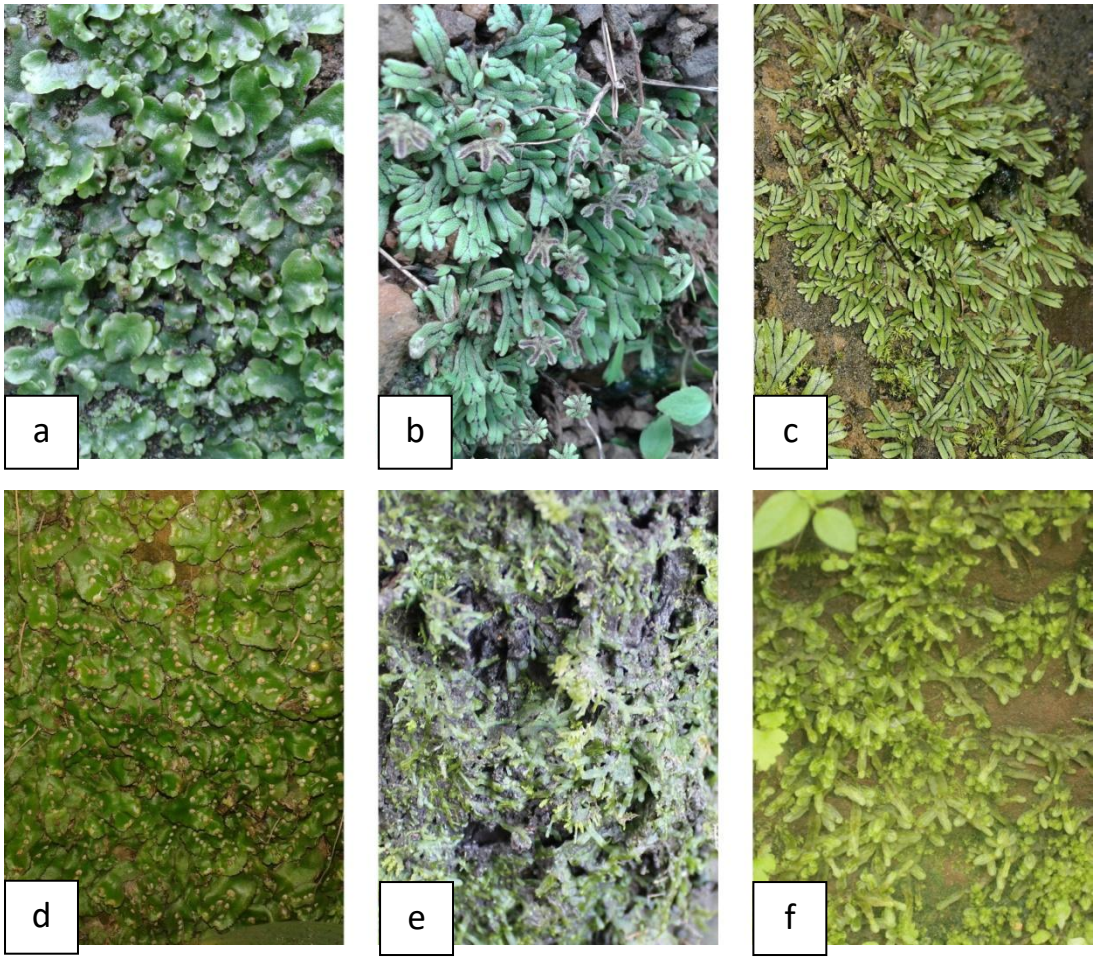


Photo Plate 3:

a. *Marchantia paleacea* Bertol.

b. *Marchantia emarginata* Reinw., Blume & Nees

c. *Marchantia linearis* Lehm. & Lindenb.

d. *Plagiochasma appendiculatum* Lehm. & Lindenb.

e. *Metzgeria conjugata* Lindb.

f. *Pallavicinia lyellii* (Hook.) Gray

Photo Plate 4:

a. *Riccardia chamedryfolia* (With.) Grolle

b. *Aneura pinguis* (L.) Dumort.

c. *Cyathodium cavernarum* Kunze

d. *Riccia glauca* L.

e. *Riccia fluitans* L.

f. *Plagiochila asplenioides* (L.) Dumort.

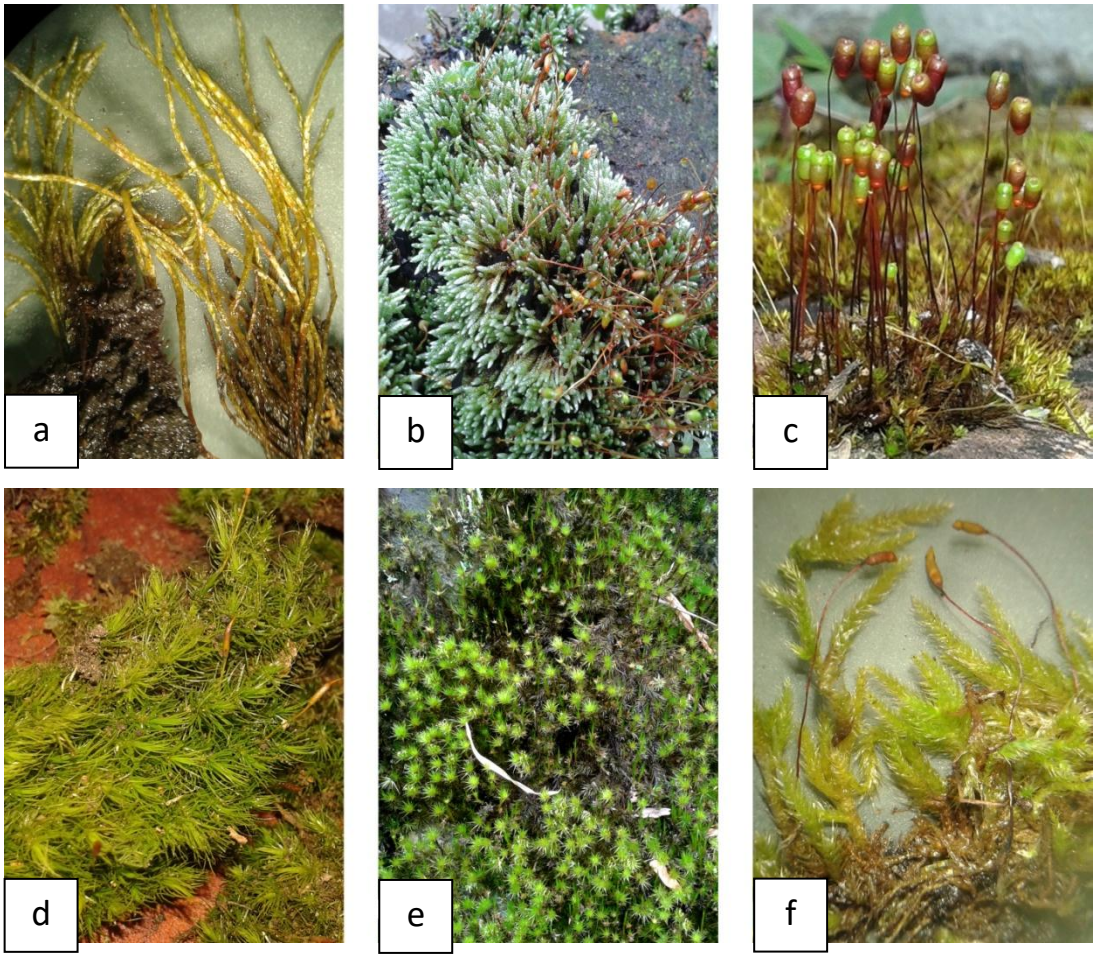


Photo Plate 5:

a. *Anomobryum filiforme* var. *concinnatum* (Spruce) Loeske

b. *Bryum argenteum* Hedw.

c. *Bryum coronatum* Schwägr.

d. *Dicranum scoparium* Hedw.

e. *Campylopus introflexus* (Hedw.) Brid.

f. *Brachythecium plumosum* (Hedw.) Schimp.

Photo Plate 6:

a. *Erythrodontium julaceum* (Hook. ex Schwägr.) Paris

b. *Fabronia assamica* Dixon

c. *Cyathophorella tonkinensis* (Broth. & Paris) Broth.

d. *Octoblepharum albidum* Hedw.

e. *Leucobryum javense* (Brid.) Mitt.

f. *Leucobryum glaucum* (Hedw.) Ångstr.

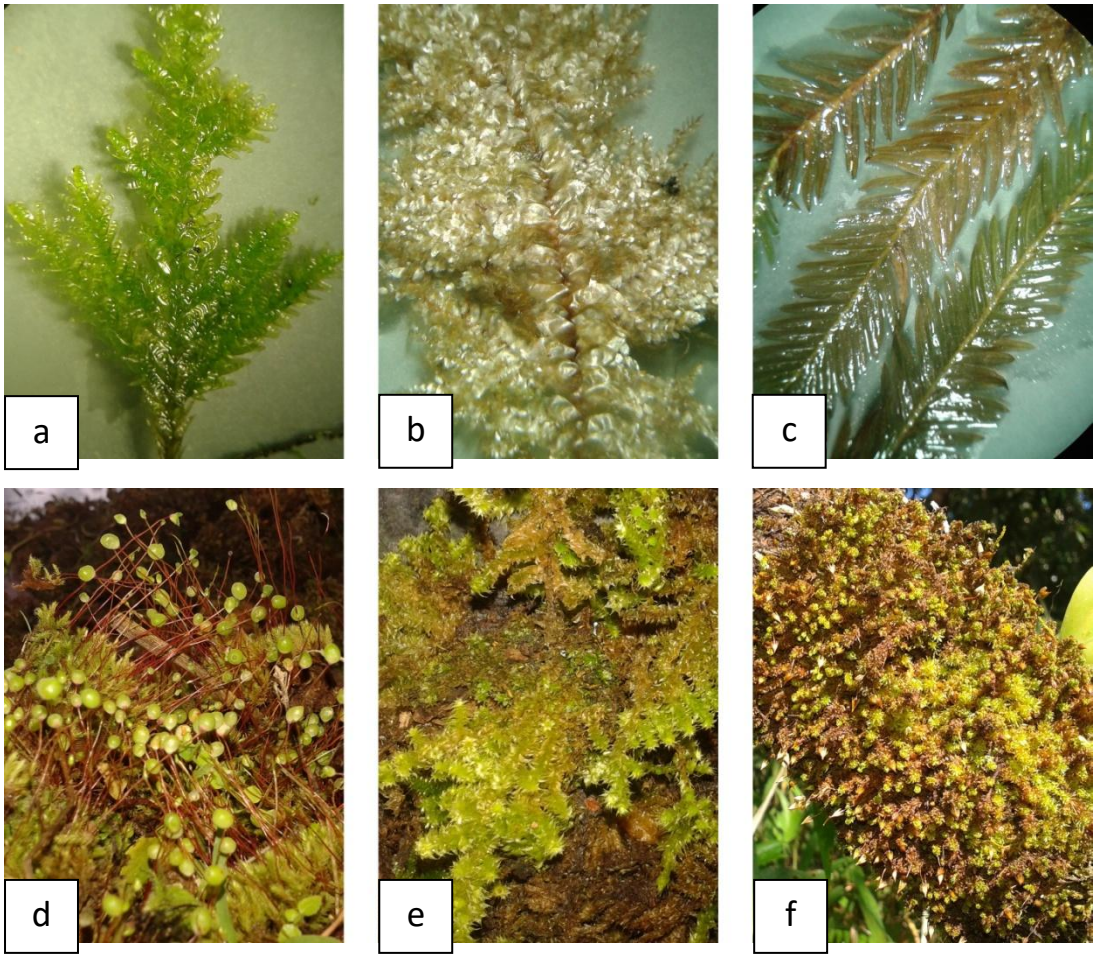


Photo Plate 7:

a. *Neckera pennata* Hedw.

b. *Homaliodendron microdendron* (Mont.) M. Fleisch.

c. *Fissidens taxifolius* Hedw.

d. *Philonotis fontana* (Hedw.) Brid.

e. *Meteoriopsis reclinata* (Müll. Hal.) M. Fleisch.

f. *Macromitrium sulcatum* (Hook.) Brid.

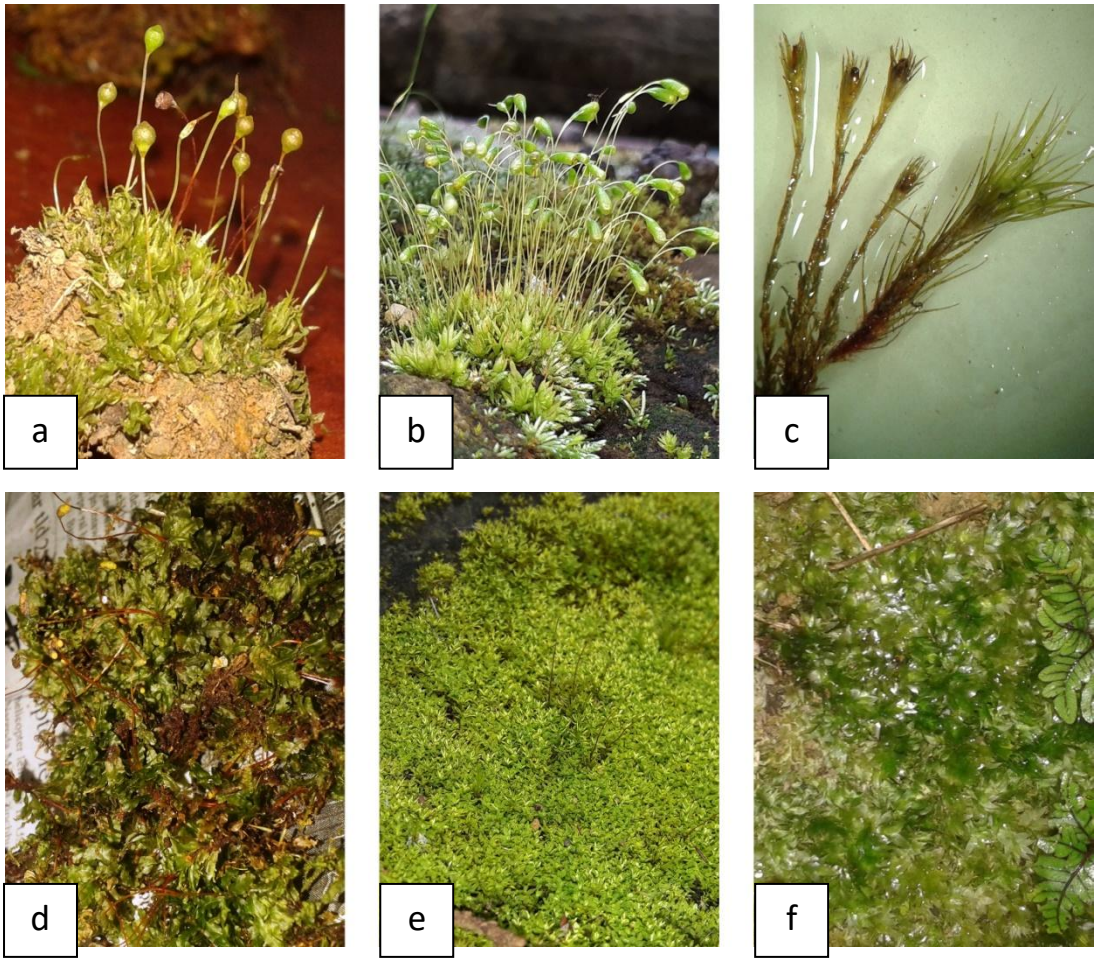


Photo Plate 8:

a. *Physcomitrium pyriforme* (Hedw.) Hampe

b. *Funaria hygrometrica* Hedw.

c. *Garckea flexuosa* (Griff.) Margad. & Nork.

d. *Plagiomnium rostratum* (Schrad.) T.J. Kop.

e. *Hyophila involuta* (Hook.) A. Jaeger

f. *Hookeria acutifolia* Hook. & Grev.

Photo Plate 9:

a. *Rhodobryum giganteum* (Schwägr.) Paris

b. *Schoenobryum concavifolium* (Griff.) Gangulee

c. *Brachymenium nepalense* Hook.

d. *Tayloria hornschuchii* (Grev. & Arn.) Broth.

e. *Solmsiella biseriata* (Austin) Steere

f. *Racopilum cuspidigerum* (Schwägr.) Ångström

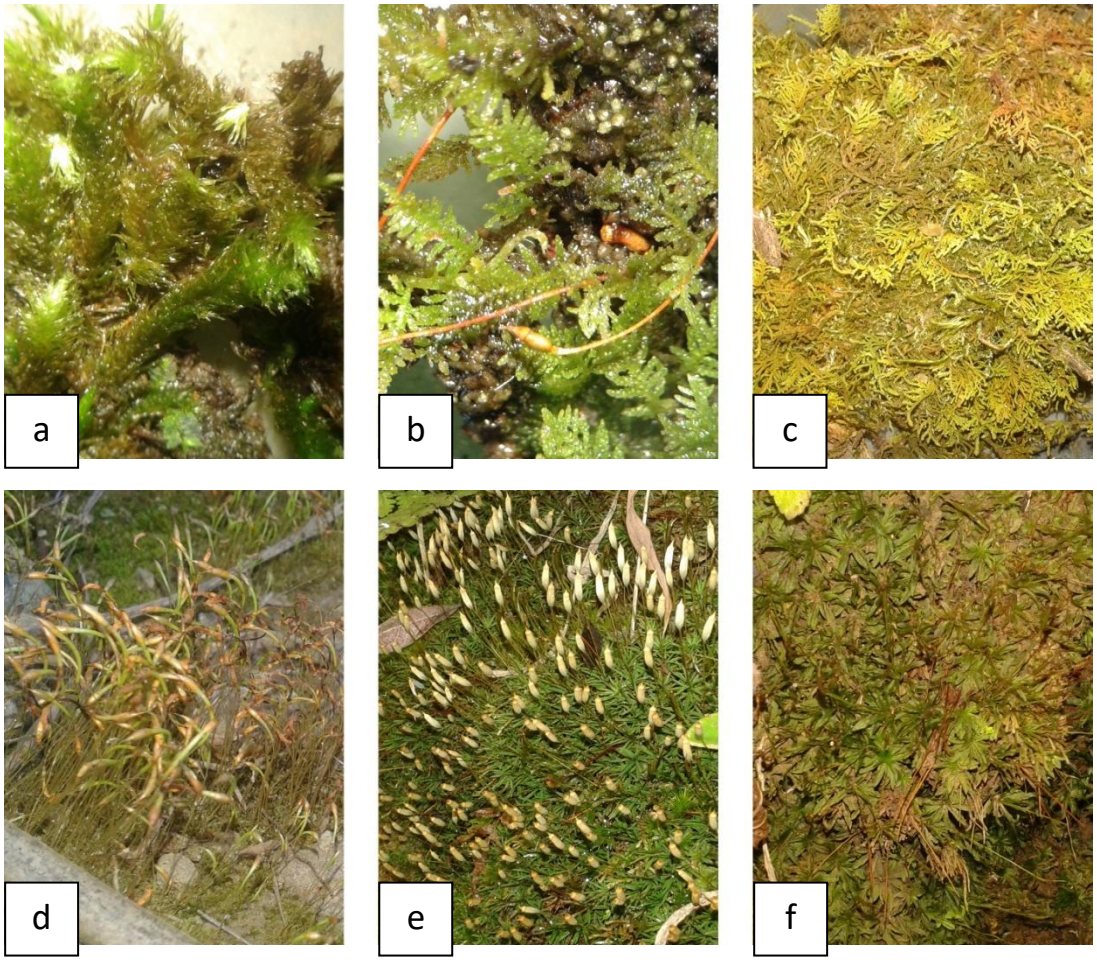


Photo Plate 10:

a. *Trachypodopsis serrulata* (P. Beauv.) M. Fleisch.

b. *Thuidium delicatulum* (Hedw.) Schimp.

c. *Thuidium tamariscinum* (Hedw.) Schimp.

d. *Trematodon longicollis* Michx.

e. *Pogonatum neesii* (Müll. Hal.) Dozy

f. *Atrichum undulatum* (Hedw.) P. Beauv.

Table 1. Lists of documented Bryophyte species with family, accession number and comparative distribution in the study sites.

Family	Species	Accession Number	MNP	DTR	TWS	TTWS
Bartramiaceae	*Bartramia brevifolia* Brid.	MZU/Bot/Bryo-064	+	+	+	+
	Philonotis fontana (Hedw.) Brid.	MZU/Bot/Bryo-063	+	+	+	+
Brachytheciaceae	*Brachythecium plumosum* (Hedw.) Schimp.	MZU/Bot/Bryo-059	+	+	+	+
	Eurhynchium riparioides (Hedw.) P.W. Richards	MZU/Bot/Bryo-060	+	+	+	+
	Homalothecium sericeum (Hedw.) Schimp.	MZU/Bot/Bryo-062	+	+	+	+
	Rhynchostegiella menadensis (Sande Lac.) E.B. Bartram	MZU/Bot/Bryo-061	+	+	+	+
	Rhynchostegium riparioides (Hedw.) Cardot	MZU/Bot/Bryo-054	+	+	+	+
Bruchiaceae	*Trematodon longicollis* Michx.	MZU/Bot/Bryo-094	+	+	+	+

Bryaceae	*Anomobryum filiforme* var. *concinnatum* (Spruce) Loeske	MZU/Bot/Bryo-001	+	+	+	+
	Brachymenium exile (Dozy & Molk.) Bosch & Sande Lac.	MZU/Bot/Bryo-002	+	+	+	+
	Brachymenium nepalense Hook.	MZU/Bot/Bryo-003	+	+	+	+
	Bryum alpinum Huds. ex With.	MZU/Bot/Bryo-010	+	-	+	-
	Bryum apiculatum Schwägr	MZU/Bot/Bryo-004	+	+	+	+
	Bryum argenteum Hedw.	MZU/Bot/Bryo-006	+	+	+	+
	Bryum cellulare Hook.	MZU/Bot/Bryo-005	+	+	+	+
	Bryum coronatum Schwägr.	MZU/Bot/Bryo-007	+	+	+	+
	Bryum pseudotriquetrum (Hedw.) P. Gaertn., B. Mey. & Scherb.	MZU/Bot/Bryo-013	-	+	+	+

	Bryum uliginosum (Brid.) Bruch & Schimp.	MZU/Bot/Bryo-014	+	+	+	+
	Rhodobryum giganteum (Schwägr.) Paris	MZU/Bot/Bryo-009	+	+	+	-
	Rhodobryum roseum (Hedw.) Limpr.	MZU/Bot/Bryo-011	+	+	-	-
Cryphaeaceae	*Schoenobryum concavifolium* (Griff.) Gangulee	MZU/Bot/Bryo-074	+	-	-	+
Daltoniaceae	*Cyathophorella tonkinensis* (Broth. & Paris) Broth.	MZU/Bot/Bryo-086	+	-	+	-
Dicranaceae	*Campylopodiella stenocarpa* (Wilson) P. Muell. & J.-P. Frahm	MZU/Bot/Bryo-015	-	+	-	+
	Campylopus ericoides (Griff.) A. Jaeger	MZU/Bot/Bryo-019	+	+	+	+
	Campylopus fragilis (Brid.) Bruch & Schimp.	MZU/Bot/Bryo-016	+	+	+	+
	Campylopus introflexus (Hedw.) Brid.	MZU/Bot/Bryo-017	+	+	+	+

	Campylopus richardii Brid.	MZU/Bot/Bryo-018	+	+	-	+
	Dicranum flagellare Hedw.	MZU/Bot/Bryo-020	+	-	+	+
	Dicranum scoparium Hedw.	MZU/Bot/Bryo-021	+	-	-	-
	Leucobryum aduncum Dozy & Molk.	MZU/Bot/Bryo-023	+	+	-	+
	Leucobryum glaucum (Hedw.) Ångstr.	MZU/Bot/Bryo-024	+	+	+	+
	Leucobryum humillimum Cardot	MZU/Bot/Bryo-025	+	+	+	+
	Leucobryum javense (Brid.) Mitt.	MZU/Bot/Bryo-022	+	+	+	+
Ditrichaceae	*Garckea flexuosa* (Griff.) Margad. & Nork.	MZU/Bot/Bryo-098	+	+	+	+
Entodontaceae	*Erythrodontium julaceum* (Hook. ex Schwägr.) Paris	MZU/Bot/Bryo-087	+	+	+	+
Erpodiaceae	*Erpodium mangiferae* Müll. Hal.	MZU/Bot/Bryo-081	+	-	+	-

	Solmsiella biseriata (Austin) Steere	MZU/Bot/Bryo-082	-	-	+	-
Fabroniaceae	*Fabronia assamica* Dixon	MZU/Bot/Bryo-088	+	+	-	-
Fissidentaceae	*Fissidens bryoides* Hedw.	MZU/Bot/Bryo-029	+	+	+	+
	Fissidens taxifolius Hedw.	MZU/Bot/Bryo-027	+	+	+	+
	Fissidens virens Thwaites & Mitt.	MZU/Bot/Bryo-026	+	+	-	-
	Fissidens zollingeri Mont.	MZU/Bot/Bryo-028	+	+	+	+
Funariaceae	*Entosthodon wichurae* M. Fleisch.	MZU/Bot/Bryo-050	+	-	+	-
	Funaria hygrometrica Hedw.	MZU/Bot/Bryo-051	+	+	+	+
	Physcomitrium pyriforme (Hedw.) Hampe	MZU/Bot/Bryo-053	+	+	+	+
	Physcomitrium sphaericum (C.F. Ludw.) Fürnr.	MZU/Bot/Bryo-052	+	+	+	+

Hookericeae	*Hookeria acutifolia* Hook. & Grev.	MZU/Bot/Bryo-069	+	-	-	-
	Hookeriopsis utacamundiana (Mont.) Broth.	MZU/Bot/Bryo-070	+	-	+	-
Hylocomiaceae	*Macrothamnium macrocarpum* (Reinw. & Hornsch.) M. Fleisch.	MZU/Bot/Bryo-089	+	-	-	-
Hypnaceae	*Hypnum cupressiforme* Hedw.	MZU/Bot/Bryo-078	+	+	+	+
Hypopterygiaceae	*Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hal.	MZU/Bot/Bryo-099	+	-	-	-
Leskeaceae	*Duthiella declinata* (Mitt.) Zanten	MZU/Bot/Bryo-079	+	+	+	+
	Duthiella wallichii (Mitt.) Müll. Hal.	MZU/Bot/Bryo-101	+	+	+	+
	Leskea gracilescens Hedw.	MZU/Bot/Bryo-075	+	+	+	+
Leucodontaceae	*Forsstroemia indica* (Mont.) Paris	MZU/Bot/Bryo-036	+	+	+	+

	Leucodon julaceus (Hedw.) Sull.	MZU/Bot/Bryo-100	+	+	+	+
Meteoriaceae	*Meteorium buchananii* (Brid.) Broth.	MZU/Bot/Bryo-057	+	+	+	+
	Meteoriopsis reclinata (Müll. Hal.) M. Fleisch.	MZU/Bot/Bryo-055	+	+	+	+
	Meteoriopsis squarrosa (Hook. ex Harv.) M. Fleisch.	MZU/Bot/Bryo-056	+	+	+	+
	Papillaria leuconeura (Müll. Hal.) A. Jaeger	MZU/Bot/Bryo-058	+	+	+	+
Mniaceae	*Plagiomnium ellipticum* (Brid.) T.J. Kop.	MZU/Bot/Bryo-073	+	+	+	+
	Plagiomnium rostratum (Schrad.) T.J. Kop.	MZU/Bot/Bryo-072	+	+	+	+
	Plagiomnium succulentum (Mitt.) T.J. Kop.	MZU/Bot/Bryo-071	+	+	+	+
Myuriaceae	*Myurium rufescens* (Reinw. & Hornsch.) M. Fleisch.	MZU/Bot/Bryo-090	-	+	-	-

Neckeraceae	*Homaliodendron flabellatum* (Sm.) M. Fleisch.	MZU/Bot/Bryo-030	+	+	+	+
	Homaliodendron microdendron (Mont.) M. Fleisch.	MZU/Bot/Bryo-031	+	+	+	+
	Neckera pennata Hedw.	MZU/Bot/Bryo-032	+	-	+	-
	Neckeropsis crinita (Griff.) M. Fleisch.	MZU/Bot/Bryo-033	+	-	-	-
	Neckeropsis exserta (Hook. ex Schwägr.) Broth.	MZU/Bot/Bryo-035	+	-	-	-
	Neckeropsis semperiana (Hampe) A. Touw	MZU/Bot/Bryo-034	+	+	+	-
Octoblepharaceae	*Octoblepharum albidum* Hedw.	MZU/Bot/Bryo-091	+	+	+	+
Orthotrichaceae	*Groutiella goniorrhyncha* (Dozy & Molk.) E.B. Bartram	MZU/Bot/Bryo-066	+	+	+	+
	Macromitrium nepalense (Hook. & Grev.) Schwägr.	MZU/Bot/Bryo-068	+	+	+	+

	Macromitrium sulcatum (Hook.) Brid.	MZU/Bot/Bryo-067	+	+	+	+
Plagiotheciaceae	*Plagiothecium neckeroideum* Schimp.	MZU/Bot/Bryo-080	+	+	+	-
	Pseudotaxiphyllum elegans (Brid.) Z. Iwats.	MZU/Bot/Bryo-083	+	-	+	-
Polytrichaceae	*Atrichum undulatum* (Hedw.) P. Beauv.	MZU/Bot/Bryo-041	+	+	+	+
	Pogonatum aloides (Hedw.) P. Beauv.	MZU/Bot/Bryo-042	+	+	+	+
	Pogonatum contortum (Menzies ex Brid.) Lesq.	MZU/Bot/Bryo-008	+	+	+	+
	Pogonatum microstomum (R. Br. ex Schwägr.) Brid.	MZU/Bot/Bryo-012	+	+	+	+
	Pogonatum neesii (Müll. Hal.) Dozy	MZU/Bot/Bryo-043	+	+	+	+
	Pogonatum proliferum (Griff.) Mitt.	MZU/Bot/Bryo-044	-	-	-	+
Pottiaceae	*Barbula indica* (Hook.) Spreng.	MZU/Bot/Bryo-085	+	+	+	+

	Hyophila involuta (Hook.) A. Jaeger	MZU/Bot/Bryo-084	+	+	+	+
	Pohlia cruda (Hedw.) Lindb.	MZU/Bot/Bryo-065	+	+	+	+
Pterobryaceae	*Pterobryopsis acuminata* (Hook.) M. Fleisch.	MZU/Bot/Bryo-092	+	+	+	+
Pterigynandraceae	*Trachyphyllum inflexum* (Harv.) A. Gepp	MZU/Bot/Bryo-095	+	+	+	+
Racopilaceae	*Racopilum cuspidigerum* (Schwägr.) Ångström	MZU/Bot/Bryo-093	+	+	+	+
Rhizogoniaceae	*Pyrrhobryum spiniforme* (Hedw.) Mitt.	MZU/Bot/Bryo-038	+	+	+	+
	Rhizogonium spiniforme (Hedw.) Bruch	MZU/Bot/Bryo-102	+	+	+	+
Sematophyllaceae	*Radulina hamata* (Dozy & Molk.) W.R. Buck & B.C. Tan	MZU/Bot/Bryo-039	+	+	+	-
	Sematophyllum subhumile (Müll. Hal.) M. Fleisch.	MZU/Bot/Bryo-037	+	+	+	+

	Wijkia tanytricha (Mont.) H.A. Crum	MZU/Bot/Bryo-040	+	+	+	-
Splachnaceae	*Tayloria hornschuchii* (Grev. & Arn.) Broth.	MZU/Bot/Bryo-096	-	-	+	-
Stereophyllaceae	*Stereophyllum anceps* (Bosch & Sande Lac.) Broth.	MZU/Bot/Bryo-097	+	+	-	+
Thuidiaceae	*Pelekium bifarium* (Bosch & Sande Lac.) M. Fleisch.	MZU/Bot/Bryo-045	+	+	+	+
	Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk.	MZU/Bot/Bryo-049	+	+	+	+
	Thuidium delicatulum (Hedw.) Schimp.	MZU/Bot/Bryo-047	+	+	+	+
	Thuidium pristocalyx (Müll. Hal.) A. Jaeger	MZU/Bot/Bryo-046	+	+	+	+
	Thuidium tamariscinum (Hedw.) Schimp.	MZU/Bot/Bryo-048	+	+	+	+
Trachypodaceae	*Trachypodopsis serrulata* (P. Beauv.) M. Fleisch.	MZU/Bot/Bryo-076	+	+	+	+

	Trachypus bicolor Reinw. & Hornsch.	MZU/Bot/Bryo-077	+	+	+	+
Aneuraceae	*Aneura pinguis* (L.) Dumort.	MZU/Bot/Bryo-130	-	+	+	-
	Riccardia chamedryfolia (With.) Grolle	MZU/Bot/Bryo-131	+	-	+	-
Aytoniaceae	*Asterella angusta* (Stephani) Pandé, K.P. Srivast. & Sultan Khan	MZU/Bot/Bryo-103	+	+	+	+
	Asterella khasiana (Griff.) Grolle	MZU/Bot/Bryo-104	+	+	+	+
	Plagiochasma appendiculatum Lehm. & Lindenb.	MZU/Bot/Bryo-106	+	+	+	+
	Reboulia hemisphaerica (L.) Raddi	MZU/Bot/Bryo-105	+	+	+	+
Calypogeiaceae	*Calypogeia arguta* Nees & Mont. ex Nees	MZU/Bot/Bryo-143	+	-	+	-
Cephaloziellaceae	*Cephaloziella divaricata* (Sm.) Warnst.	MZU/Bot/Bryo-145	+	+	+	-

Fossombroniaceae	*Fossombronia himalayensis* Kashyap	MZU/Bot/Bryo-133	+	-	+	-
	Fossombronia indica Stephani	MZU/Bot/Bryo-111	+	-	+	-
	Fossombronia pusilla (L.) Dumort.	MZU/Bot/Bryo-132	+	-	+	-
Jubulaceae	*Frullania acutiloba* Mitt.	MZU/Bot/Bryo-114	-	+	-	+
	Frullania dilatata (L.) Dumort.	MZU/Bot/Bryo-115	+	+	+	+
	Frullania ericoides (Nees ex Mart.) Mont.	MZU/Bot/Bryo-113	+	+	+	+
	Frullania retusa Mitt.	MZU/Bot/Bryo-112	+	+	+	+
	Frullania tamarisci (L.) Dumort.	MZU/Bot/Bryo-116	+	+	+	+
	Jubula complanata (L.) Corda	MZU/Bot/Bryo-117	+	+	+	+
Jungermanniaceae	*Jungermannia appressifolia* Mitt.	MZU/Bot/Bryo-134	+	+	+	+

	Jungermannia macrocarpa Stephani	MZU/Bot/Bryo-135	+	+	+	+
Lejeuneaceae	*Lejeunea cavifolia* (Ehrh.) Lindb.	MZU/Bot/Bryo-122	+	+	+	+
	Lejeunea flava (Sw.) Nees	MZU/Bot/Bryo-124	+	-	+	+
	Lopholejeunea abortiva (Mitt.) Stephani	MZU/Bot/Bryo-151	+	+	+	+
	Lopholejeunea indica Udar & U.S. Awasthi	MZU/Bot/Bryo-125	+	+	+	+
	Ptychanthus striatus (Lehm. & Lindenb.) Nees	MZU/Bot/Bryo-123	+	+	+	+
	Trocholejeunea sandvicensis Mizut.	MZU/Bot/Bryo-126	+	-	-	-
Lepidoziaceae	*Bazzania tridens* (Reinw., Blume & Nees) Trevis.	MZU/Bot/Bryo-140	-	-	-	+
Lophocoleaceae	*Lophocolea bidentata* (L.) Dumort.	MZU/Bot/Bryo-147	-	+	+	+
Marchantiaceae	*Dumortiera hirsuta* (Sw.) Nees	MZU/Bot/Bryo-139	+	+	+	+

	Marchantia emarginata Reinw., Blume & Nees	MZU/Bot/Bryo-120	+	+	+	+
	Marchantia linearis Lehm. & Lindenb.	MZU/Bot/Bryo-121	+	+	+	+
	Marchantia paleacea Bertol.	MZU/Bot/Bryo-118	-	-	+	+
	Marchantia papillata Raddi	MZU/Bot/Bryo-119	+	+	+	+
Metzgeriaceae	*Metzgeria conjugata* Lindb.	MZU/Bot/Bryo-138	+	+	+	+
Pallaviciniaceae	*Pallavicinia lyellii* (Hook.) Gray	MZU/Bot/Bryo-141	+	+	+	+
Pelliaceae	*Pellia epiphylla* (L.) Corda	MZU/Bot/Bryo-142	+	+	+	+
Plagiochilaceae	*Plagiochila asplenioides* (L.) Dumort.	MZU/Bot/Bryo-127	+	+	+	+
	Plagiochila chinensis Stephani	MZU/Bot/Bryo-128	+	+	+	+
	Plagiochila fruticosa Mitt.	MZU/Bot/Bryo-129	+	+	+	+

Porellaceae	*Porella campylophylla* (Lehm. & Lindenb.) Trevis.	MZU/Bot/Bryo-144	+	+	+	+
Radulaceae	*Radula javanica* Gottsche	MZU/Bot/Bryo-146	+	+	+	-
Ricciaceae	*Riccia discolor* Lehm. & Lindenb.	MZU/Bot/Bryo-110	+	+	+	+
	Riccia fluitans L.	MZU/Bot/Bryo-107	+	-	+	-
	Riccia glauca L.	MZU/Bot/Bryo-108	+	-	+	-
	Riccia huebeneriana Lindenb.	MZU/Bot/Bryo-109	+	+	+	+
Targioniaceae	*Cyathodium cavernarum* Kunze	MZU/Bot/Bryo-136	+	+	+	+
	Targionia hypophylla L.	MZU/Bot/Bryo-137	+	+	+	+
Anthocerotaceae	*Anthoceros angustus* Stephani	MZU/Bot/Bryo-148	+	+	+	+
	Anthoceros erectus Kashyap	MZU/Bot/Bryo-149	+	+	+	+

	Phaeoceros laevis (L.) Prosk.	MZU/Bot/Bryo-150	+	+	+	+

MNP = Murlen National Park; DTR = Dampa Tiger Reserve; TWS = Tawi Wildlife Sanctuary; TTWS = Thorangtlang Wildlife Sanctuary; + = Present; - = Absent.

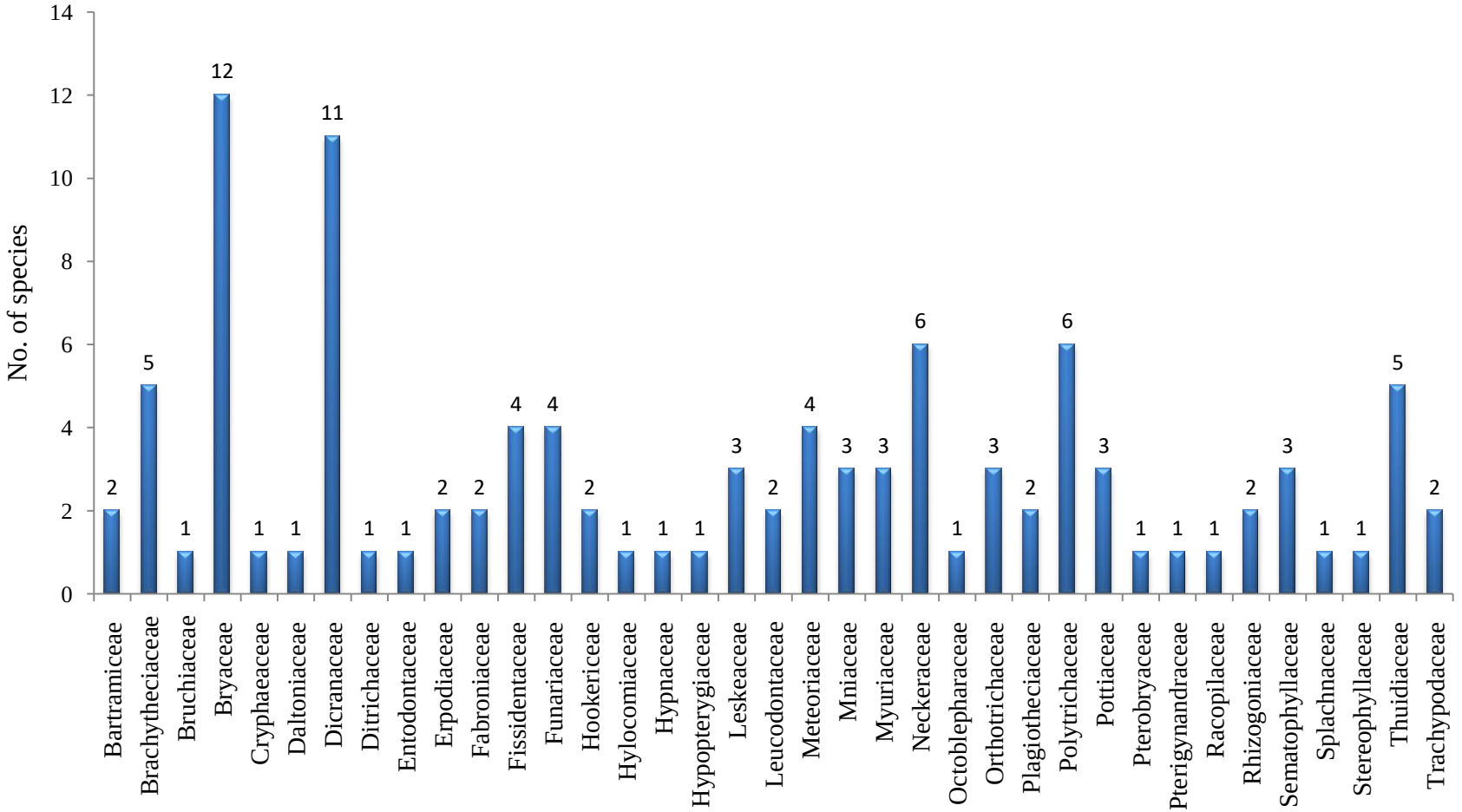


Figure 5. Distribution of Moss species in different families.

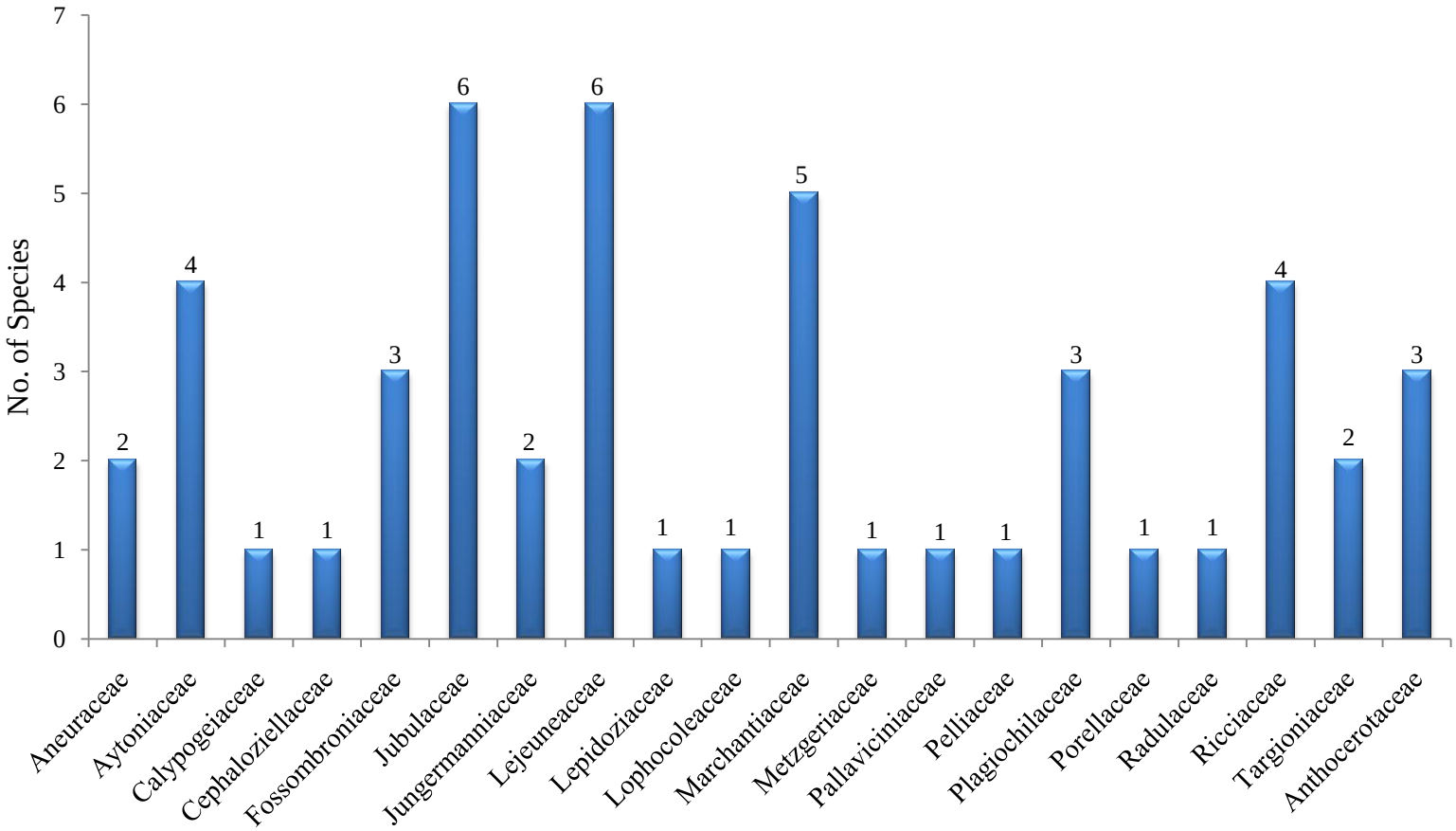


Figure 5.1. Distribution of Liverwort and Hornwort species in different families.

Table 2. Floristic analysis of Bryophyte flora of the selected study sites.

Study Site	No. of Families	No. of Genera	No. of Species
Murlen National Park	51	91	140
Dampa Tiger Reserve	46	80	122
Tawi Wildlife Sanctuary	49	88	132
Thorangtlang Wildlife Sanctuary	43	73	116

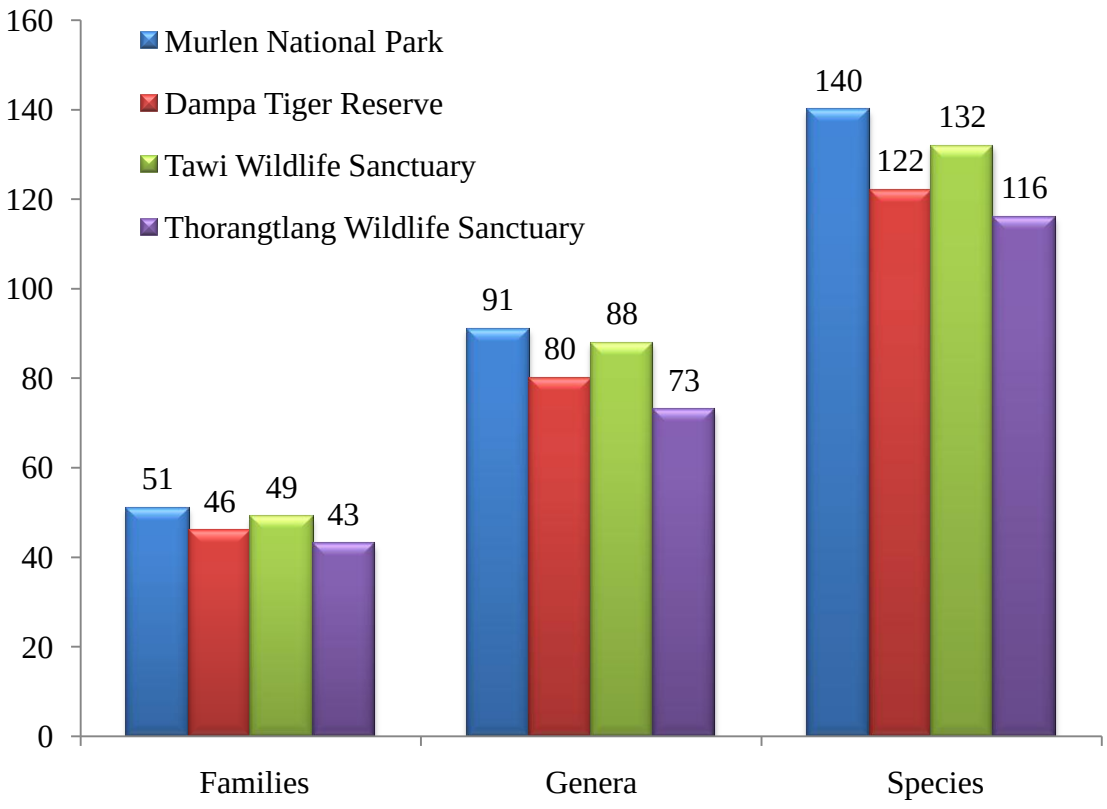


Figure 5.2. Distribution of Bryophyte species in the study sites.

5.2. Phytochemicals Screening of methanolic extracts of selected species

The crude extracts of selected species *Atrichum undulatum*, *Pogonatum neesii*, *Dumortiera hirsuta* and *Marchantia linearis* were analysed for the presence of various phytochemicals such as: alkaloids, flavonoids, tannins, phenols, terpenoids, steroids and saponins by standard methods (Harborne, 1973; Trease and Evans, 1989) and the results are given in the table 4.

Table 3. Phytochemicals screening of methanolic extracts of selected species.

Phytochemicals	***Atrichum undulatum***	***Pogonatum neesii***	***Dumortiera hirsuta***	***Marchantia linearis***
Alkaloids	-	-	+	+
Flavonoids	+	+	+	+
Phenols	+	+	+	+
Saponins	-	-	+	-
Steroids	+	+	+	+
Tannins	+	+	-	-
Terpenoids	+	+	+	+

+ = Present; - = Absent

5.3. Determination of Antioxidant activity of methanolic extract of selected species using DPPH.

Table 4. DPPH radical scavenging activity of BHT.

Concentration (µg/ml)	Percentage of Inhibition, I (%)	IC50 (µg/ml)
10	30.05	
20	37.86	
40	48.42	
		42.20
60	62.84	
80	70.65	
100	83.35	

Table 4.1. DPPH radical scavenging activity of methanolic extracts of *Atrichum undulatum*.

Concentration (µg/ml)	Percentage of Inhibition, I (%)	IC50 (µg/ml)
10	2.35	
20	7.41	

40	15.93	113.235
60	26.49	
80	30.05	
100	46.90	

Table 4.2. DPPH radical scavenging activity of methanolic extracts of *Pogonatum neesii*.

Concentration (µg/ml)	Percentage of Inhibition, I (%)	IC50 (µg/ml)
10	10.152	
20	16.345	
40	26.395	95.011
60	39.492	
80	41.015	
100	51.065	

Table 4.3. DPPH radical scavenging activity of methanolic extracts of *Dumortiera hirsuta*.

Concentration (µg/ml)	Percentage of Inhibition, I (%)	IC50 (µg/ml)
10	18.578	
20	23.654	
40	39.695	63.831
60	54.01	
80	59.796	
100	67.005	

Table 4.4. DPPH radical scavenging activity of methanolic extracts of *Marchantia linearis*.

Concentration (µg/ml)	Percentage of Inhibition, I (%)	IC50 (µg/ml)
10	16.345	
20	20.609	
40	28.730	81.818

60	38.984
80	46.395
100	61.624

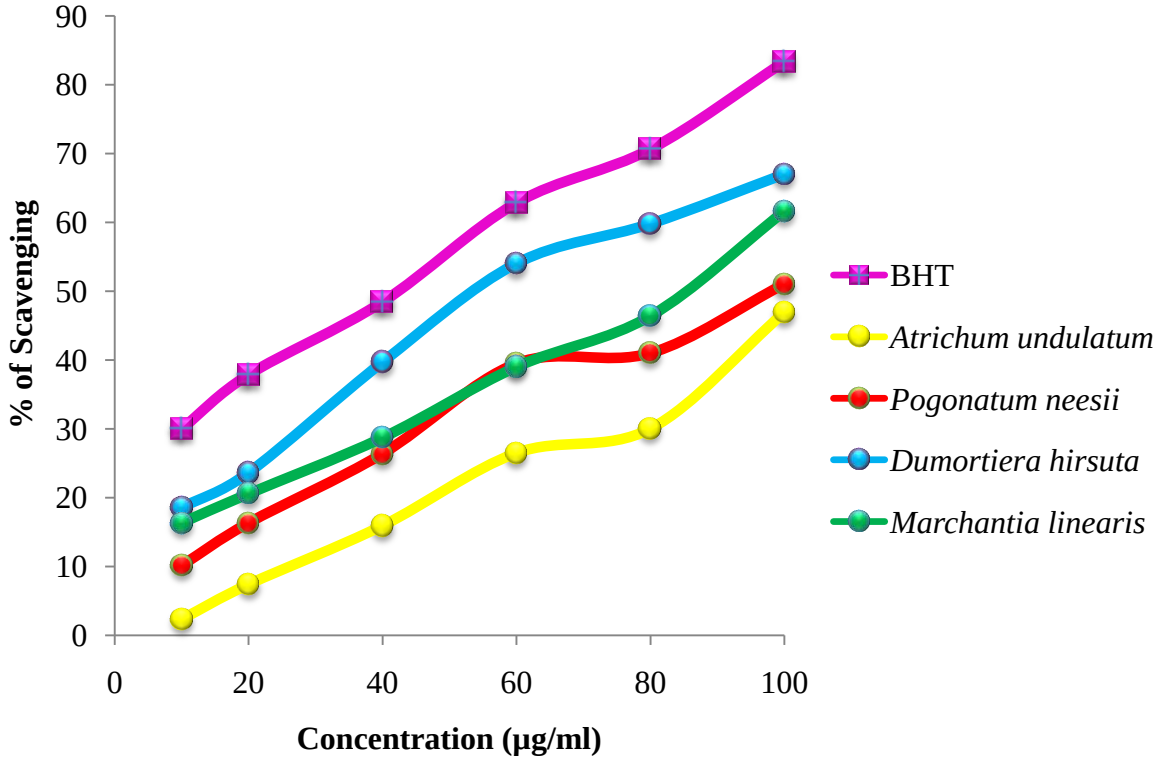


Figure 6. DPPH scavenging activity of BHT and Methanolic extracts of selected species

5.4. Antibacterial activity of crude extracts of the selected species

Antibacterial activity of methanolic extracts of the selected species was tested against pathogenic bacteria *Bacillus subtilis* (ATCC-11774), *Escherichia coli* (ATCC-10536) and *Klebsiella pneumoniae* (ATCC-10031) using Agar well diffusion assay method (Murray *et al*., 1995; Olurinola, 1996). The diameters of inhibition zone were measured and the results were expressed as mean ± SD of three replicates. The data were subjected to ANOVA using SPSS programme. P value ≤0.05 were regard as significant. The maximum inhibition zone 23 mm diameter was shown by the positive control against *Escherichia coli*. Among the selected species the crude extract of *Dumortiera hirsuta* has the highest antibacterial activity against *Klebsiella pneumonia*e with 18 mm diameter of inhibition zone. The crude extracts of *Atrichum undulatum* and *Pogonatum neesii* exhibited the least activity against *Bacillus subtilis* having 9 mm diameter of inhibition zone.

Table 5. Antibacterial activity of methanolic extract of *Atrichum undulatum*.

Concentration (mg/ml)	**Diameter of inhibition zone in mm**		
	***Klebsiella pneumoniae* (ATCC - 10031)**	***Escherichia coli* (ATCC - 10536)**	***Bacillus subtilis* (ATCC - 11774)**
10	10±0.04	10±0.08	9±0.28
30	12±0.96	12±0.01	11±0.20
50	15±0.72	14±0.52	13±0.06
Control	22±0.45	23±0.73	22±0.45

Table 5.1. One way analysis of variance (ANOVA) of antibacterial activity of methanolic extracts of *Atrichum undulatum* at CTRL, 10 mg/ml, 30 mg/ml and 50 mg/ml. * denotes significant at p≤0.05.

Parameters	Source of Variance	F	p-value
Klebsiella pneumoniae	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	5.392	0.025*
Escherichia coli	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	5.762	0.021*
Bacillus subtilis	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	4.594	0.038*

Table 6. Antibacterial activity of methanolic extract of *Pogonatum Neesii.*

Concentration (mg/ml)	Diameter of inhibition zone in mm		
	Klebsiella pneumoniae **(ATCC - 10031)**	***Escherichia coli*** **(ATCC - 10536)**	***Bacillus subtilis*** **(ATCC - 11774)**
10	10±0.38	10±0.03	9±0.18
30	12±0.60	12±0.96	12±0.10
50	15±0.75	14±0.76	14±0.98
Control	22±0.45	23±0.73	22±0.45

Table 6.1. One way analysis of variance (ANOVA) of antibacterial activity of methanolic extracts of *Pogonatum Neesii* at CTRL, 10 mg/ml, 30 mg/ml and 50 mg/ml. * denotes significant at p≤0.05.

Parameters	Source of Variance	F	p-value
Klebsiella pneumoniae	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	6.324	0.017*
Escherichia coli	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	6.696	0.014*
Bacillus subtilis	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	4.642	0.037*

Table 7. Antibacterial activity of methanolic extract of *Dumortiera hirsuta.*

Concentration (mg/ml)	Diameter of inhibition zone in mm		
	***Klebsiella pneumoniae* (ATCC - 10031)**	***Escherichia coli* (ATCC - 10536)**	***Bacillus subtilis* (ATCC - 11774)**
10	11±0.87	10±0.97	11±0.05
30	13±0.88	12±0.90	13±0.95
50	18±0.22	17±0.16	17±0.31
Control	22±0.45	23±0.73	22±0.45

Table 7.1. One way analysis of variance (ANOVA) of antibacterial activity of methanolic extracts of *Dumortiera hirsuta* at CTRL, 10 mg/ml, 30 mg/ml and 50 mg/ml. * denotes significant at p≤0.05.

Parameters	Source of Variance	F	p-value
Klebsiella pneumoniae	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	7.108	0.012*
Escherichia coli	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	7.315	0.011*
Bacillus subtilis	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	6.390	0.016*

Table 8. Antibacterial activity of methanolic extract of *Marchantia linearis.*

Concentration (mg/ml)	Diameter of inhibition zone in mm		
	Klebsiella pneumoniae **(ATCC - 10031)**	***Escherichia coli*** **(ATCC - 10536)**	***Bacillus subtilis*** **(ATCC - 11774)**
10	10±0.90	10±0.82	11±0.31
30	13±0.77	11±0.31	12±0.02
50	17±0.38	14±0.71	15±0.90
Control	22±0.45	23±0.73	22±0.45

Table 8.1. One way analysis of variance (ANOVA) of antibacterial activity of methanolic extracts of *Marchantia linearis* at CTRL, 10 mg/ml, 30 mg/ml and 50 mg/ml. * denotes significant at p≤0.05.

Parameters	Source of Variance	F	p-value
Klebsiella pneumoniae	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	7.440	0.011*
Escherichia coli	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	6.991	0.013*
Bacillus subtilis	CTRL x 10 mg/ml x 30 mg/ml x 50 mg/ml	4.267	0.045*

5.5. Discussion

In this present study 151 species were documented and they belong to 98 genera and 57 families in Mizoram. Of these, the mosses were represented by 102 species of 68 genera and 37 families, while Liverworts were represented by 46 species of 28 genera and 19 families. Hornworts were represented by 3 species of 2 genera and 1 family. The most dominant family was Bryaceae having a total of 12 species followed by Dicranaceae with 11 species. The other dominant families were Jubulaceae, Lejeuneaceae, Neckeraceae and Polytrichaceae having 6 species each, followed by Marchantiaceae, Brachytheciaceae, Thuidiaceae with 5 species each; Aytoniaceae, Ricciaceae, Fissidentaceae, Funariaceae and Meteoriaceae with 4 species each; Anthocerotaceae, Plagiochilaceae, Leskeaceae, Mniaceae, Orthotrichaceae, Pottiaceae, Sematophyllaceae and Fossombroniaceae with 3 species each; Aneuraceae, Jungermanniaceae, Targioniaceae, Bartramiaceae, Erpodiaceae, Hookeriaceae, Leucodontaceae, Plagiotheciaceae, Rhizogoniaceae, and

Trachypodaceae with 2 species each. All the other families have only 1 species each (Table no. 1).

Among the selected study sites Murlen National Park harbours the highest Bryophyte diversity having 140 different species in 91 genera and 51 familes (Table2). *Dicranum scoparium, Hookeria acutifolia, Macrothamnium macrocarpum, Hypopterygium tamarisci, Neckeropsis crinita, Neckeropsis exserta* and *Trocholejeunea sandvicensis* occur only in Murlen National Park. A total of 122 species belonging to 80 genera and 46 families were collected from Dampa Tiger Reserve and *Myurium rufescens* occurs only in this site. From Tawi Wildlife Sanctuary a total of 132 species belonging to 88 genera and 49 families were collected; *Tayloria hornschuchii* and *Solmsiella biseriata* occur in this site only. Thorangtlang Wildlife Sanctuary harbours the least number of Bryophyte in terms of diversity, a total of 116 species belonging to 73 genera and 43 families were collected from here. *Pogonatum proliferum* and *Bazzania tridens* occur in this site only.

Table 9. Bryophyte species showing specific distribution in the study sites.

Site	Species	Family
TWS	*Dicranum scoparium* Hedw.	Dicranaceae
	Hookeria acutifolia Hook. & Grev.	Hookeriaceae
	Hypopterygium tamarisci (Sw.) Brid. ex Müll. Hal.	Hypopterygiaceae
	Macrothamnium macrocarpum (Reinw. & Hornsch.) M. Fleisch.	Hylocomiaceae
	Neckeropsis crinita (Griff.) M. Fleisch.	Neckeraceae
	Neckeropsis exserta (Hook. ex Schwägr.) Broth.	

	Trocholejeunea sandvicensis Mizut.	Lejeuneaceae
DTR	*Myurium rufescens* (Reinw. & Hornsch.) M. Fleisch.	Myuriaceae
TWS	*Solmsiella biseriata* (Austin) Steere	Erpodiaceae
	Tayloria hornschuchii (Grev. & Arn.) Broth.	Splachnaceae
TTWS	*Bazzania tridens* (Reinw., Blume & Nees)	Lepidoziaceae
	Pogonatum proliferum (Griff.) Mitt.	Polytrichaceae

MNP = Murlen National Park; DTR = Dampa Tiger Reserve; TWS = Tawi Wildlife Sanctuary; TTWS = Thorangtlang Wildlife Sanctuary

Most of the Bryophyte species were common to all the selected sites except few species are present to two or three sites only. *Rhodobryum roseum, Fabronia assamica* and *Fissidens virens* were present at Murlen National Park and Dampa Tiger Reserve only. *Bryum alpinum, Riccia fluitans, Riccia glauca, Cyathophorella tonkinensis, Erpodium mangiferae, Entosthodon wichurae, Hookeriopsis utacamundiana, Neckera pennata, Pseudotaxiphyllum elegans, Riccardia chamedryfolia, Calypogeia arguta, Fossombronia himalayensis, Fossombronia indica* and *Fossombronia pusilla* were collected from Murlen National Park and Tawi Wildlife Sanctuary only. *Schoenobryum concavifolium* was present in Murlen National Park and Thorangtlang Wildlife Sanctuary only. *Aneura pinguis* was collected from Dampa Tiger Reserve and Tawi Wildlife Sanctuary only. *Campylopodiella stenocarpa* and *Frullania acutiloba* were collected from Dampa Tiger Reserve and Thorangtlang Wildlife Sanctuary only. *Marchantia paleacea* was identified from Tawi Wildlife Sanctuary and Thorangtlang Wildlife Sanctuary only. *Bryum pseudotriquetrum, Dicranum flagellare, Leucobryum aduncum, Rhodobryum giganteum, Neckeropsis semperiana,*

Plagiothecium neckeroideum, *Radulina hamata*, *Stereophyllum anceps*, *Wijkia tanytricha*, *Cephaloziella divaricata*, *Lejeunea flava*, *Radula javanica* and *Lophocolea bidentata* were found to be common in three selected sites.

Plants produce numerous secondary substances such as alkaloid, flavonoids, terpenoids, phenols, tannins, saponins, etc., which were responsible for the metabolic activities of the plants and in different mechanisms. Being poisonous and toxic, some phytochemicals like alkaloids protect the plants from the attack of various microorganisms like fungi, bacteria, insects, birds and other herbivorous animals. (Nikolajeva *et al*., 2012; Asakawa, 2007; Aruna and Krishnappa, 2018).

Several hundred compounds have been isolated from Byophytes and their structures have been elucidated (Asakawa, 1995, 1999, 2001). The secondary metabolites identified from Bryophytes include terpenoids, flavonoids, bibenzyls, and derivatives of fatty acids (Barel *et al*., 1993); acetophenols (Lorimer and Perry, 1993); aryl- benzofurans (Von Reusz and Konig, 2004).

The alkaloids have been associated with medicinal uses for centuries and one of their common biological properties was their cytotoxicity (Nobori *et al*., 1994). Flavonoids are hydroxylated phenolic substance known to be synthesized by plants in response to microbial infection and they have been found to be antimicrobial substances against wide array of microorganisms in vitro (Marjorie, 1996). The phenolic compounds are one of the largest and most ubiquitous groups of plant metabolites (Singh *et al*., 2007). Some of the characteristic of saponins include formation of foams in aqueous solutions, hemolytic activity, cholesterol binding properties and bitterness (Sodipo *et al*., 2000; Raquel, 2007). Phenols and steroids

were found responsible for anticancer activity (Li *et* al., 2003). Steroids have been reported to have antibacterial properties (Raquel, 2007). Tannins bind to proline rich protein and interfere with protein synthesis. Tannins were known to be useful in the treatment of inflamed or ulcerated tissues and they have remarkable activity in cancer prevention (Ruch *et al*., 1989; Motar *et al*., 1985). Terpenoids were known to have expectorant and antitussive activity. Steroids have been reported to possess anti-inflammation activities (Chawla *et al*., 1987).

Phytochemical screening revealed the presence of flavonoids, phenols, steroids and terpenoids in all the selected species. Alkaloids were present in *Marchantia linearis* and *Dumortiera hirsuta*; tannins were present in *Atrichum undulstum* and *Pogonatum neesii*, while saponins were present in *Dumortiera hirsuta* only. The alkaloids and tannins were antagonistic for each other hence they were not always found together in single plant (Bartholow, 2005).

Free radicals were involved in different disorders like ageing, cancer, cardiovascular disease, diabetes, rheumatoid arthritis, epilepsy and degradation of essential fatty acids (Singhal *et al*., 2011; Ben *et al*., 2011) The generation of free radical can bring about thousands of reactions and thus cause extensive tissue damage. Lipids, proteins and DNA were all susceptible to attack by free radicals. Antioxidants may offer resistance against oxidative stress by scavenging the free radicals. Superoxides were produced from molecular oxygen due to oxidative enzymes of body as well as via non-enzymatic reaction such as auto-oxidation (Hemmani and Parihar, 1998).

Antioxidative metabolites like polyphenols and flavonoids of plant origin were important for maintenance of health as well as prevention from various degenerative diseases (Benzie and Strain, 1996). They act as primary antioxidants and were known to react with free redicals to protect DNA from oxidative damage, inhibitory against tumor cell (Rice-Evans *et al*., 1996). Polyphenols scavenge free radicals such as peroxide, hydroperoxide or lipid peroxyl and inhibit the oxidative mechanisms that can lead to degenerative diseases (Xu-Dan, 2011). The reducing capacity of a compound may serve as a significant indicator of its potential antioxidant activity. However, the activities of antioxidants have been attributed to various mechanisms such as prevention of chain initiation, decomposition of peroxides, reducing capacity and radical scavenging (Khatun *et al*., 2011).

Antioxidant compounds with a good reducing power functions as good electron and hydrogen-atom donors and therefore be able to terminate radical chain reaction by converting free radicals and reactive oxygen species to more stable products (Sies, 1986).

According to DPPH radical scavenging activity results (Table 5-5.4), the IC50 value of BHT was 42.20 µg/ml having the highest antioxidant activity. Among the methanolic extracts of the selected species *Dumortiera hirsuta* had the highest antioxidant activity with an IC50 value of 63.83 µg/ml followed by *Marchantia linearis* with an IC50 value of 81.81 µg/ml and that of *Pogonatum neesii* was 95.01 µg/ml. The extract of *Atrichum undulatum* had the lowest activity with an IC50 value of 113.23 µg/ml.

The extracts of all the selected species exhibited antioxidant activity with the highest activity exhibiting inhibition of DPPH radical at 67.00% by *Dumortiera hirsuta* at a concentration of 100 µg/ml. The plant extracts contained compounds that were capable of donating hydrogen to a free radical in order to remove electrons responsible for radicals' reactivity. The efficacy of the extracts may be due to the presence of steroids, alkaloids, flavonoids and polyphenols in the methanolic extracts of the selected four species of Bryophytes.

Medicinal plants represent a rich source of antimicrobial agents and were used medicinally in different countries of the world and were a source of many potent and powerful drugs (Srivastava *et al*., 1996). Several species of Bryophyte were used in traditional medicine. Though they live in close contact with them they are not infected by bacteria and fungi since they possess phytochemicals which protect them from being attacked by these microorganisms.

An evaluation of literatures (Asakawa, 1981, 1984, 1988, 1990; Asakawa *et al*., 1976, 1980; Banerjee and Sen, 1979; Basile *et al*., 1999; Belcik and Weigner, 1980; Castaldo-Cobianchi *et al*., 1988; Dikshit *et al*., 1982; Gupta and Singh, 1971; Hayes, 1947; Hoof *et al*., 1981; Kamory *et al*., 1995; Lorimer and Perry, 1993, 1994; Madsen and pates, 1952; Matsuo *et al*., 1982; McCleary *et al*., 1960, 1966; Pavletic and Stilinovic, 1963; Wolters, 1964) showed antimicrobial effects of alcoholic and aqueous extracts of about 150 species of hepatics and mosses against gram positive and negative bacteria

The crude extracts of all the selected species had shown positive results against the tested pathogenic bacteria (Table 6-9.1). Among the selected four species

the crude extract of *Dumortiera hirsuta* has the highest antibacterial activity at a concentration of 50 mg/ml against *Klebsiella pneumoniae* with 18 mm diameter of inhibition zone, while the crude extracts of *Atrichum undulatum* and *Pogonatum neesii* exhibited the least activity against *Bacillus subtilis* having 9 mm diameter of inhibition zone at a concentration of 10 mg/ml. The antibacterial activity could be due to the presence of terpenoids (Toyota and Asakawa, 1999). The factors responsible for susceptibility of the bacteria to the extracts may be attributed to the presence of secondary plant metabolites which were soluble in the tested solvents and to the structural differences in the cell envelope compositions of the Gram negative and the Gram positive bacteria (Devi *et al*., 2009).

As a whole the selected two liverworts species *Dumortiera hirsuta* and *Marchantia linearis* have higher antibacterial activities compared to the selected two moss species *Atrichum undulatum* and *Pogonatum neesii.* The significant values of one way analysis of variance (ANOVA) also validated the efficacy of the crude extracts of the selected species in treating the tested bacteria.

SUMMARY AND CONCLUSION

Mizoram is located in the far northeastern part of India lying in between coordinates 21°56'N to 24°31'N latitude and 92°16'E to 93°26'E longitude. It has a climate ranging from moist tropical to moist sub-tropical and enjoys a moderate climate, it is neither too hot nor too cold and falls under tropical monsoon type of climate. The temperature ranges from 11°C to 24°C during winter and it varies from 18°C to 29°C during summer. The annual rainfall ranges from 2100 mm to 3500 mm. The region is influenced by south west monsoon and it usually rains from May to September. The study was confined to four districts of Mizoram i.e. Aizawl, Lunglei, Champhai and Mamit. The following protected areas were selected for study sites *viz*. Murlen National Park located in Champhai district, Dampa Tiger Reserve located in Mamit district, Tawi Wildlife Sanctuary located in Aizawl district and Thorangtlang Wildlife Sanctuary located in Lunglei District.

The collections of Bryophyte specimens were executed during May, 2014 - August, 2017. All the essential field data were noted with the help of GPS. The collected specimens of Bryophytes were placed in a handmade thick paper envelope having 10x14 cm in size with a field label data: altitude, collection number, date of collection, vegetation types, place of collection and associated habitats. The collected specimens were air-dried to avoid fungal damage.

The identifications of collected specimens were done at Central National Herbarium, Botanical Survey of India, Kolkata; Bryological Laboratory, National Botanical Research Institute, Lucknow, BSI, Shillong and Laboratory of Ecology

and Biodiversity, MZU. The collected specimens were studied carefully with microscopes, identified and described morphologically by their diagnostic characters. The identified species were described with the help of available literatures**,** given accession numbers and deposited to Laboratory of Ecology and Biodiversity, Department of Botany, School of Life Science, Mizoram University, Tanhril, Mizoram.

A total of 151 species belonging to 98 genera and 57 families have been identified and recorded from the study sites. Of these, the mosses are represented by 102 species of 68 genera and 37 families, while Liverworts are represented by 46 species of 28 genera and 19 families. Hornworts are represented by 3 species of 2 genera and 1 family. The most dominant family was Bryaceae having a total of 12 species followed by Dicranaceae with 11 species. The other dominant families were Jubulaceae, Lejeuneaceae, Neckeraceae and Polytrichaceae having 6 species each, followed by Marchantiaceae, Brachytheciaceae, Thuidiaceae with 5 species each; Aytoniaceae, Ricciaceae, Fissidentaceae, Funariaceae and Meteoriaceae with 4 species each; Anthocerotaceae, Plagiochilaceae, Leskeaceae, Mniaceae, Orthotrichaceae, Pottiaceae, Sematophyllaceae and Fossombroniaceae with 3 species each; Aneuraceae, Jungermanniaceae, Targioniaceae, Bartramiaceae, Erpodiaceae, Hookeriaceae, Leucodontaceae, Plagiotheciaceae, Rhizogoniaceae, and Trachypodaceae with 2 species each. All the other families have only 1 species each.

Among the selected study sites Murlen National Park harbours the highest Bryophyte diversity having 140 different species in 91 genera and 51 familes. *Dicranum scoparium, Hookeria acutifolia, Macrothamnium macrocarpum,*

Hypopterygium tamarisci, *Neckeropsis crinita*, *Neckeropsis exserta* and *Trocholejeunea sandvicensis* occur only in Murlen National Park. A total of 122 species belonging to 80 genera and 46 families were collected from Dampa Tiger Reserve and *Myurium rufescens* occurs only in this site. From Tawi Wildlife Sanctuary a total of 132 species belonging to 88 genera and 49 families were collected; *Tayloria hornschuchii* and *Solmsiella biseriata* occur in this site only. Thorangtlang Wildlife Sanctuary harbours the least number of Bryophyte in terms of diversity, a total of 116 species belonging to 73 genera and 43 families were collected from here. *Pogonatum proliferum* and *Bazzania tridens* occur in this site only.

Most of the Bryophyte species were common to all the selected sites except few species are present to two or three sites only. *Rhodobryum roseum*, *Fabronia assamica* and *Fissidens virens* were present at Murlen National Park and Dampa Tiger Reserve only. *Bryum alpinum*, *Riccia fluitans*, *Riccia glauca*, *Cyathophorella tonkinensis*, *Erpodium mangiferae*, *Entosthodon wichurae*, *Hookeriopsis utacamundiana*, *Neckera pennata*, *Pseudotaxiphyllum elegans*, *Riccardia chamedryfolia*, *Calypogeia arguta*, *Fossombronia himalayensis*, *Fossombronia indica* and *Fossombronia pusilla* were collected from Murlen National Park and Tawi Wildlife Sanctuary only. *Schoenobryum concavifolium* was present in Murlen National Park and Thorangtlang Wildlife Sanctuary only. *Aneura pinguis* was collected from Dampa Tiger Reserve and Tawi Wildlife Sanctuary only. *Campylopodiella stenocarpa* and *Frullania acutiloba* were collected from Dampa Tiger Reserve and Thorangtlang Wildlife Sanctuary only.

Marchantia paleacea was identified from Tawi Wildlife Sanctuary and Thorangtlang Wildlife Sanctuary only.

Four species of Bryophytes were selected for phytochemical study, consisting of two species of moss- *Atrichum undulatum* and *Pogonatum neesii* and two species of liverworts- *Dumortiera hirsuta* and *Marchantia linearis.* Powdered plants were extracted with 200 ml methanol in Soxhlet apparatus for 24 hours. The crude extracts of selected species were analysed for the presence of various phytochemicals such as: alkaloids, flavonoids, tannins, phenols, terpenoids, steroids and saponins by standard methods (Harborne, 1973; Trease and Evans, 1989).

Phytochemical screening revealed the presence of flavonoids, phenols, steroids and terpenoids in all the selected species. Alkaloids were present in *Marchantia linearis* and *Dumortiera hirsuta*; tannins were present in *Atrichum undulstum* and *Pogonatum neesii*, while saponins were present in *Dumortiera hirsuta* only. The alkaloids and tannins were antagonistic for each other hence they were not always found together in single plant (Bartholow, 2005).

Antioxidant activity of the crude extracts of selected species were estimated by the free radical scavenging activity using 1,1-Diphenyl-2-picrylhydrazyl (DPPH) assay method described by Huang *et al*.,(2005). The IC50 value of BHT was 42.20 µg/ml having the highest antioxidant activity. Among the methanolic extracts of the selected species *Dumortiera hirsuta* had the highest antioxidant activity with an IC50 value of 63.83 µg/ml followed by *Marchantia linearis* with an IC50 value of 81.81 µg/ml and that of *Pogonatum neesii* was 95.01 µg/ml. The extract of *Atrichum undulatum* had the lowest activity with an IC50 value of 113.23 µg/ml.

The extracts of all the selected species exhibited antioxidant activity with the highest activity exhibiting inhibition of DPPH radical at 67.00% by *Dumortiera hirsuta* at a concentration of 100 µg/ml.

Antibacterial activity of methanolic extracts of selected species was tested against pathogenic gram positive bacteria *Bacillus subtilis* (ATCC-11774) and gram negative bacteria *Escherichia coli* (ATCC-10536) and *Klebsiella pneumoniae* (ATCC-10031) using Agar well diffusion assay method (Murray *et al*., 1995; Olurinola, 1996). The diameters of inhibition zone were measured and the results were expressed as mean ± SD of three replicates. The data were subjected to ANOVA using SPSS programme. P value ≤0.05 were regard as significant. The maximum inhibition zone 23 mm diameter was shown by the positive control against *Escherichia coli*. Among the selected species the crude extract of *Dumortiera hirsuta* has the highest antibacterial activity against *Klebsiella pneumonia*e with 18 mm diameter of inhibition zone. The crude extracts of *Atrichum undulatum* and *Pogonatum neesii* exhibited the least activity against *Bacillus subtilis* having 9 mm diameter of inhibition zone.

The methanolic extracts of all the selected species exhibited antioxidant activity by scavenging free radicals of DPPH. The efficacy of the extracts may be due to the presence of steroids, alkaloids, flavonoids and polyphenols in the methanolic extracts of the selected four species of Bryophytes.

The crude extracts of all the selected species had shown positive results against the tested pathogenic bacteria. The antibacterial activity could be due to the presence of terpenoids (Toyota and Asakawa, 1999). As a whole the selected two

liverworts species *Dumortiera hirsuta* and *Marchantia linearis* have higher antibacterial activities compared to the selected two moss species *Atrichum undulatum* and *Pogonatum neesii.* The significant values of one way analysis of variance (ANOVA) also validated the efficacy of the crude extracts of the selected species in treating the tested bacteria.

It has been observed that Mizoram harbours rich bryodiversity and the reported taxa were adapted to a wide range of habitats preferring shady, moist places of the plains or slope of hills in the study areas. All the species reported presently were new distributional records for the State.

Field observations revealed that the disturbances and threat to the bryodiversity of the state was associated with many human activities like expansion of agricultural lands, construction of roads, destruction of forests, execution of unplanned developmental activities; and habitat destruction through expanding human activities such as over exploitation of forest resources, shifting cultivation, expanding human population and other anthropogenic factors have resulted in degeneration of bryodiversity in this state. Therefore, serious attentions and efforts are required to save valuable bryoflora of this state.

Phytochemical screening revealed the presence of various phytochemicals in all the selected species. The extracts of all the selected species exhibited antioxidant activity because they contained compounds that were capable of donating hydrogen to a free radical in order to remove electrons responsible for radicals' reactivity. The efficacy of the extracts may be due to the presence of steroids, alkaloids, flavonoids and polyphenols in the selected four species of Bryophytes.

Further researches and studies involving isolation, characterization and purification of these phytochemicals and screening for antibacterial effects may result in the development of potent drugs which will be less toxic having high therapeutic value to mankind.

a.

b.

c.

d.

Photo Plate 1:

a. Central National Herbarium

b. With Dr Aziz, Scientist ‘E’, Botanical Survey of India

c. Some herbarium specimens of Bryophytes at Central National Herbarium

d. Working on Bryophyte herbarium specimens

a.

b.

c.

d.

Photo Plate 2:

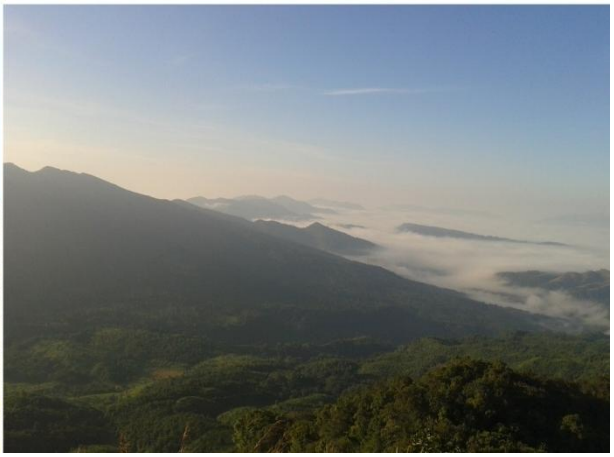
a. Field visit and specimen collection at Murlen National Park

b. Areas of Murlen National Park

c. Field visit and specimen collection at Dampa Tiger Reserve

d. Areas of Dampa Tiger Reserve

a.



b.

c.

d.

Photo Plate 3:

a. Field visit and specimen collection at Tawi Wildlife Sanctuary

b. Areas of Tawi Wildlife Sanctuary

c. Field visit and specimen collection at Thorangtlang Wildlife Sanctuary

d. Areas of Thorangtlang Wildlife Sanctuary

APPENDICES

Appendix I: List of Papers Published in Journals

1. Ramchandra Laha and **Lalhriatpuia**. (2015). Diversity of Bryophytes in Aizawl District, Mizoram, Northeast India. International Journal of Science and Research, 4(4): 1654-1657.

2. **Lalhriatpuia** and Ramachandra Laha. (2015). Bryophyte diversity in Mamit district, Mizoram, Northeast India. International Journal of Pharma and Bio Sciences, 6(4): (B) 1204- 1209.

UGC Journal Number: 17357 as on 2016.

3. **Lalhriatpuia**, R.C.Laha and P.C.Lalremruata. (2018). A preliminary Study of Moss Flora of Murlen National Park. Int. J. Life Sci. Res., 6(2): 58-63.

UGC Journals Number:-44761 as on 2018.

4. P.C. Lalremruata, R.C. Laha, **Lalhriatpuia** and Zothanmawia. (2017). A first note on lichens of Tawi wildlife sanctuary, Mizoram. International Journal of Pharma and Bio Sciences, 8(3): (B) 182-187.

UGC Journal Number: 17357 as on 2016.

5. P.C.Lalremruata, R.C.Laha, **Lalhriatpuia** and R. Vanlalpeka (2018). Diversity of Lichens; Its threat need conservation in Mizoram. Int. J. Life Sci. Res., 6(2): 69-75.

UGC Journal Number: 44761 as on 2018.

6. R.C.Laha, **Lalhriatpuia**, Rosie Lalmuanpuii, Lucy Laldinfeli and P.C. Lalremruata. (2016). Indigenous uses of antidiabetic plants by ethnic inhabitant of Mizoram, Northeast India. J. Med. Plant stud., 4(6): 181-184.

7. R.C.Laha, **Lalhriatpuia**, Rosie Lalmuanpuii, Lucy Laldinfeli and P.C. Lalremruata (2016). Diversity and ethnobotanical uses of Wild Edible fruits in Mizoram, Northeast India. Int. J. Pharma. Biol. Sci., 8(2): 132-142.

UGC Journal Number- 46322 as on 2018.

8. R.C. Laha, **Lalhriatpuia**, P.C.Lalremruata and R. Vanlalpeka. (2017). Forest Wild vegetable used by the Lai tribe in Lawngtlai district of Mizoram, India. Int. J. Life Sci. Res., 6(3): 212-217.

UGC Journal Number-44761 as on 2018.

9. R.C. Laha, **Lalhriatpuia**, P.C.Lalremruata and R. Vanlalpeka. (2017). Ethnomedicinal plants used by Mara tribe in Siaha District of Mizoram, India. Int. J. Interdisp. Res. Innov., 6(3): 365-368.

UGC Journal Number-63976 as on July 2018.

10. R.C. Laha, **Lalhriatpuia**, P.C.Lalremruata and R. Vanlalpeka. (2017). Ethnomedicinal plants used by Lai tribe in Lawngtlai District of Mizoram, India. Int. J. basic and applied res., 8(11): 371-376.

UGC Journal number- 64041 as on 2018.

11. Rosie Lalmuanpuii, Ramachandra Laha, **Lalhriatpuia** and P.C. Lalremruata. (2018). Diversity assessment of wild vegetables in Aizawl District, Mizoram, North East India. Int. J. basic and applied Res., 8(9): 45-49.

UGC Journal number- 64041 as on 2018.

12. Ramachandra Laha, **Lalhriatpuia**, P.C. Lalremruata and R. Vanlalpeka. (2018). Ethnobotanical uses of Bamboos among different tribes in Mizoram, Northeast India. International Journal of Pharmacy and Biological Sciences, 8(3): 329-332.

UGC Journal Number- 46322 as on 2018.

13. Ramachandra Laha and **Lalhriatpuia**. (2018). Diversity of Non-timber forest product yielding plants in Aizawl district of the Northeastern state of Mizoram in India. Journal of Tropical Forestry, 34: 44-61.

Appendix II: List of Papers Published in Proceedings

1. **Lalhriatpuia** and R. C. Laha. (2016). Bryophyte Diversity in Tawi Wildlife Sanctuary, Aizawl District, Mizoram, Northeast India. Proceeding of the Mizoram Science Congress. Science and Technology for Shaping the Future of Mizoram, pp. 43-46. ISBN 978-93-85926-49-5.

2. **Lalhriatpuia** and R. C. Laha. (2017). A study on bryodiversity of Murlen National Park, Mizoram, India. Proceeding of National Conference on Biodiversity, Conservation and Utilization of Natural Resources with reference to Northeast India, pp. 14-18. ISBN- 978- 818653578- 0.

Appendix III: Lists of Paper Presented

1. 'Bryophyte Diversity in Tawi Wildlife Sanctuary, Aizawl District, Mizoram, Northeast India'. Mizoram Science Congress held at Mizoram University during 13th -14th October, 2016.

2. 'A study on bryodiversity of Murlen National Park, Mizoram, India '. National Seminar on "Biodiversity, Conservation and Utilization of Natural Resources with reference to Northeast India (BCUNRNEI) organized by Department of Botany, Mizoram University, Aizawl during 30th - 31st March, 2017.

Appendix IV: Seminar and Workshop Attended

1. Seminar on 'Science for Nation Building' held at Pi Zaii Hall, Synod Conference Centre, Aizawl, Mizoram on 1st October, 2015 organised by Mizo Acadamy of Science in collaboration with the National Council for Science and Technology Communication, Department of Science and Technology, New Delhi.

2. 'Mizoram Science Congress' held at Mizoram University during 13th -14th October, 2016 organized by MISTIC, MSS, MAS, STAM, MMS, GSM and BIOCONE. Sponsored by NEC, DST (SERB) and MISTIC.

3. National Seminar on 'Biodiversity, Conservation and Utilization of Natural Resources with reference to Northeast India (BCUNRNEI)' during 30th - 31st March, 2017, organized by Department of Botany, Mizoram University, Aizawl.

4. ‘Statistical and Computing Methods for Life-Science Data Analysis’ during 5th - 10th March, 2018 organized by Biological Anthropology Unit, Indian Statistical Institute, Kolkata and Department of Botany, Mizoram University, Aizawl.

5. One Day National Workshop on ‘IPR and Plant Protection with special reference to NE India’ on 18th December, 2019 organized by Department of Botany, Mizoram University and Department of Horticulture, Government of Mizoram.

6. One Day Awareness Programme cum Workshop on ‘Invasive Alien Plants in Himalayas: Status, Ecological Impact and Management (Mizoram & Tripura Chapter)’, organized by Botanical Survey of India in collaboration with Department of Botany, Mizoram University, Aizawl, on 26th April, 2019 under National Mission for Himalayan Studies.

REFERENCES

Alam, A. (2012). Some Indian bryophytes known for their biologically active compounds. International Journal of Apllied Biology and pharmaceutical Technology, 3(2): 239-246.

Alam, A., Verma, P. K., Asthana, G. and Yadav, S. (2011). Moss Flora of Palni Hills (Tamil Nadu), India- A Checklist. Archive for Bryology, 112: 1-8.

Ando, H. (1983). Use of bryophytes in China 2. Mosses indispensable to the production of Chinese gallnuts. Proc. Bryol. Soc. Jap. 3: 124-125.

Anonymous. (2019). India State of Forest Report. Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India, Vol. II. Kaulagarh Road, Dehra Dun, pp. 183.

Aruna, K. B. and Krishnappa, M. (2018). Phytochemistry and Antimicrobial activities of *Pogonatum microstomum* (R. Br. ex Schwägr.) Brid. (Bryophyta; Musci: Polytrichaceae). International Journal of Botany Studies, 3(1): 120-125.

Asakawa, Y. (1995). Chemical constituents of the bryophytes, In: Progress in the Chemistry of Organic Natural Products, 65 (eds. W. Herz, G. W. Kirby, R. E. Moore, W. Steglich, and C. Tamm), Springer, Vienna, pp. 1-562.

Asakawa, Y. (1981). Biologically active substances obtained from bryophytes. J. Hattori Botanical Laboratory, 50: 123-142.

Asakawa, Y. (1984). Some biologically active substances isolated from hepaticae: terpenoids and lipophilic aromatic compounds. J. Hattori Botanical Laboratory, 56: 215 -219.

Asakawa, Y. (1988). Biologically active substances found in hepaticae. S. 277 ff. In A.-U. Rahman (Ed.), Studies in Natural Products Chemistry. Elsevier, Amsterdam.

Asakawa, Y. (1990). Biologically active substances obtained from bryophytes, pp. 259-287. In R. N. Chopra & S. C. Bhatia (Eds.), Bryophytes development, Physiology and Biochemistry. CRC Press, Boca Raton, FL.

Asakawa, Y. (1999). Phytochemistry of bryophytes: biologically active terpenoids and aromatic compounds liverworts, In: Phytochemicals in Human Health Protection, Nutrition, and Plant Defense (Ed. J. Romeo), Kluwer Academic/Plenum Publishers, New York, pp. 319-342.

Asakawa, Y. (2001). Recent advances in phytochemistry of bryophytes - acetogenins, terpenoids, and bis(bibenzyl)s from selected japanese, Taiwanese, New Zealand, Argentinean, and European liverworts. Phytochemistry, 56: 297-312.

Asakawa, Y. (2007). Biologically active compounds from bryophytes. Pure and Applied Chemistry, 79: 557-580.

Asakawa, Y., Takemoto, T., Fujiki, H. and Sugimura, T. (1980). Biologically active substances isolated from liverworts. Planta Medica, 39: 233.

Asakawa, Y., Toyota, M., Ishida, T. and Aratani, T. (1976). Biologically active substances of *Porella*. IV. Sesquiterpenes of six *Porella* species, p. 39. (Abstract) In the 20th centuary of Terpenes, Essential Oils and Aromatics. Symposium papers.

Asakawa, Y., Toyota, M., Taira, Z. and Takemoto, T. (1982). Biologically active cyclic bisbenzyls and terpenoids isolated from liverworts. 25th symposium on chemistry of natural products. Symposium papers, pp. 337-344.

Asthana, A. K. and Srivastava, S. C. (1991). Indian Hornworts: A taxonomic study. Bryophytorum Bibliotheca, 42: 1-158.

Asthana, G., Srivastava, S. C. and Asthana, A. K. (1995). The genus *Cheilolejeunea* in India. Lindbergia, 20: 125-143.

Banerjee, R. D. and Sen, S. P. (1979). Antibiotic activity of bryophytes. The Bryologist, 82: 141-153.

Bansal P. and Nath V. (2012). A new record of *Bryum coronatum* Schwaegr. (Bryophyte) in Meghalaya, India. Taiwania, 57: 294-299.

Bansal P., Nath, V. and Chaturvedi, S. K. (2011). Epiphytic bryophytes of *Thuja orientalis* in Nagaland North- eastern India. Bangladesh J. Plant Taxon. 18(2): 163-167.

Barbhuiya, H. A. and Singh, S. K. (2012). Liverwort and Hornwort of Borail Wild Life Sanctuary, Assam, India. Archive for Bryology, 134: 1-12.

Bartholow, R. (2005). A Practical Treatise On Materia Medica And Therapeutics. Kessinger Publishing, pp. 828.

Barukial, J. (2011a). A Bryofloristic Ecological Assessment of Assam, India. Indian Journal of Fundamental and Applied Life Sciences, 1(3): 98-106.

Barukial, J. (2011b). A Study Of moss diversity in Assam valley wet evergreen forests. Indian Journal of Fundamental and Applied Life Sciences, 1(4): 1-8.

Barukial, J. and Gogoi, P. (1998). An Ecological Assessment of Moss Vegetation of Nambor Reserve Forest, Assam, India. Advances of Plant Sciences, 11(1): 113-117.

BarukiaL, J., Gogoi, P. and Barrua, P. K. (2002a). A checklist of Bryophytes of Brahmaputra Valley. Advances in Plant Science, 15: 89-94.

Barukial, J., Gogoi, P. and Barua, P. K. (2002b). An Enumeration of Mosses and Their Ecology of Proposed Joydihing Wildlife Sanctuary, Assam, India. Advances of Plant Sciences, 15(1): 97-102.

Barukiyal, J. (2011). A study of moss diversity in Assam valley wet evergreen forests. Indian Journal of Fundamental and Applied Life Sciences, 1(4): 1-8.

Basile, A., Giordano, S., Lopez-Saez, J. A. and Cobianchi, R. C. (1999). Antibacterial activity of pure flavonoids isolated from mosses. Phytochemistry, 52(8): 1479-1482.

Beike, A. K., Decker, E. L., Frank, W., Lang, D., Marco, V. S., Zimmer, A. D. and Reski, R. (2010). Applied Bryology and Bryotechnology. Tropical Bryology, 3: 22-32.

Belcik, F. P. and Wiegner, N. (1980). Antimicrobial activities or antibiosis of certain eastern U.S. liverwort, lichen and moss extracts. J. Elisha Mitchell Sci. Soc. 96: 94.

Ben Marzoug, H. N., Romdhane, M., Lebrihi, A., Mathieu, F., Couderc, F., Abderraba, M., *et al*., (2011). *Eucalyptus oleosa* essential oils: chemical composition and antimicrobial and antioxidant activities of the oils from different plant parts (stems, leaves, flowers and fruits). Molecules, 16(2): 1695-1709.

Benedix, E. H. (1953). Indomalayische Cololejeuneen. Feddes Repertorium, Beihefte, 134: 1-88.

Benzie, I. and Strain, J. (1996). The ferric reducing ability of plasma (FRAP) as a measure of antioxidant power: The FRAP assay. Anal. Biochem. 239: 70-76.

Bharadwaj, D. C. (1948). Studies in Indian Hepaticae. V. On a new species of *Aspiromitus* St. from Kandy, Ceylon *Aspiromitus manillispora* Bharadwaj sp. nov. J. Indian Bot. Soc. 17: 200-205.

Bharadwaj, D. C. (1950). Studies in Indian Anthocerotaceae: I. The morphology of *Anthoceros crispulus* (Mont.) Douin. Jour. Indian Bot. Soc. 29: 145-163.

Bharadwaj, D. C. (1958). Studies in Indian Anthocerotaceae: II. The morphology of *Anthoceros* cf. *gemmulosus* (Hattori) Pande. Jour. Indian Bot. Soc. 37: 75-94.

Bharadwaj, D.C. (1960). Studies in Indian Anthocerotaceae: III. The morphology of *Anthoceros erectus* Kash. and some other species. Jour. Indian Bot. Soc. 39: 568-592.

Bland, J. (1971). Forests of Lilliput. Prentice-Hall, Inc., Englewood Cliffs, pp. 210.

Borel, C., Welthz, D. H., Fernandez, I. and Colmenares, M. (1993). Dicranin, an antimicrobial and 15-lipoxygenase inhibitor from the moss *Dicranum scoparium*. Journal of Natural Products, 56: 1071-7.

Braun, A. (1864). Uebersicht des naturlichen. In: P. Ascherson, Flora der Provinz Brandenburg, 1(2): 22.

Brotherus, V. F. (1899). Report on a collection of mosses made by Dr. T.L. Walker in Coorg during the cold weather of 1897-98. Rec. bot Surv. India, 1: 311-329.

Campbell, D. H. (1918). The structure and development of Moses and ferns (Archegoniatae), Macmillan, New York, pp. 708.

Campbell, D.H. (1940). The evolution of the land plants (Embryophyta), Stanford University Press, California, pp. 731.

Castaldo-Cobianchi, R., Giordano, S., Basile, A. and Violante, U. (1988). Occurrence of antibiotic activity in *Conocephalum conicum*, *Mnium undulatum* and *Leptodictyum riparium* (Bryophytes). Giornale Botanico Italiano, 122: 303-312.

Champion, H. G. and Seth, S. K. (1986). A revised Survey of Forest Types of India, Govt. of India Press, New Delhi, pp. 404.

Chawla, A.S., Handa, S. S., Sharma, A. K. and Kaith, B. S. (1987). Plant anti-inflammatory agents. J. Sci. Ind. Res, 46: 414-223.

Chopra, R. N. and Vashistha, B. D. (1994). Bryophyte Morphogenetic Study, In: Botany of India (History and Progress), I edited by Johri BM (Oxford IBH Publishing Co. Pvt. Ltd., New Delhi), pp. 437-453.

Chopra, R. S. (1938). Notes on Indian Hepaticae. I. South India. Proceedings of the Indian Academy of Science 7 B, pp. 239-251.

Chopra, R. S. (1943). A census of Indian Hepatics. J. Indian Bot. Soc. 22: 237-260.

Chopra, R. S. (1975). Taxonomy of Indian Mosses. CSIR Publication, New Delhi, India, pp.133-134.

Crum, H. A. (2001). Structural Diversity of Bryophytes. The University of Michigan Herbarium, Ann Arbor, MI, pp. 379.

Dandotiya, D., Govindapyari, H., Suman, S. and Uniyal, P. L. (2011). Checklist of the bryophytes of India. Archive for bryology, 88: 1-126.

Daniels, A. E. D. (1998). Ecological adaptations of some bryophytes of the Western Ghats. J. Ecobiol. 10: 261-270.

Daniels, A. E. D. (2001). *Cololejeunea furcilobulata* (Berrie et Jones) Schuster and *Heteroscyphus argutus* (Reinw. et al.) Schiffn. from Mahendragiri hills of Kanyakumari District of South India. In: Nath, V. and A.K. Asthana (ed.), Perspectives in Indian Bryology, Dehra Dun, pp. 301-307.

Daniels, A. E. D. and Daniel, P. (2003a). An Addition to the bryoflora of India. Bull. Bot. Surv. India, 45(1- 4): 225-226.

Daniels, A. E. D. and Daniel, P. (2003b). *Fissidens griffithii* Gangulee (Musci: Fissidentales) -An addition to the bryoflora of India. Indian J. Forestry, 26: 193-194.

Daniels, A. E. D. and Daniel, P. (2003c). Additions to the bryoflora of Peninsular India. Indian J. Forestry, 26: 389-396.

Daniels, A. E. D. and Daniel, P. (2004). *Leptolejeunea balansae* (Hepaticae: Jungermanniales) -a new record of Bryoflora from the Indian mainland. J. Bombay Nat. Hist. Soc. 101: 333.

Dash, P.K., Sahu, D. K. and Saxena, D. K. (2009). Bryoflora of Baphlamali hill in Eastern Ghats of Orissa, India. *Newsletter,* 15(1): 3-8

Dassler, H. G. and Ranft, H. (1969). Das Verhalten von Flechten und Moosen under Einfluss einer Scchwerel dioxide behasung. Flora, Abt. B. 1958: 454-461.

Devi, K., Thirumaran, G., Arumugam, R. and Anantharaman, P. (2009). Antibacterial activity of selected medicinal plants from Parangipettai coastal regions; Southeast coast of India. World Appl Sci J. 7(9): 1212-1215.

Dikshit, A. D., Pandey, D. K. and Nath, S. (1982). Antifungal activity of some bryophytes against human pathogens. J. Indian Botanical Society, 61: 447-448.

Ding, H. (1982). Medicinal spore-bearing plants of China. Shanghai, pp. 409.

Dixon, H. N. (1909). Mosses from western Ghats. J. Bot. London, 47: 157-164.

Dixon, H. N. (1914). Report on the mosses collected by Mr. C. E. C. Fischer and others from south India and Ceylon. Rec. Bot. Surv. India, 6: 75-89.

Dixon, H. N. (1921). On a collection of mosses from Kangra District. J. Indian Bot. Soc. 2: 174-188.

Dixon, H. N. (1930). Additions to the moss flora of North Western Himalaya. Ann. Bryol. 3: 51-70.

Dixon, H. N. (1937). Mosses collected from Assam. J. Bombay Nat. Hist. Soc. 39(4): 769-795.

Easa, P. S. (2003). Biodiversity documentation for Kerala. Part 4: Bryophytes. KFRI Handbook, KFRI, Peechi, Kerala,17: 1-47.

Eldridge, D. J. (1993). Cryptogams, vascular plants, and soil hydrological relations: Some preliminary results from the semi-arid woodlands of eastern Australia. Great Basin Naturalist, 53: 48-58.

Eldridge, D. J. (1998). Trampling of microphytic crusts on calcareous soils, and its impact on erosion under rain-impacted flow. Catena, 33: 221-239.

Evans, A. W. (1939). The classification of the Hepaticae. Botanical Review, 5: 49-96.

Flowers, S. (1957): Ethnobryology of the Goshute Indians of Utah. Bryologist, 60: 11-14.

Foreau, G. (1961). The moss flora of Palni Hills. J. Bombay Nat. Hist. Soc. 58: 13-47.

Foreau, G. (1964). Some south Indian mosses. J. Bombay Nat. Hist. Soc. 61(1): 223 - 226.

Frahm, J. P. (2004). Recent developments of commercial products from bryophytes. Bryologist, 107: 277-283.

Gangulee, H. C. (1969-1980). Mosses of Eastern India and adjacent regions. Fasc. 1-8. Calcutta, pp. 1-2142.

Glime, J. M. (2007). Economic and Ethnic Uses of Bryophytes. Fl North America: America Editorial Committee, 27: 14-41.

Glime, J. M. and Saxena, D. (1991). Uses of Bryophytes. Today and Tomorrow's Printers and Publisher, New Delhi, pp. 100.

Gradstein, S. R. (1990). Morphology and classification of the Hepaticae: an introduction. In Chemistry and Chemical Taxonomy of Bryophytes, eds. H.D. Zinsmeister and R. Mues. Oxford: Oxford University Press, pp. 3-17.

Gradstein, S. R., Churchill, S. P. and Salazar, A. N. (2001). Guide to the Bryophytes of Tropical America. In Memoirs of the New York Botanical Garden, 86: 1-577.

Greven, H. C. (1992). Changes in the moss flora of the Netherlands. Biol. Conserv. 59: 133-137.

Gupta, K. G. and Singh, B. (1971). Occurrence of antibacterial activity in moss extracts. Res. Bull. Punjab Univ. 22: 237-239.

Hallingbäck, T. and Hodgetts, N. (2000). Status survey and conservation action plan for bryophytes: mosses, liverworts and hornworts. IUCN/SSC Bryophyte Specialist Group. IUCN, Gland, Switzerland and Cambridge, U.K. pp. 106.

Harborne, J. B. (1973). Phytochemical methods, Chapman and Hall Ltd., London, pp. 49-188.

Hayes, L. E. (1947). Survey of higher plants for presence of antibacterial substances. Botanical Gazette, 108: 408-414.

Hemmani, T. and Parihar, M. S. (1998). Reactive oxygen species and oxidative damage. Indian J Physiol Pharmacol. 42: 440.

Hirota, J. (1981). Bonkei: Tray Landscapes. Tokyo, Pp. 128.

Hofstede, R., Wolf, J. and Benzing, D. (1993). Epiphytic biomass and nutrient status of a Colombian upper montane rain forest. Selbyana, 14: 37-45.

Hoof, L. V., Vanden, B. D. A., Petit, E. and Vlietinck, A. J. (1981). Antimicrobial and antiviral screening of Bryophyta. Fitoterapia, 52: 223-229.

Howe, M. A. (1899). The Hepaticae and Anthocerotes of California. Mem. Torrey Bot. Club, 7: 1-208.

Hu, R. (1987). Bryology. Higher Education Press, Beijing, China, pp. 465.

Huang, D. B. and Ou Prior, R. L. (2005). The chemistry behind antioxidant capacity assays Reviews. Journal of Agriculture and Food Chemistry, 53: 1841-1856.

Ishikawa, I. (1974). Bryophyta in Japanese gardens 2. Hikobia, 7: 65-78.

Isoe, S. (1983). Terpene dials. Biological activity and synthetic study. 48th Annual Meeting of the Chemical Society of Japan. Proceedings Papers II, pp. 849-850.

Jeglum, J. K. (1971). Plant indicators of pH and water level in peatlands at Candle Lake, Saskatchewan. Canadian Journal of Botany, 49: 1661-1676.

Joshi, D.Y. and Biradar, N.V. (1984). Studies on the hepatic flora of western Ghats with special reference to Maharashtra, India. J. Hattori Bot. Lab. 56: 45-52.

Kachroo, P. (1969). Hepaticae of India -A taxonomic survey and census I. Floristic and taxonomic considerations. J. Sci., Univ. Kashmir, 6: 39-55.

Kachroo, P. (1970a). Hepaticae of India -A taxonomic survey and census II. Takakiaceae through Marsupellaceae. J. Sci., Univ. Kashmir, 7: 176-200.

Kachroo, P. (1970b). Hepaticae of India -A taxonomic survey and census IV. Lejeuneaceae. Bull. Bot. Surv. India, 12: 226-241.

Kachroo, P. (1973). Hepaticae of India -A taxonomic survey and census III. Plagiochilaceae through Pleuroziaceae. J. Sci., Univ. Kashmir, 11: 141-161.

Kachroo, P., Bapna K. R. and Dhar, G.L. (1977). Hepaticae of India - A taxonomic survey and census V. Fossombroniaceae through Anthocerotaceae. J. Indian Bot. Soc. 56: 62-86.

Kamory, E., Keserü, G. M. and Papp, B. (1995). Isolation and antibacterial activity of Marchantin A, a cyclic bis (biphenyl) constituent of Hungarian *Marchantia polymorpha*. Planta Medica, 61: 387-388.

Kandpal, V., Chaturvedi, P., Negi, K., Gupta, S. and Sharma, A. (2016). Evaluation of the antibiotic and biochemical potential of bryophytes from Kumaun Hills and Taral Belt of Himalayas. International J. of Pharmacy and Pharmaceutical Sciences, 8: 65-69.

Kashyap, S. R. (1915). Morphological and biological notes on new and little Known West - Himalayan liverworts III. The New Phytologist, 14: 4.

Kashyap, S. R. (1929). Liverworts of western Himalayas and Panjab plains. Vol. 1, University of Panjab, Lahore, pp.129.

Kashyap, S. R. and Chopra, R. N. (1932). Liverworts of western Himalayas and Panjab plains. Vol. 2. University of Panjab, Lahore, pp. 137.

Khatun, S., Chatterjee, N. C. and Cakilcioglu, U. (2011). Antioxidant activity of the medicinal plant Coleus forskohlii Briq. African J Biotech. 10(13): 2530-2535.

Kumar, S. S. and Maniselvan, P. (1994). A report on the moss flora of Udhagamandalam in south India -I. Res. Bull. Panjab Univ. 44: 99-103.

Kumar, K., Singh, K. K., Asthana, A. K. and Nath, V. (2000). Ethnotherapeutics of bryophyte *Plagiochasma appendiculatum* among the Gaddi tribes of Kangra Valley, H.P. India. Pharm Biol, 38: 353-356.

Kurschner, H. and Parolly, G. (2004). Phytomass and water-storing capacity of epiphytic rain forest communities in S Ecuador. Ecosociological studies in Ecuadorian bryophyte communities. IV. Botanische Jahrbu ¨cher fu ¨r Systematik, 125: 489-504.

Lal, J. (2005). A Checklist of Indian Mosses. Bishen Singh Manhendra Pal Singh, Dehra Dun, India.

Lal, J. (2007). Mosses of gangetic plains -a neglected bryogeographic zone of India In: Nath, V. and Asthana, A.K. (eds.) Current Trends in Bryology, Bishen Singh and Mahendra Pal Singh, Dehra Dun, India, pp. 287-330.

Lalhriatpuia and Ramachandra Laha. (2015). Bryophyte diversity in Mamit District, Mizoram, Northeast India. Int J Pharm Bio Sci. (B). 6(4): 1204-1209.

Lalhriatpuia, Ramachandra Laha and Lalremruata, P. C. (2018). A Preliminary Study of Moss Flora of Murlen National Park Mizoram India. International Journal of Life Sciences Research, 6(2): 58-63.

Li, H., Wang, Z. and Liu, Y. (2003). Review in the studies on tannins activity of cancer prevention and anticancer. Zhong-Yao-Cai, 26(6): 444-448.

Longton, R. E. (1992). The role of bryophytes and lichens in terrestrial ecosystems. In 'Bryophytes and Lichens in a Changing Environment'. (Eds J. W. Bates and A. M. Farmer.) Cambridge Press: Oxford, pp. 32-76.

Lorimer, S. D. and Perry, N. B. (1993). An antifungal bibenzyl from the New Zealand liverwort *Plagiochila stevensoniana*. J. Natural Products, 56: 1444-1450.

Lorimer, S. D. and Perry, N. B. (1994). Antifungal Hydroxy acetophenones from the New Zealand liverwort *Plagiochila fasciculata*. Planta Medica, 60: 386-387.

Madsen, G. C. and Pates, A. L. (1952). Occurrence of antimicrobial substances in chlorophyllose plants growing in Florida. Botanical Gazette, 113: 293-300.

Mägdefrau, K. (1982). Life forms of bryophytes. In Smith, A.J.E. (Ed.), Bryophyte Ecology. Chapman and Hall, London, pp. 45-58.

Mäkinen, A. (1987). *Sphagnum* moss bags in air pollution monitoring in the city of Helsinki. Symposia Biologica Hungarica, 35: 755-775.

Maniselvan, P. and Kumar, S. S. (1998). Preliminary survey of moss flora of Kodaikanal -I. Res. Bull. Panjab Univ. 48: 21-24.

Maniselvan, P. and Kumar, S. S. (2000). A report on the moss flora of Udhagamandalam in south India -II. Res. Bull. Panjab Univ. 49: 29-34.

Manju, C. N., Rajesh, K. P. and Madhusoodanan, P. V. (2008). Checklist of Bryophytes of Kerala, India. Tropical Bryology Research Reports, 7: 1-26.

Marjorie, C. (1996). Plant products as antimicrobial agents. Clinical Microbiol. Rev. 12: 564-582.

Maschke, J. (1981). Moose als Bioindikatoren von Schwermetall-immissionen: Eine Übersicht der bereits untersuchten lokalen und regionalen Gegiete. Bryophytorum Bibliotheca. Vaduz, 22: 492.

Matsuo, A., Yuki, S., Higashi, R., Nakayama, M. and Hayashi, S. (1982). Structure and biological activity of several sesquiterpenoids having a novel herbertane skeleton from the liverwort *Herberta adunca*. pp. 242-249. (Abstract) In 25th Symposium on Chemistry of Natural Products, Symposium Papers (in Japanese with English summary).

McCleary, J. A. and Walkington, D. L. (1966). Mosses and antibiosis. Rev. Bryol. Lichenol. 34: 309-314.

McCleary, J. A., Sypherd, P. S. and Walkington, D. L. (1960). Mosses as possible sources of antibiotics. Science, 131: 108.

McCleary, J. A., Sypherd, P. S. and Walkington, D. L. (1966). Mosses and antibiosis. Revue Bryologique Llichénologique, 34: 309-314.

Merkuria, T., Steiner, U., Hindorf, H., Frahm, J. P. and Dehne, H. W. (2005). Bioactivity of bryophyte extracts against *Botrytis cinerea*, *Alternaria solani* and *Phytophtora infestans*. Journal of Applied Botany and Food Quality, 79: 89-93.

Miller, N. G. and Miller, H. (1979). Make ye the bryophytes. Horticulture, 57(1): 40-47.

Mitten, W. (1859). Musci Indiae Orientalis, an enumeration of the mosses of the East Indies. Journal of the Proceedings of the Linnean Society, supplement to Botany, 1: 1-171.

Mitten, W. (1861). Hepaticae Indiae Orientalis: an enumeration of the Hepaticae of the East Indies. Journal of the proceedings of the Linnean Society. Botany, 5: 385-392.

Montagne, C. (1842). Cryptogamae Nilgherienses seu plantarum cellularium in montibus peninsulae indicae Neel-Gherries dictis a Cl. Perrottet collectarum enumeratio. Musci. Annales des Sciences Naturelles; Botanique, sér. 2(17): 243-256.

Motar, M. L. R., Thomas, G. and Barbosa, F. J. M. (1985). Effects of *Anacardium occidentale* stem bark extract on *in vivo* inflammatory models. J Ethnopharm. 95(2-3): 139-142.

Müller, C. (1853). Musci neilgherrensis. Bot. Zeitung (Regensburg), 11: 17-62.

Murray, P. R., Baroon, E. J., Pfaller, M.A., Tenover, F. C. and Yolke, R. H. (1995). Manual of Clinical Microbiology. 6th Edn., American Society for Microbiology, Washington, D.C.

Nair, M. C. and Madhusoodanan, P. V. (2001). Contribution to the bryophyte flora of Eravikulam National Park, Kerala. J. Econ. Tax. Bot. 25: 569-574.

Nair, M. C. and Madhusoodanan, P. V. (2002). Studies on the bryophyte flora of Kerala (south India) -An introduction. J. Econ. Tax. Bot. 26: 697-708.

Nair, M. C., Rajesh, K. P. and Madhusoodanan, P.V. (2005). Bryophytes of Wayanad in Western Ghats. Malabar Natural History Society, Kozhikode, India.

Nath, V. and Asthana, A. K. (1995). Potential bryophytes - utility and future prospects. App Bot Abst. 15: 205-215.

Nath, V. and Asthana, A. K. (1998). Diversity and distribution of genus *Frullania* Raddi in South India. J. Hattori Bot. Lab. 85: 63-82.

Nikolajeva. V., Liepina, L., Petrina, Z., Krumina, G., Grube, M. and Muiznieks, I. (2012). Antibacterial activity of extracts of extracts of some bryophytes. Advance in Microbiology, 2: 345-353.

Nobori, T., Miurak, K., Wu, D. J., Takabayashik, L.A. and Carson, D. A. (1994). Deletion of cyclin dependent kinase-4 inhibitor gene in multiple human Cancer. Nature, 46: 753-756.

Olurinola, P. F. (1996). A laboratory manual of pharmaceutical microbiology, Idu, Abuja, Nigeria, pp. 69-105.

Pant, G. and Tewari, S. D. (1990). Bryophytes and mankind. Ethnobotany, 2: 97-103.

Parihar, N. S., Lal B. and Katiyar, N. (1994). Hepatics and Anthocerotes of India. A new Annotated Checklist. Central book depot. Allahabad.

Parker, J. D., Burkepile, D. E., Collins, D. O., Kubanek, J. and Hay, M. E. (2000). Stream mosses as chemically-defended refugia for freshwater macroinvertebrates. Oikos, 116: 302-312.

Pavletic, Z. and Stilinovic, B. (1963). Untersuchungen über die antibiotische Wirkung von Moosextrakten auf einige Bakterien. Acta Botanica Croatica, 22: 133-139.

Perin, F. (1962). Woodland mosses - A little-used growing medium. Amer. Orchid Soc. Bull. 31: 988.

Pospisil, V. (1975). Die Bedeutung der Moose Pterogoneurum subsessessile (Brid.)Jur. und P. ovatum (Hedw.)Dix. als Indikatoren der Klimaagebiete in der Tschechoslowakei. Casopis Moravskeho Musea v Brne. Vedy Prirodni. Acta Musei Moraviae. Scientiae Naturales, 60: 125-146.

Potier de la Varde, R. (1928). Mousses nouvelles de l'Asie meridionale. - Ann. Crypt. exot. 1: 279-281.

Proctor, M. C. F. (2009). Physiological ecology. In Bryophyte Biology, 2nd edn, eds. B. Goffinet and A. J. Shaw. Cambridge: Cambridge University Press, pp. 237-268.

Proskauer, J. (1951). Studies on Anthocerotales. III. Bull. Torrey Bot. Club, 78: 347.

Proskauer, J. (1957). Studies on Anthocerotales V. Phytomorphology, 7: 113-135.

Radwan, S. S. (1991). Sources of C20-polyunsaturated fatty acids for biotechnological use. Appl. Microbiol. Biotech. 35: 421-430.

Raghavan, R. S. and Wadhwa, B. M. (1968). Mosses of Agumbe-Hulical Ranges, Shimoga District. Bulletin of the Botanical Survey of India, 10: 344-347.

Raghavan, R. S. and Wadhwa, B. M. (1970). Mosses of Agumbe (Shimoga District, Mysore State) II. Key to species and new records for India. Maharashtra Vidnyan Mandir Patrika, 5: 28-35.

Ramachandra Laha and Lalhriatpuia. (2015). Diversity of Bryophytes in Aizawl District, Mizoram, Northeast India. International Journal of Science and Research, 4(4): 1654-1657.

Rao, N. D. (1982). Responses of Bryophytes to Air Pollution. In: Bryophyte Ecology, Smith, A.J.E. (Ed.). Chapman and Hall, London, pp. 445-447.

Raquel, F. E. (2007). Bacterial lipid composition and antimicrobial efficacy of cationic steroid compounds, Biochemica et Biophysica Acta, pp. 2500-2509.

Renzaglia, K. S., Duff, R. J., Nickrent, D. L. and Garbary, D. J. (2000). Vegetative and reproductive innovations of early land plants: Implications for a unified phylogeny. Philosoph. Trans. Roy. Soc. London B. 355: 769-793.

Rhoades, F. M. (1995). Nonvascular epiphytes in forest canopies: worldwide distribution, abundance and ecological roles.. In: Lowman M.D. and Nadkarni N.M.eds, Forest canopies. Academic Press, San Diego, USA, pp. 353-407.

Rice-Evans, C. A., Miller, N. J. and Paganga, G. (1996). Structure antioxidant activity relationship of flavonoids and phenolic acids. Free Radical Bio Med. 20: 933-956.

Rothmaler, W. (1951). Die Abteilungen und Klassen der Pflanzen, Feddes Repert, 54: 256-266.

Ruch, R. J., Cheng, S. J. and Klaunig, J. E. (1989). Prevention of cytotoxicity and inhibition of Intercellular communication by antioxidant catechins isolated from Chinese green tea. Carcinogens, 10: 1003-1008.

Sawant, U. J. and Karadge, B. A. (2010). Antimicrobial activity of some bryophytes (liverworts and a hornwort) from Kolhapur district. Pharmacognosy Journal, 2(16): 29-32.

Schimper, W. P. (1879). Palaeophytologie. In: K.A. Zittel. Handbuch der Palaeontologie. 2, Lief, 1: 1-152.

Schofield, W. B. (1969). Some Common Mosses of British Columbia. Brit. Col. Prov. Museum. Handbook No 28. Victoria, pp. 262.

Schuster, R. M. (1953). Boreal Hepaticae, A manual of the liverworts of Minnesota and adjacent regions. The American Midl. Nat. 49: 257-684.

Schuster, R. M. (1958). Annotated key to the orders, families and genera of Hepaticae of America north of Mexico. The Bryologist, 61: 1-66.

Schuster, R. M. (1984). Evolution, phylogeny and classification of the Hepaticae. New Manual of Bryology, Michinan, Japan, pp. 892-1070.

Sies, H. (1986). “Biochemistry of oxidative stress” Angewandte Chemie International, 25: 1058-1071.

Singh, A. P. and Nath, V. (2006). Studies on the genus Lopholejeunea (Spruce) Schiffn. from Meghalaya, India. Phytotaxonomy, 6: 26-38.

Singh, A. P. and Nath, V. (2007). Hepaticae of Khasi and Jaintia hills: Eastern Himalayas. Bishen Singh Mahendra Pal Singh, Dehra Dun, India, pp. 382.

Singh, A. P., Kumar, D. and Nath, V. (2008). Studies on the Genera *Frullania* Raddi and *Jubula* Dum. from Meghalaya (India): Eastern Himalayas. Taiwania, 53(1): 51-84.

Singh, D. K. (1994). Distribution of family Notothylaceae in India and its phytogeographical significance. Adv. Pl. Sci. Res. 2: 28-43.

Singh, D. K. (1997). Liverworts. In: Mudgal, V. and Hajra, P. K. (ed.), Floristic studies and conservation strategies in India, Dehra Dun, 1: 235-300.

Singh, M., Govindrajan, R., Nath, V., Rawat, A. K. S. and Mehrotra, S. (2006). Antimicrobial, wound healing and antioxidant activity of *Plagiochasma appendiculatum* Lehm. Et Lind. Journal of Ethnopharmacology, 107: 67-72.

Singh, R., Singh, S. K. and Arora, S. (2007). Evaluation of antioxidant potential of ethyl acetate extract / fractions of *Acacia auriculiformis* and *A. cunn*. Fod. Chem. Toxicol. 45: 1216-1223.

Singh, S. K. (2018). Contribution to the Hepaticae and Anthocerotae of Mizoram .ix Genus *Marchantia* L. The Indian Forester, 144(5): 461-464.

Singh, S. K. and Barbhuiya, H. A. (2008). Contribution to the Hepaticae and Anthocerotae of Mizoram. Three New Taxa of *Frullania* from India, Taiwania, 57(2): 106-116.

Singh, S. K. and Singh, D. K. (2007). Some new and noteworthy records of Hepaticae and Anthocerotae from Western Himalaya, India. Cryptog. Bryol. 28:257.

Singh, S. K. and Singh, D. K. (2009). Hepaticae and Anthocerotae of great Himalayan National Park and its environs (HP), India. BSI, Dehra Dun, India.

Singhal, M., Paul, A., Singh, H.P. and Dubey, S.K. (2011). Synthesis and evaluation of nitric oxide scavenging activity of methyl semicarbazone derivatives. Pharm. online, 1: 644-650.

Smith, G. M. (1938). Cryptogamic Botany Vol. II. Algae and Fungi I Edition. McGraw-Hill Book Company, New York and London, pp. 547.

Smith, G.M. (1955). Cryptogamic Botany Vol. II. Bryophytes and Pteridophytes II Edition. Tata MacGraw Hill Publishing Company Ltd., New Delhi, pp. 399.

Sodipo, O. A., Akiniyi, J. A. and Ogunbamosu, J. U. (2000). Studies on certain characteristics of extracts of bark of *Pansinystalia macruceras* (K schemp) picrre Exbeille. Global J. pure Appl. Sci. 6: 83-87.

Srivastava, A. and Srivastava, S.C. (2002). Indian Geocalycaceae (Hepaticae). A taxonomic study. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.

Srivastava, J., Lambert, J. and Vietmeyer, N. (1996). Medicinal plants: An expanding role in development. World Bank Technical Paper. No. 320.

Srivastava, K. P. (1964). Bryophytes of India. I. Ricciaceae. Bull. Nat. Bot. Gard. Lucknow, 104: 1-103.

Stephani, F. (1900-1924). Species Hepaticarum, 1-6. Génèva.

Takhtazan, A. L. (1953). Phylogenetic principles of the system of higher plants. The Botanical Review, 19: 1-45.

Taoda, H. (1972). Mapping of the atmospheric pollution in Tokyo based upon epiphytic bryophytes. Jap. J. Ecol. 22: 125-133.

Tewari, S. D. and Pant, G. (1994). Bryophytes of Kumaon Himalaya. Bishen Singh Mahendra Pal Singh. Dehra Dun, India.

Toyota, M. and Asakawa, Y. (1999). Sesquiterpenoids and cyclic bis(bibenzyls) from the Pakistani Liverwort *Plagiochasma appendiculatum*. J. Hattori Botanical Laboratory, 86: 161-167.

Trease, G. E. and Evans, W. C. (1989). Pharmacognosy.13th Ed. Balliere Tindall, London, pp. 176-180.

Ucuncu, O., Cansu, T. B., Ozdemir, T., Alpaykaraoglu, S. and Yayli, N. (2010). Chemical composition and antimicrobial activity of the essential oils of mosses (*Tortula muralis* Hedw., *Homalothecium lutescens* (Hedw.) H. Rob., *Hypnum cupressiforme* Hedw, and *Pohlia nutans* (Hedw.) Lindb. from Turkey. Turkish Journal of Chemistry, 34: 825-834.

Udar, R. (1976). Bryology in India: In Pama Primlane, (ed.), Chron. Bot. New Delhi.

Udar, R. and Srivastava, S.C. (1975). Notes on south Indian Hepaticae I. J. Bombay Nat. Hist. Soc. 72: 401-406.

Udar, R. and Srivastava, S.C. (1977). Notes on south Indian Hepaticae II. The genus *Herberta* Gray. J. Bombay Nat. Hist. Soc. 74: 255-263.

Vanderpoorten, A. and Goofinet, B. (2009). Introduction to Bryophytes. Cambridge University Press. Pp. 44.

Vitt, D. H. (1984). Classification of the Bryopsida. In The new manual of bryology 2.

Vitt, D. H. and Wieder, R. K. (2009). The structure and function of bryophyte dominated peatlands. In Bryophyte Biology. 2nd edn, eds. B. Goffinet and A. J. Shaw. Cambridge: Cambridge University Press, pp. 357-391.

Von Reusz, S. H. and König, W. A. (2004). Corsifurans A–C, 2-arylbenzofurans of presumed stilbenoid origin from Corsinia coriandrina (Hepaticae). Phytochemistry, 65(23): 3113-3118.

William C. S. (1954). Bryophytes: Botanical Review, New York Botanical Garden Press, 20: 425.

Wolters, B. (1964). Die Verbreitung antifungaler Eigenschaften bei Moosen. Planta, 62: 88-96.

Wu, P. C. (1977). *Rhodobryum giganteum* (Schwaegr.) Par can be used for curing cardiovascular disease. Acta Phytotax. Sin. 15: 93.

Wu, P. C. (1982). Some uses of mosses in China. Bryol. Times, 13: 5.

Wyatt, R. (1982). Population ecology of bryophytes. The Journal of the Hattori Botanical Laboratory, 52, 179-198.

Wyatt, R. (1994). Population genetics of bryophytes in relation to their reproductive biology. Journal of the Hattori Botanical Laboratory, 76: 147-157

Xu-Dan, G., Yu-Jie M., John, P., Jin-Ming, G., Liang-Li, Y. and Min, W. (2011). Phenolics content and antioxidant activity of tartary buckwheat from different locations, Molecules, 16: 9850-9867.

Yamaguchi, T. (1993). A revision of the genus *Leucobryum* (Musci) in Asia. Journal of Hattori Botany Laboratory, 73: 1-123.

Zechmeister, H. G., Grodzińska, K. and Szarek-Łukaszewska, G. (2003). Bryophytes. In: Markert, B. A., Breure, A. M. and Zechmeister, H.G. (eds) Bioindicators and biomonitors: principles, concepts and applications. Elsevier, Amsterdam, pp. 329-330.

Zhu, R. L., Wang, D., Xu, L., Shi, R. P., Wang, J. and Zheng, M. (2006). Antibacterial activity in extracts of some bryophytes from China and Mongolia. The Journal of the Hattori Botanical Laboratory, 100: 603-615.

Zinsmeister, H. D., Becker, H. and Eicher, T. (1991). Moose, eine Quelle biologisch aktiver Naturstoffe. Angewandte Chemie, 103: 134-15

BIO-DATA

NAME : Lalhriatpuia

FATHER'S NAME : Lalrelliana

MOTHER'S NAME : Zaihnuni

DATE OF BIRTH : 13. 03. 1988

ADDRESS : M-79(3), Tuithiang, Aizawl,

Mizoram- 7961001

ACADEMIC RECORD :

Sl. No.	Examination Pass	Subject	Board	Division with %	Year
1	HSLC	-	MBSE	67.8	2004
2	HSSLC	Science	MBSE	49	2006
3	B.Sc	Botany	MZU	66.5	2009
4	M.Sc	Botany	MZU	59.94	2011

Ph.D REGN. NO. AND DATE : MZU/Ph.D/674 of 23.05.2014

DEPARTMENT : Botany

TITLE OF RESEARCH : Diversity Assessment of Bryophytes in Mizoram and Phytochemical study of important medicinal species

SUPERVISOR : Dr. J. Lalbiaknunga

PARTICULARS OF THE CANDIDATE

NAME : Lalhriatpuia

DEGREE : Ph. D

DEPARTMENT : Botany

TITLE OF THESIS : Diversity Assessment of Bryophytes in Mizoram and Phytochemical study of important medicinal species

DATE OF ADMISSION : 20.08.2013

APPROVAL OF RESEARCH PROPOSAL

1. BOARD OF STUDIES : 29.04.2014

2. SCHOOL BOARD : 23.05.2014

MZU REGISTRATION NO : 325 of 2006-07

REGISTRATION NO. & DATE : MZU/Ph. D/ 674 of 23.05.2014

EXTENSION : Letter No. 16-2/MZU/(Acad)/15/321
Dated. 17th January, 2019
Extension up to 22.05.2021

HEAD

DEPARTMENT OF BOTANY

ABSTRACT

DIVERSITY ASSESSMENT OF BRYOPHYTES IN MIZORAM AND PHYTOCHEMICAL STUDY OF IMPORTANT MEDICINAL SPECIES

By

Lalhriatpuia

Department of Botany

Supervisor: Dr J. Lalbiaknunga

Submitted

In partial fulfilment of the requirement for the Degree of Doctor of Philosophy in Botany of Mizoram University, Aizawl

Bryophytes are a large group of non-vascular, spore bearing plants that includes mosses, liverworts and hornworts. They grow in moist and shady places on different habitats, they are strictly habitat specific, shade and moisture loving plants. They are the second largest group of plants after flowering plants, with estimated 15,000 (Hallingbäck and Hodgetts, 2000; Gradstein *et al*., 2001) to 25,000 species worldwide (Crum, 2001). Their life cycle involves a heteromorphic alternation of generation between sporophytic and gametophytic generations that differ in form and function. The actual plant is represented by the dominant gametophytic generation, which is the most evolved haploid generation in the whole plant kingdom. The sporophytic generation which remains attached to the haploid gametophytic plant is nourished by the gametophore. The spore mother cells, after meiotic division, form spore tetrads having haploid spores. The elater mother cells form elaters, which help in the dispersal of spores. Under suitable conditions, the spores germinate to form new gametophytes. Many species also reproduce asexually which enables them to survive in unfavourable conditions.

Bryophytes have been divided into three classes:

1. Hepaticopsida (Hepaticae - liverworts)
2. Anthocerotopsida (Anthocerotae - Hornworts)
3. Bryopsida (Musci - Mosses)

They contribute to a substantial proportion of the global biomass in a range of ecosystems and hence play a major role in the cycling of carbon and nutrients through growth and decomposition of peat. Bryophytes are an important component of the vegetation in many regions of the world. They play a vital role in functioning

of ecosystem, and constitute a major part of the biodiversity in moist forest, wetland, mountain, and tundra ecosystems. They help stabilize the soil surface against wind and water erosion by binding erosion-prone soil particles into more stable soil aggregates. They are important components of the hydrological, chemical, and organic matter cycles (Hofstede *et al.*, 1993; Rhoades, 1995). They play important roles as colonizers and soil stabilizers in areas where soil surface conditions have declined as a result of increased infiltration (Eldridge, 1993), a food source for birds and mammals (Longton, 1992), as nesting material and protective habitat for amphibians, various Bryophytes are used as herbal medicines (Flowers, 1957) for the treatment of cardiovascular diseases, boils, eczema, cuts, bites, wounds, and burns. Bryophytes hold rich reservoir of unique phytochemicals imparting them a strong defense mechanism to survive under highly diverse habitats despite having a non-lignified structure. There is huge potential to utilize this untapped resource in modern healthcare as eco-friendly antibiotics and antioxidants (Kandapal *et al*., 2016). They are potential sources of new antibiotics and anticancerous substances (Chopra and Vasishtha, 1994). They can be used as indicator species of air pollution (Taoda, 1972; Greven, 1992; Rao, 1982; Maschke, 1981; Mäkinen, 1987) and are also suitable as bio-indicators of water pollution. Bryophytes also have some ethnic values and possess antimicrobial and wound healing properties. They possess a large variety of secondary metabolites (Zinsmeister *et al.*, 1991) and thus provide considerable potential for biotechnological and biopharmaceutical applications. Several secondary metabolites and chemicals were isolated so far from different species but the mechanisms behind their activity are still widely unexplored (Beike *et al.*, 2010). Many Bryophytes are used as herbal medicines; the mosses and liverworts

are medicinal plants and are said to possess certain biological activity and effect; Antibacterial activity against gram-positive and gram-negative bacteria was reported from mosses (Merkuria *et al.*, 2005; Zhu *et al.*, 2006) and liverworts (Asakawa, 2007).

India has a rich and varied Bryophyte flora due to its diversified topography, variable climatic condition, and geographical position are important components of species diversity and flourish well in tropical, subtropical and temperate forest. Northeast India is unique from the biodiversity point of view that harbours rich Bryophytic wealth among bryogeographical regions of the country. The combination of different factors climatic, edaphic, temperature, precipitation, humidity, altitude, forest types favors growth of rich and luxuriant vegetation of Bryophytes. In spite of above facts, there is no floristic account of Bryophytes as well as utilization of plant resources of this region is available. In view of this knowledge gap, the present study focused on diversity and phytochemical analysis of Bryophytes growing in ecologically important forest sites of Mizoram.

Objective

The following aims were set to carry out the proposed work in this study under captivity:

1. Collection and identification of Bryophytes from selected sites.
2. Phytochemical screening and antioxidant activity of selected species.
3. To study antimicrobial activity of selected species.

Materials and Methods

Mizoram is located in the far northeastern part of India lying in between coordinates 21°56'N to 24°31'N latitude and 92°16'E to 93°26'E longitude. It has a climate ranging from moist tropical to moist sub-tropical and enjoys a moderate climate, it is neither too hot nor too cold and falls under tropical monsoon type of climate. The temperature ranges from 11°C to 24°C during winter and it varies from 18°C to 29°C during summer. The annual rainfall ranges from 2100 mm to 3500 mm. The region is influenced by south west monsoon and it usually rains from May to September. The study was confined to four districts of Mizoram i.e. Aizawl, Lunglei, Champhai and Mamit. The following protected areas were selected for study sites *viz*. Murlen National Park located in Champhai district, Dampa Tiger Reserve located in Mamit district, Tawi Wildlife Sanctuary located in Aizawl district and Thorangtlang Wildlife Sanctuary located in Lunglei District.

The collections of Bryophyte specimens were executed during May, 2014 - August, 2017. All the essential field data were noted with the help of GPS. The collected specimens of Bryophytes were placed in a handmade thick paper envelope having 10x14 cm in size with a field label data: altitude, collection number, date of collection, vegetation types, place of collection and associated habitats. The collected specimens were air-dried to avoid fungal damage.

The identifications of collected specimens were done at Central National Herbarium, Botanical Survey of India, Kolkata; Bryological Laboratory, National Botanical Research Institute, Lucknow, BSI, Shillong and Laboratory of Ecology and Biodiversity, MZU. The collected specimens were studied carefully with

microscopes, identified and described morphologically by their diagnostic characters. The identified species were described with the help of available literatures**,** given accession numbers and deposited to Laboratory of Ecology and Biodiversity, Department of Botany, School of Life Science, Mizoram University, Tanhril, Mizoram.

Four species of Bryophytes were selected for phytochemical study, consisting of two species of moss- *Atrichum undulatum* and *Pogonatum neesii* and two species of liverworts- *Dumortiera hirsuta* and *Marchantia linearis.* Powdered plants were extracted with 200 ml methanol in Soxhlet apparatus for 24 hours. The crude extracts of selected species were analysed for the presence of various phytochemicals such as: alkaloids, flavonoids, tannins, phenols, terpenoids, steroids and saponins by standard methods (Harborne, 1973; Trease and Evans, 1989).

Antioxidant activity of the crude extracts of selected species were estimated by the free radical scavenging activity using 1,1-Diphenyl-2-picrylhydrazyl (DPPH) assay method described by Huang *et al*.,(2005).

Antibacterial activity of methanolic extracts of selected species was tested against pathogenic gram positive bacteria *Bacillus subtilis* (ATCC-11774) and gram negative bacteria *Escherichia coli* (ATCC-10536) and *Klebsiella pneumoniae* (ATCC-10031) using Agar well diffusion assay method (Murray *et al*., 1995; Olurinola, 1996). The diameters of inhibition zone were measured and the results were expressed as mean ± SD of three replicates. The data were subjected to ANOVA using SPSS programme. P value ≤ 0.05 were regard as significant.

Results and Discussion

A total of 151 species belonging to 98 genera and 57 families have been identified and recorded from the study sites. Of these, the mosses are represented by 102 species of 68 genera and 37 families, while Liverworts are represented by 46 species of 28 genera and 19 families. Hornworts are represented by 3 species of 2 genera and 1 family. The most dominant family was Bryaceae having a total of 12 species followed by Dicranaceae with 11 species. The other dominant families were Jubulaceae, Lejeuneaceae, Neckeraceae and Polytrichaceae having 6 species each, followed by Marchantiaceae, Brachytheciaceae, Thuidiaceae with 5 species each; Aytoniaceae, Ricciaceae, Fissidentaceae, Funariaceae and Meteoriaceae with 4 species each; Anthocerotaceae, Plagiochilaceae, Leskeaceae, Mniaceae, Orthotrichaceae, Pottiaceae, Sematophyllaceae and Fossombroniaceae with 3 species each; Aneuraceae, Jungermanniaceae, Targioniaceae, Bartramiaceae, Erpodiaceae, Hookeriaceae, Leucodontaceae, Plagiotheciaceae, Rhizogoniaceae, and Trachypodaceae with 2 species each. All the other families have only 1 species each.

Among the selected study sites Murlen National Park harbours the highest Bryophyte diversity having 140 different species in 91 genera and 51 familes. *Dicranum scoparium*, *Hookeria acutifolia*, *Macrothamnium macrocarpum*, *Hypopterygium tamarisci*, *Neckeropsis crinita*, *Neckeropsis exserta* and *Trocholejeunea sandvicensis* occur only in Murlen National Park. A total of 122 species belonging to 80 genera and 46 families were collected from Dampa Tiger Reserve and *Myurium rufescens* occurs only in this site. From Tawi Wildlife Sanctuary a total of 132 species belonging to 88 genera and 49 families were

collected; *Tayloria hornschuchii* and *Solmsiella biseriata* occur in this site only. Thorangtlang Wildlife Sanctuary harbours the least number of Bryophyte in terms of diversity, a total of 116 species belonging to 73 genera and 43 families were collected from here. *Pogonatum proliferum* and *Bazzania tridens* occur in this site only.

Most of the Bryophyte species were common to all the selected sites except few species are present to two or three sites only. *Rhodobryum roseum*, *Fabronia assamica* and *Fissidens virens* were present at Murlen National Park and Dampa Tiger Reserve only. *Bryum alpinum*, *Riccia fluitans*, *Riccia glauca*, *Cyathophorella tonkinensis*, *Erpodium mangiferae*, *Entosthodon wichurae*, *Hookeriopsis utacamundiana*, *Neckera pennata*, *Pseudotaxiphyllum elegans*, *Riccardia chamedryfolia*, *Calypogeia arguta*, *Fossombronia himalayensis*, *Fossombronia indica* and *Fossombronia pusilla* were collected from Murlen National Park and Tawi Wildlife Sanctuary only. *Schoenobryum concavifolium* was present in Murlen National Park and Thorangtlang Wildlife Sanctuary only. *Aneura pinguis* was collected from Dampa Tiger Reserve and Tawi Wildlife Sanctuary only. *Campylopodiella stenocarpa* and *Frullania acutiloba* were collected from Dampa Tiger Reserve and Thorangtlang Wildlife Sanctuary only. *Marchantia paleacea* was identified from Tawi Wildlife Sanctuary and Thorangtlang Wildlife Sanctuary only.

Phytochemical screening revealed the presence of flavonoids, phenols, steroids and terpenoids in all the selected species. Alkaloids were present in *Marchantia linearis* and *Dumortiera hirsuta*; tannins were present in *Atrichum*

undulstum and *Pogonatum neesii*, while saponins were present in *Dumortiera hirsuta* only. The alkaloids and tannins were antagonistic for each other hence they were not always found together in single plant (Bartholow, 2005).

The methanolic extracts of all the selected species exhibited antioxidant activity by scavenging free radicals of DPPH, the highest activity exhibiting inhibition of DPPH radical at 67.00% by *Dumortiera hirsuta* at a concentration of 100 µg/ml. The efficacy of the extracts may be due to the presence of steroids, alkaloids, flavonoids and polyphenols in the methanolic extracts of the selected four species of Bryophytes. Among the methanolic extracts of the selected species *Dumortiera hirsuta* had the highest antioxidant activity with an IC50 value of 63.83 µg/ml followed by *Marchantia linearis* with an IC50 value of 81.81 µg/ml and that of *Pogonatum neesii* was 95.01 µg/ml. The extract of *Atrichum undulatum* had the lowest activity with an IC50 value of 113.23 µg/ml.

The crude extracts of all the selected species had shown positive results against the tested pathogenic bacteria. Among the selected species the crude extract of *Dumortiera hirsuta* has the highest antibacterial activity against *Klebsiella pneumonia*e with 18 mm diameter of inhibition zone. The crude extracts of *Atrichum undulatum* and *Pogonatum neesii* exhibited the least activity against *Bacillus subtilis* having 9 mm diameter of inhibition zone. The antibacterial activity could be due to the presence of terpenoids (Toyota and Asakawa, 1999). The significant values of one way analysis of variance (ANOVA) also validated the efficacy of the crude extracts of the selected species in treating the tested bacteria.

It has been observed that Mizoram harbours rich bryodiversity and the reported taxa were adapted to a wide range of habitats preferring shady, moist places of the plains or slope of hills in the study areas. All the species reported presently were new distributional records for the State.

Field observations revealed that the disturbances and threat to the bryodiversity of the state was associated with many human activities like expansion of agricultural lands, construction of roads, destruction of forests, execution of unplanned developmental activities; and habitat destruction through expanding human activities such as over exploitation of forest resources, shifting cultivation, expanding human population and other anthropogenic factors have resulted in degeneration of bryodiversity in this state. Therefore, serious attentions and efforts are required to save valuable bryoflora of this state.

Phytochemical screening revealed the presence of various phytochemicals in all the selected species. The extracts of all the selected species exhibited antioxidant activity as well as antibacterial activity. The efficacy of the extracts may be due to the presence of steroids, alkaloids, flavonoids and polyphenols in the selected four species of Bryophytes.

Further researches and studies involving isolation, characterization and purification of these phytochemicals and screening for antibacterial effects may result in the development of potent drugs which will be less toxic having high therapeutic value to mankind.