STUDY ON BRYOPHYTES AND THEIR ECONOMIC IMPORTANCE IN AIZAWL DISTRICT, MIZORAM

BY

TLANGTHANPUII TLANGTE

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Submitted in partial fulfillment of the requirement of the Degree of

Doctor of Philosophy in Environmental Science

Mizoram University, Aizawl.

CERTIFICATE

This is to certify the thesis entitled, **"Study of Bryophytes and their economic importance in Aizawl District, Mizoram",** submitted by Tlangthanpuii Tlangte, a research scholar in the Department of Environmental Science, Mizoram University Aizawl, embodied the record of the original investigation carried out by her, under my supervision. It is further certified that the scholar's bonafide researches and the research findings have not been submitted for the award of any degree in this or any other university or institute

She is now to submit the thesis for examination for the award of the Degree of Doctor of Philosophy in Environmental Science.

(PROF. H LALRAMNGHINGLOVA) (PROF. LALNUNTLUANGA)

DECLARATION

I, Ms. Tlangthanpuii Tlangte, hereby declare that the subject matter of this thesis entitled, **"Study of Bryophytes and their Economic importance in Aizawl District Mizoram"** is the research done by me under the supervision and guidance of Prof. Lalnuntluanga and Prof. H Lalramnghinglova Department of EnvironmentalScience, Mizoram University, Aizawl. The content 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 research degree in any other University or institute

This thesis is being submitted to the Mizoram University, Aizawl for the degree of Doctor of philosophy in Environmental Science

HEAD OF DEPARTMENT TLANGTHANPUII TLANGTE

SUPERVISOR

JOINT SUPERVISOR

ACKNOWLEDGEMENTS

It gives me a great pleasure to express my deep sense of gratitude and honor to my Supervisor Prof. Lalnuntluanga, Department of Environmental Science, Mizoram University, Aizawl, for his compassionate and excellent guidance.

I am very much grateful to my Co – supervisor Prof. H. Lalramnghinglova for rendering necessary guidance, valuable suggestions, immense knowledge and constant encouragement during the course of study.

I am grateful to all faculty member of the Department of Environmental Science, Mizoram University, for providing all necessary helps required during the research work.

I wish to express my sincere gratitude and indebtedness to all the villagers of the villages which were visited during the research work for their kind hospitality, and for sharing their valuable knowledge and information.

I would also like to express my heartfelt thanks to the National Botanical Research Institute (NBRI) for their kind help in identification and consultation of herbarium.

I am grateful to all my colleagues at Government High School Samlukhai who were kind and patient, always understanding and co – operative during the research work.

I also thank my family and friends for their constant support, encouragement and enthusiasm throughout the research work.

I am deeply grateful to all my research fellow for helping me in my field works, without whom the completion of this study would not have been possible.

Above all, I thank the Almighty God for the countless blessings and guidance that he bestowed upon me. His unending provisions helped me in every bit of my work.

Date: (TLANGTHANPUII TLANGTE)

CONTENTS

List of Tables

List of Figures

CHAPTER – 1

INTRODUCTION

Bryophyta, a division of plant kingdom, includes mosses and allied plants; commonly describe as liverworts. Mosses are very small plants, at times microscopic, differentiated into stem and leaves. Liverworts are macroscopic plants which are thalloid as well as leafy. Bryophytes are essentially small plants from a few millimeters to a few centimeters. Exceptionally, some of the mosses attain giant proportion (70 – 100 cm) and there are some giant thallose liverworts. They are widely distributed and generally confine at an altitudinal ranges between 1000 – 8000 m. They are an important component of vegetation in many regions of the world and constitute a major components of biodiversity in moist environments, wetlands and mountain ecosystems (Hallingback and Hotsgetts, 2000). They are one of the oldest groups of plants and represent significant element of diverse vegetation complexes. Their role in terrestrial ecosystems, such as modification of habitat, nutrient cycling and maintenance of soil nutrient status, primary production etc. is significant (Brown, 1982, Pocs, 1982). Their biomass production is important in sub-arctic ecosystems and mountainous tropical rain forests (Longton, 1988; Pòcs, 1980), but they are significant ecological factor in a variety of habitats (e.g. bogs, water springs, alpine grasslands). On the other hand, a wide range of species can grow in areas unable to be colonised by any other plant which is significant for many aspects in bioindication also. Bryophytes colonise nearly every kind of terrestrial substrate (e.g. bare stones, bark, skeletons, etc.) and grow in freshwater but are absent from saline water bodies (salt lakes, oceans).

Bryophytes occupy an important place in the plant kingdom, although they were thought to be of little economic value. They are the simplest and the most primitive of the land plants. They are the pioneers to colonise terrestrial habitat from aquatic environment. Their adaptation to a terrestrial mode of life is partial as water is indispensable in one stage or another in their life cycle. Hence, they are also known as the *amphibians* of the plant kingdom. They have a remarkable capacity to absorb water and turn fresh in no time, which has given them the name, the *resurrection plants*. These plants occur more commonly during rainy seasons and also in humid areas. Their growth is gregarious and within a short period they become as abundant as to occupy large areas, but usually do not form a very conspicuous part of the vegetation. Though basically terrestrial, there are a few aquatic forms such as *Riccia fluitans, Ricciocarpus natans* and *Riella spp*. Moreover, *Cryptothallus* and *Buxbaumia* are saprophytic genera of liverworts and mosses on contrary to the rest of the bryophytes, which are autotrophic. In comparison with higher plants use of bryophytes for human consumption is negligible due to their low caloric value (Forman, 1968) and poor organoleptic properties. Traditionally, use of bryophytes as a food source is limited for famine periods; however in Northern regions of Europe and America bryophytes are used as an ingredient of bread or soup. In circumpolar regions bryophytes are a common animal feed (Glime, 2007). Despite their small size, they comprise major components of the biomass and photosynthetic production in forest ecosystems (Frego, 2007). Bryophytes are widely used as bioindicators of environment for their unique capacity to absorb the pollutants and very specific responses as some species are extremely sensitive to pollutants and exhibit visible injury symptoms even in the presence of very minute

quantities of pollutants (Sahu, *et al.,* 2007). They have several biological features making them particularly suited to serve as study organism in macro evolutionary population genetics and ecological research. Bryophytes are used in medicines, household purposes, horticulture, agriculture, and fuel in industries and as ecological indicators throughout the world (Nath and Asthana, 2005). They play a significant role in the global carbon budget and CO_2 exchange (Delucia *et al*., 2003), plant succession (Cremer and Mount, 1965), production and phytomass (Frahm, 1990), nutrient cycling and water retention (Pócs 1980). They also play a significant role in fungal symbioses which is a new insight in the Twenty First Century (Pressel *et. al*., 2010). Some acrocarpous mosses like *Grimmia anodon* Bruch and Schimp. and *Tortella tortuosa* (Hedw.) Limpr. have antifungal and antibacterial properties (Elibol *et. al.*,2011). Bryophytes due to the presence of high number of biologically active compounds in their composition are commonly used in ethnopharmacology and as medicinal plants for treatment of wounds and burns (Asakawa *et al*., 2013; Cheng *et al*., 2012; Fu *et al*., 2012; Singh *et al*., 2006). More specifically bryophytes demonstrate antibacterial, antifungal, antiviral activities, antioxidant, antiplatelet, antithrombin, insecticidal, neuroprotective activities, as well as cytoxicity in respect to cancer cells (Spjut *et al*., 1986; Cheng *et al*., 2012).

The division Bryophyta (Gr. bryon=moss) includes over 25000 species of non-vascular embryophytes such as mosses, liverworts and hornworts. Bryophytes are small plants (2cm to 60cm) that grow in moist shady places. They don't attain great heights because of absence of roots, vascular tissues, mechanical tissues and cuticle. They are terrestrial but require external water to complete their life cycle. Hence, they are called "Amphibians of plant kingdom". The fossil record indicates

that bryophytes evolved on earth about 395 – 430 million years ago (i.e. during Silurian period of Paleozoic era). The study of bryophytes is called bryology. Hedwig is called 'Father of Bryology'. Shiv Ram Kashyap is the 'Father of Indian Bryology'.

Liverworts (hepatics) as well as mosses (musci) are worldwide in distribution and are capable to grow abundantly in humid climate of temperate and tropical region. Liverworts are luxuriantly represented in humid tropics and become rare in arctic environment. Mosses can, however, survive in severe condition of arctic and alpine region and can also stand submergence in water to semi-arid conditions. Some of the mosses pull through after years of dehydration and others can withstand extensive periods of freezing. A few mosses can be seen growing on the seashore but bryophytes are not recorded from sea.

Bryophytes have special nature to grow on certain habitats such as rocks of preferred type, barks of especial type, decomposed logs and stumps, on such soil, which have a suitable moisture and humus, exposure and pH. Moss carpet on the forest floor provides suitable substrata for seed germination and seedling growth of higher plants. Many species of Sphagnum are aquatic some time they form floating mates. *Riccia fluitans* is also an aquatic bryophyte. Some bryophytes are saprophytic in nature as *Buxbaumia* and *Cryptothallus*, which generally grow on the dead organic matter, Cryptothallus totally lack chlorophyll and nutrients are absorbed by the associated *mycorrhiza* (Bahuguna *et al.,* 2013). The special character of the bryophytes is that they absorb water within no time and get fresh when they are dried in unfavorable conditions, thus they are also named as "Resurrection plants". The

epiphytic bryophytes are found in tropical rainforests, with plenty of water and nutrients. Thus, the broad leaves forest create a good environment for these lower plants. Epiphytic bryophytes occur on irregular surface of bark and twigs and depression on branches as well as require fissures for their establishment, which provide a place for them as well as humus and moisture. In alpine regions, a rich vegetation of turf forming bryophytes occurs and the species diversity is very high within a limited space. It has also been observed that where organic material rich soil is present, there is the richer bryoflora, along with the vascular (Bahuguna *et al.*, 2013).

According to the latest recommendations of ICBN (International Code of Botanical Nomenclature), bryophytes have been divided into three classes.

1. Hepaticae (Hepaticopsida = Liverworts)

2. Anthocerotae (Anthocertopsida= Hornworts)

3. Musci (Bryopsida= Mosses)

India is one of the 12 mega diversity countries in the world. The large area and the variety of phytoclimatic conditions within its different biogeographical zones contribute to the great diversity of the flora. These biogeographical zones with diverse topographical variations and climatic conditions have been devided into seven bryogeographical regions. They are Western and Eastern Himalaya, Punjab and West Rajasthan, Gangetic Plains, central India, the Western and Eastern Ghats and the Deccan Plateau (Daniel and Daniel, 2013). Bryophytes thrive in humid climates, but can be found all over the world, even in arid regions. As a consequence

of slow evolution (Szweykowski, 1984), many dominant species can be found all over the world, or show at least a circumpolar distribution.

A total of 2489 taxa of bryophytes reported from India, comprising 1786 species under 355 genera of mosses, 675 species under 121 genera of liverworts and 25 species under 6 genera of hornworts (Dandotya, 2011). A total of 31 species of bryophytes including 20 liverworts, 2 hornworts and 9 mosses under 17 family and 22 genera are reported for the first time from the Bothamalai hills in the Eastern Ghats of India (Dash *et al*., 2009). All the species reported here are new distributional records of occurrence for the State. The distribution of species at different altitudes and different microclimates were encountered in the hills. Currently the critical habitat of the bryophytes is under threat against the ongoing anthropogenic activities like open cast mining in this region. 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). Barukial (2011) has done the enumeration of 127 species of Mosses under 71 genera belonging to 27 families from the Assam Valley Wet Evergreen forests, Assam, India. Manju *et al.* (2008) have published the checklist of the bryophytes of Kerala, India. In the checklist a total of 465 bryophyte taxa are accepted, comprising 148 taxa of liverworts, 10 taxa of hornworts and 307 taxa of mosses. Western Ghats (includes Nilgiris, Anamalais, Palnis and Agasthyamalai) and the Eastern Ghats (includes Shervaroys) bryogeographical regions. (Daniels 2010).

Growth of human population and a need to develop healthy diets requires looking for new, alternative food as well as for sources of important food ingredients,

like antioxidants. Further, caloric value of food considering abundance of high calority food nowadays, is by far not the main direction of activities in search for alternative food plants (Haines and Renwick, 2009). In this respect bryophytes are highly relevant and prospective object of studies. Nowadays bryophyte availability for practical applications does not depend on their field sampling possibilities, but they can be grown using biotechnological approaches (in reactors) as axenical cultures, but also in large scales (ton quantities – Sphagnum farming) (Beike *et al*., 2010; Pouliot *et al*., 2014). To advance the studies of alternative food sources, it is important to study bryophyte and their extract composition.

Typically bryophytes show a decline in vitality, which, for example, can be detected by changes in colour following damages in the chloroplast structure or less vigorous growth by individuals or populations. Sometimes there is also a change in the reproduction mode, favouring asexual reproduction under stress. The ultimate response is population loss and finally extinction. It is alarming to note that very small action has been taken to counteract the deterioration of the bryophyte flora in a global context, and even less has been done in terms of local, practical bryophyte conservation (Hallingbäck, 1995). The conservation of bryophyte is very important in view of their critical role in ecosystem dynamics. They can be conserved by establishment of moss gardens and protected areas, sacred groves and in-vitro technique and also by regular monitoring, and periodic collection of data on rare and threatened species (Dandotya *et al.,* 2011). Bryologists are becoming increasingly aware of the threatened status of the bryophyte flora, and resolutions expressing concern have been adopted at various conferences (Geissler 1982, Tan *et al*., 1991; Koponen, 1992; Bisang and Urmi, 1995). Bryophytes are threatened partly because

of their morphology and reproduction rates. They are fragile organisms, sensitive to drought, and have a relatively low growth rate and therefore desiccate quickly during periods of dry weather. They are highly vulnerable to disturbance and also extremely sensitive to pollution as they lack a cuticle. Bryophytes are also threatened because of their lack of "image" within the sphere of nature conservation. They are not large, charismatic species, and this, coupled with a lack of understanding of how they contribute towards ecosystem functioning, often results in their being overlooked by the general public and conservation groups. Unfortunately, many areas of the lowland regions of East and Southeast Asia where species diversity is extremely high are highly threatened due to habitat destruction. (Hallingback and Hodgetts, 2000).

1.1 Scope of study

Despite their small size, they comprise major components of the biomass and photosynthetic production in forest ecosystems (Frego, 2007). Different kinds of anthropogenic activities like population growth, urbanization, agriculture, and clear felling practice together with monoculture, infrastructure development, over exploitation of natural resources result in the modification of the microclimate which can lead to the complete habitat loss, deterioration of traditional management system have cause tremendous threat to the existence of bryophyte in the state. A number of bryophytes are exposed to constantly increasing infringement upon natural vegetation, large area are being removed annually. The bryophytes are unique group of plant 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). Therefore, it appears that an extensive decline has occurred since the main cause of which is certainly the increasing level of deforestation throughout the State. The topography of Aizawl District Mizoram which include, temperate forest, sub-tropical forest, tropical forest and the forest which lies between tropical and sub- tropical forest. The combination of different forest types, climatic factor, edaphic factor, temperature, precipitation, humidity, altitude, favors growth of rich and abundant vegetation of bryophytes. So this study is expected to have an outcome on the distribution, economic importance and status of Bryophytic flora of Aizawl district, Mizoram. These will ensure the protection and conservation of rare and potentially economic important Bryophyte.

1.2 Objectives:

2 To document detailed account of bryophytes of the study area

3 To document the economic importance of bryophytes

CHAPTER – 2

Review of Literature:

2.1 Global:

Bryophyte communities are known for the fact that their species composition and richness is strongly influenced by external factors, especially water, light and temperature (Mägdefrau, 1982), which makes them efficient bioindicators (Frahm and Gradstein, 1991). Therefore, they constitute an important component of tropical rain forests, which provide microhabitats with diverse substrates and moderate luminosity, important factors for the establishment of members of this plant group (Pócs, 1982; Richards, 1984). Bryophytes are also quite sensitive to differences in elevation, their species richness increasing at higher elevations (Van Reenen and Gradstein, 1983; Kessler, 2000; Frahm, 1990; Frahm and Gradstein, 1991; Ah-Peng, *et al.*, 2007).

East and Southeast Asia are extremely rich and diverse in bryophytes taxa, especially as they are very diverse in topography, climate and vegetation (Hallingback and Hodgetts, 2000). Research on the distribution of liverworts in the great Himalayan National park was carried out by Singh and Singh (2008) and presence of 92 species, 39 genera under 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. India reports total 2489 taxa of bryophytes comprising 1786 species in 6 genera of hornworts (Dandotiya *et al.*, 2011).

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

The study of the flora within the Chapada Diamantina Brazil, which encompasses Chapada Diamantina National Park, intensified after 1970, most of the research being focused on the *campos rupestres*. Beginning in the late 1990's, the focus shifted to the forest areas and floristic surveys became the norm (Funch, 2008; Ribeiro-Filho *et al.*, 2009). Such studies are widely recognized as being of great importance, because many forests in the region have been destroyed by human activities, mainly to create pasture and extract timber (Funch, 2008). The bryophyte flora of the Chapada Diamantina region is rich and diverse, accounting for 80% of the taxa recorded for the State of Bahia, Brazil (Valente *et al*., 2011), and 54% of those taxa occur in forest areas (Valente *et al*., 2013). Bryophyte diversity has also been studied in other forest areas of Bahia. Surveys of mosses and liverworts conducted in areas of lower montane Atlantic Forest, in the Serra da Jiboia mountain range, near the municipality of Santa Teresinha (Valente and Pôrto, 2006; Valente *et al.*, 2009), resulted in the identification of 121 bryophytes species. Similar studies, conducted in areas of lowland Atlantic Forest near the city of Igrapiúna, North-East

region of Brazil (Bastos and Valente, 2008; Bastos and Bôas-Bastos, 2008), identified 225 species.

The fossil record of mosses is a poor indicator of absolute age of the phylum and its main lineages. Unequivocal records date from the Carboniferous (Kenrick and Crane, 1997) and *Sporogonites*, from the lower Devonian, exhibits sporophytic characters reminiscent of mosses, but in the absence of gametophyte its affinities remain ambiguous. Inferences from variation in chloroplast sequence data suggest that the transition to land occurred 425 - 490 mya roughly during the silurian or Ordovician period (Sanderson, 2003), an estimate congruent with microfossil evidence (Edward 2000, Wellman and Gray, 2000, Wellman *et al*., 2003). Another estimate based on sequence data suggests, by contrast, an origin of the terrestrial flora at about 1000 mya, with a divergence between mosses and polysporangiophytes as early as 700 mya (Heckman and Geiser, 2001).

In the early 1980s, Crosby (1980) and Vitt (1984) proposed two distinct views of bryophyte phylogeny, and in particular the relationships among the Bryopsida *sensu* Vitt. Mishler and Churchill (1985) provided the first formal cladistic analysis of the mosses. Only over a decade later have these hypotheses been critically tested further, based on inferences from earlier DNA sequence data alone or in combination with morphological characters (Newton, *et al*., 2000). Emerging from the analyses of different hypothesis are the following hypoyhesis, *Takakia* and *Sphagnum* compose the earliest divergence, but their relative branching order remains ambiguous (Renzaglia *et al*., 2007). Similarly, the Andreaeopsida and Andreaeobryopsida may compose a grade or a clade. One major contribution of these

recent studies is the resolution of *Oedipodium* as a sister taxon to all peristomate (Newton *et al*., 2000).

Bryophytes possess a large variety of secondary metabolites and thus provide a considerable potential for biotechnological and biopharmaceutical applications (Zinmeister *et al.,* 1991). 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)

Bryophytes are useful to human beings as well as to other organisms and the environment in many ways. They are the secondary colonizers on barren rocks next to lichens in plant succession in xerosere. Thus they help in weathering of soil. They are extremely good soil binders as they form large mats on forest floors and roadside cuts, thus controlling soil erosion. They are a good source of humus and hence a heaven for a number of soil-dwelling invertebrates likes earthworms. They form very good seed beds for seedlings and saplings particularly in evergreen forests. They are very good indicators of environmental pollution. Thallus extracts of *Marchantia polymorpha* and *Lunularia cruciata* show antifungal and antibacterial properties. A number of liverworts are known to be rich sources of terpenoids such as sesqui and diterpenoids, and also aromatic compounds. They are very good laboratory specimens to carry out experiments on hybridization, apogamy, apospory, DNA targeting and also to understand the process of evolution of land plants. They are also used in decorations in bouquets, vases.

2.2. National: India is one of the 12 megabiodiversity countries in the world**.** Indian sub-continent with different landscape and climate in different parts provides complimentary environment for the abundant growth of bryophytes. The country has been broadly divided into three major zones. North – Western Himalayas and adjacent regions, North – Eastern Himalayas and adjacent regions, South India (Vashistha, 1998). The large area and the variety of phytoclimatic conditions met within its different bio-geographical zones contribute to the great diversity of the Indian flora. These biogeographical zones with diverse topographical variations and climatic conditions have been divided into 8 bryogeographical regions Singh (1997): West Himalayan territory, East Himalayan territory, Punjab and west Rajasthan Plains, Gangetic Plains, Central India, Western Ghats, Eastern Ghats & Deccan Plateau, Andaman & Nicobar. Subsequently, Srivastava (1998) recognized seven bryogeographical regions in the country: The West Himalayan territory, The East Himalayan territory, Punjab and the west Rajasthan Plains, Central India, Gangetic plains, West coast region, East coast region.

Moss flora of Nilgiri Hills have been studied and the detailed accounts are available ie. Studies on moss flora of Nilgiri hills (Tamil Nadu) South India (Yadav S. 2015). Mosses of Himalayan regions have been worked out and the detailed accounts are available in Taxonomy of Indian mosses (Chopra, 1975), Mosses of western Himalayas and adjacent Plains (Chopra and Kumar, 1981), Mosses of Eastern India and adjacent regions (Gangulee, 1969 - 72), Hypnobryales Suborder Leskeineae (Musci) of the Himalayas (Vohra, 1983). Hepaticae and Anthocerotae of Great Himalayan National Park and its Environs (HP), India (Singh and Singh, 2009). Hepaticae of Khasi and Jaintia Hill (Singh and Nath, 2007). Work on The

Bryoflora of the Souththernmost and Western Ghats have been carried out by Daniel and Daniel (2013). Their works deals with 240 species and 13 intraspecific taxa belonging to 101 genera, 51 families and 16 orders in the southernmost, Western Ghats India..

Checklist of Bryophytes of India (Dandotya *et al.*, 2011); Bryophytes of Chinnar Wildlife Sanctuary (South India) a preliminary account (Manju *et al*., 2006); Mosses of the southern Western Ghats (Daniels and Daniel, 2007); Checklist of the Bryophytes of Kerala (Manju *et al*., 2008); Contribution to the bryophyte flora of India: the Aralam Wildlife Sanctuary in the Western Ghats (Manju *et al*., 2009a); Contribution to the bryophyte flora of India: Agasthyamalai Biosphere Reserve in Western Ghats (Manju *et al.* 2009 b); Moss Flora of Palni Hills (Tamil Nadu) India-A Checklist (Alam *et al*., 2011); Checklist of the bryophytes of India (Dandotya *et al.*, 2011); Moss flora of Shervaroy hills of Eastern Ghats (Kumar and Krishnmurthy, 2007); Diversity of Bryophytes in Eraviculam National Park, Kerala (South India) (Madhusoodan *et al*., 2007); Bryophyte Diversity in Mukteshwar (Uttarakhand): An Overview (Asthana and Sahu, 2013); Current Status of Genus Bryum Hedw. in Eastern Himalaya (Bansal and Nath, 2013) and Moss flora of Western Himalayas, India - An updated Checklist (Alam, 2013); Check-list of Mosses (Bryopsida) of the Kalrayan hills in the Eastern Ghats of Tamil Nadu (Sathish *et al*., 2014); A checklist of the mosses of Karnataka, India (Frahm *et al*., 2013); A Contribution to the Bryoflora of the Western Ghats in Karnataka State (Schwarz and Frahm, 2013) and An Updated Checklist of Bryophytes of Karnataka (Schwarz, 2013). A checklist of Indian Mosses (Lal, 2005); A Study of Moss diversity in Assam valley wet evergreen forests (Barukial, 2011); Study of Moss Flora and Growth Forms of Moss in Varied

Habitats in Dharmashala of Kangra District (H.P), India (Choyal and Sharma, 2011); Distribution of Moss in the Topography of Kangra District (H.P) (Sharma and Choyal, 2011),

The information of the liverworts relies typically on the works of Stephani (1900 - 1924), Chopra (1975, 1943), Kachroo (1970a, 1970b, 1973), Udar (1957, 1965), Udar *et al.* (1964, 1981, 1982a,1982b, 1983), Joshi and Biradar (1984), Asthana and Srivastava (1991), Nath and Asthana (1998), Asthana *et al.* (1995), which affect to diverse localities in southern India. The most current works are by Daniels and Daniel 2003a, 2003b, 2004, Kumar and Maniselvan (1994), Maniselvan and Kumar (1998), Maniselvan and Kumar (2000), Nair and Madhusoodhanan (2001, 2002) in Kerala, Easa (2003) which is credentials of bryophytes of Kerala, mostly based on former works.

The preliminary work on the Indian mosses date back to 1741 by Dillenius in his *Historia muscorum* which was go after much later by Linnaeus in 1753, where he incorporated several Indian mosses along with higher plants in his Species *Plantarum*. Soon after, Hamilton (1802), a medical officer in the British Embassy, prepared a collection of mosses from Nepal which was published by Hooker in 1808 as *Musci Nepalensis*. It was merely after these further severe studies on mosses were taken up by Hooker where he described several new species. In 1825 he in co-operation with Greville, Hooker published two papers on Indian mosses. In 1826 - 27, Schwägrichen incorporated a number of Indian mosses in his enhancement to Hedwig's Species *Muscorum*

The only other wide-ranging work on Indian mosses that gives several information on the environment and distribution of the South Indian mosses counting the Western Ghats is Gangulee's Mosses of eastern India and adjacent regions (1978 - 1980). Montagne (1842) reported 100 species of mosses from Nilgiris (Tamil Nadu) in his Cryptogamae Nilgheriensis, Müller (1853) reported more than 100 species of mosses from Nilgiris in Musci Nilgheriensis, Mitten (1859) reported over 700 species in his Musci Indiae Orientalis. Foreau (1961, 1964) listed 368 species from the Palni hills (W. Ghats of Madurai) which included 95 new species and 15 varieties.

2.3 North East India: Recently, a number of new records of bryophytes of Nagaland have been reported by Nath *et al*., (2011), Eshuo and Chaturvedi (2011), Chaturvedi *et al.*,(2011a), Chaturvedi and Eshuo (2012), Chaturvedi and Chaturvedi (2008). Singh and Barbhuiya (2008) made a study on Hepaticae and Anthocerotae of Mizoram and described three new taxa of Frullania from the State. This result provided motivating feature of finding and discovering further more new species of bryophytes by further studies and researches. Singh and Nath (2007) carried out the study of bryophytes in Meghalaya which helped in documentation of Hepatic wealth of the region and very promising findings in the form of discovery of new species and new records were made. In recent times, a number of studies on bryophytes have made important contribution to the Bryophyte flora of the eastern region of India and adjacent plains (Gangulee, 1980).

Lalhriatpuia and Laha(2015a) has made a study on Bryophytes diversity in Mamit district Mizoram and a total of 65 taxa of bryophytes distributed under 50

genera and 36 families have been recorded for the first time. Another study on Diversity of Bryophytes in Aizawl District, Mizoram has been made and a total of 41 taxa of bryophytes distributed under 34 genera and 24 families (Laha and Lalhriatpuia, 2015b). Singh and Barbhuiya (2012) reported several liverworts and hornworts from Assam. Singh and Barbhuya (2008) made a study of Hepataceae and Anthocerote of Mizoram and describe three new taxa of *Frullania* from the State. The results provide an interesting aspect of finding and discovering more and more new species of bryophytes through inepth studies.

CHAPTER – 3

STUDY AREA

3.1. A brief information of Aizawl district Mizoram

The state of Mizoram is located in the intense corner of Northeast India in between 21°58'N and 24°36'N latitudes and 92°29' E longitudes and surrounded by the State of Assam in the North, Manipur in the Northeast, Myanmar in the East and Bangladesh and Tripura in the West. Aizawl District located at Latitude 23.7, Longitude 92.7, and is selected as the study area owing to its representation on tropical, sub-tropical and temperate climatic conditions, these different combinations of forest types, different adaphic factor and climatic factor, different temperature and altitude is expected to have the greatest diversity and abundant vegetation of bryophytes. It is one of the eight districts of Mizoram in India. The District is bounded on the North by Kolasib district, on the west by Mamit district, on the south by Serchhip district and on the east by Champhai district. The district occupies an area of 3,576.31 square kilometres (1,380.82 sq mi). The total forest cover is 86.5 % of the total geographical Area including very dense forest (18 Sq. Km) moderately dense forest (1092 Sq. Km) and Open Forest (1984 Sq. Km) (Indian State of forest, 2017). The headquarters of the district is Aizawl city, the capital of Mizoram, the city is located North of the Tropic of Cancer in the Northern part of Mizoram and is located on the ridge 1132metres above the sea level, with Tlawng river valley to its West and Tuirial river valley to its east, in the summer the temperature ranges from 20°C - 30°C and in winter 11°C - 21°C. As on 2011 it is the most populous district of Mizoram. The District has 5 RD blocks Aibawk, Darlawn, Phullen, Thingsulthliah

and Tlangnuam. According to 2011 census Aizawl district has a population of 404,054 persons with a density of 113 inhabitants per square kilometre. Location map is shown in Fig.3.1

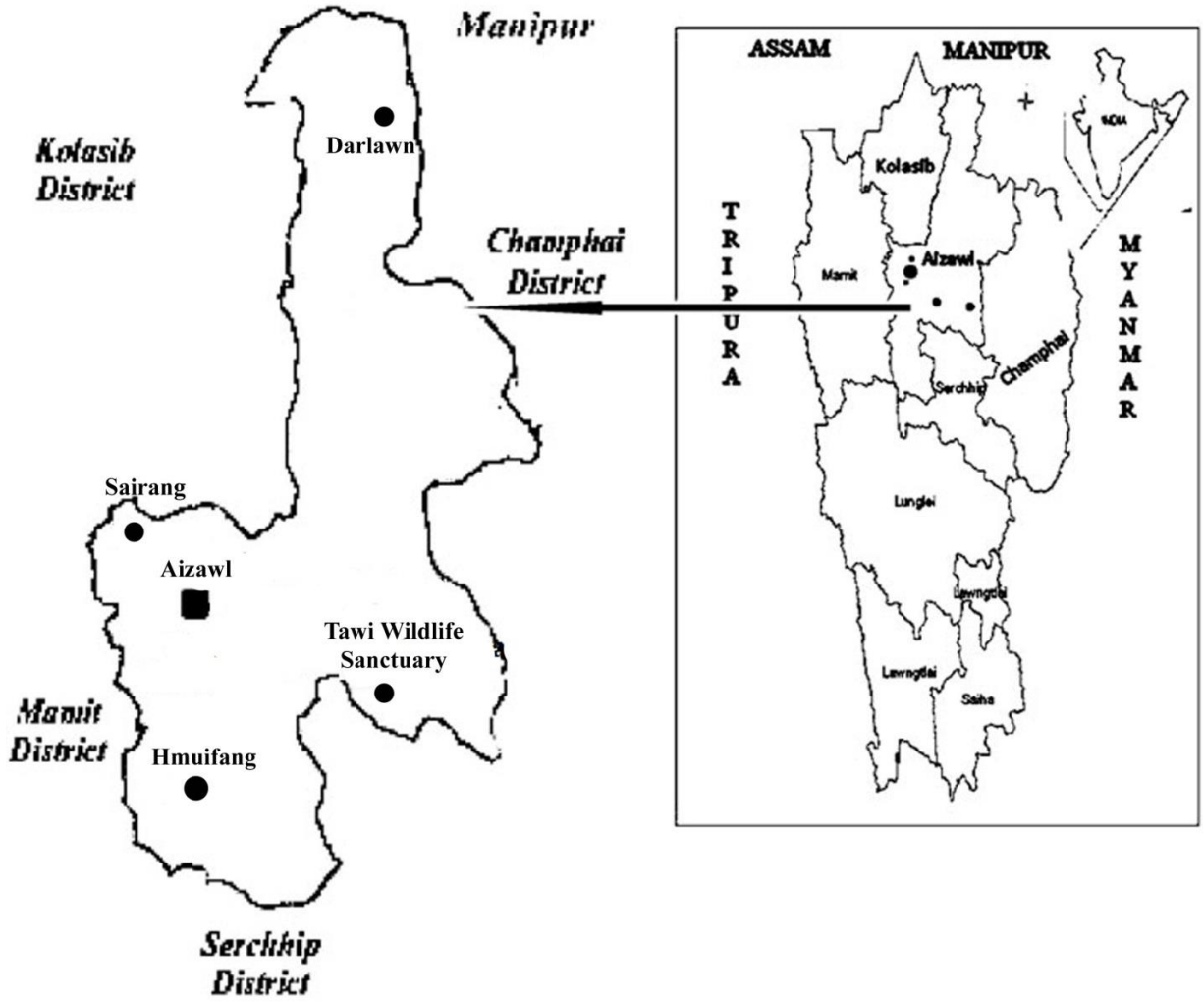

Fig.1. Map of Aizawl district showing location of study sites

3.2 Study sites:

The following sites are selected randomly for the generation of field data on the east, west, south, north and central part of Aizawl district.

3.2.1 Study Sites under Darlawn Forest division includes:-

(a) Road sides and forests of Aizawl to Darlawn → Sakawrdai villages (North-Eastern part).

(b) Aizawl to East.Phaileng → Suangpuilawn→ Vanbawng villages (Mid-Eastern part).

(c) Aizawl to Saitual→ Phullen→, Phuaibuang→, Khawlian. → NE. Tlangnuam (Hill ranges Eastern part)

Darlawn forest Division is situated at 24º 1′ 0″ North latitude, 92º 54′ 0″ East longtitude of Mizoram, its altitude ranges from 500 – 1178 metres, occupies an area of 1538 Sq.Km, it was established in 1981. Towards the North it start from the point where the river. Tuirial crosses an inter-state boundary of Mizoram and Assam. Towards the east the boundary follows inter – State boundary between Manipur and Mizoram up to the point where inter-state boundary meets river Tuivai. Towards the south the boundary crosses the source of Tuiriza lui crossing Chhirdem lui till it meets river Tuivawl. Towards the west the boundary follows river Tuirini downstream up to where it meets river Tuirial, the boundary goes along river Tuirial downstream up to the inter-state boundary between Mizoram and Assam. This study Area represents forest types between topical and sub-tropical forests.

3.2.2 Tawi wildlife sanctuary (South Eastern part): Tawi Wildlife Sanctuary is located in the South eastern part of the Aizawl District Mizoram, at 23º 32′ 02″ North latitude and 92º 56′ 48″ East longitude. Occupying an area of 35.75 Sq.km, with an altitude ranges from 500m – 1890m above the sea level, and is situated about 101

km, from the state capital Aizawl towards east. The forest is of tropical and temperature in summer ranges between 20°C – 30°C and in winter 16°C – 20°C. The sanctuary was notified as a reserved forest in 1978 vides Government of Mizoram Notification No. FOR. 15-C/74-78/21 dt.29.11.78. One of the first Sanctuary in Mizoram, the forest is protected area and moderately rich and unexplored and harbors a unique and diversified flora. The climate of Mizoram is tropical monsoon type of climate. So, Tawi Wildlife Sanctuary which is located in Aizawl District falls under the North Central part of the state enjoys a moderate climate owing to its tropical location. Aizawl District falls under the direct influence of South West monsoon. As such the area receives an adequate amount of rainfall which is responsible for humid tropical climate characterized by short winter and long summer with heavy rainfall. The soil is acidic in nature due to heavy rainfall it contains a high amount of organic Carbon and is high in available Nitrogen low in Phosphorous and Potassium content. On the basis of rainfall and humidity the soil moisture is classified as Udic and the classification of the soil has been done according to soil taxonomy on the basis of their physiochemical and morphological properties. Most of the streams within Tawi Wildlife Sanctuary flow towards the Western side, while few streams namely Vaidan Lui, Khuai Lui and their tributaries flow towards East.

3.2.3 Hmuifang subtropical forest (Southern part): Hmuifang area is situated in the Southern part of Aizawl at about 50 km away from the state capital Aizawl with an average elevation of 1619 m. The survey area lies between the co-ordinates 23°27′22″ N - 23°27′31″ N latitudes and 92°45′19″ E - 92°45′24″ E longitudes. The mountain area is still covered with virgin forests reserved for a very long time but is

now under threats due to anthropogenic activities. Hmuifang tourist Resort, located at the scenery peak of the mountain which has been created and maintained by the Department of Tourism Mizoram, which is one of the main causes of loss of biodiversity around the mountain. The most common tree present in the area are *Quercus leucotrichophora, Callophyllum Polyanthum, Rubia caerdifolia, Eliocarpus aristatus*. The vegetations of the study area fall under Sub-tropical Forest type, the texture class of the soil falls under loamy sand and it is under humid sub-tropical climate. The average annual rainfall is about 267.13 mm. The temperature ranges from 20°C - 29°C during summer and winter temperature ranges from 7°C - 21°C (Source: State Meteorological Centre, DST Govt. of Mizoram).

3.2.4 Aizawl to Sairang road sides (Western part): The area lies in the western part of aizawl district, situated in between 23º 44′ 51″ North latitude and 92º 43′ 54″ East longtitude. Its altitude ranges from 200 – 600 m. It represents tropical type of forest and bamboo forest. The temperature ranges from 11°C - 32°C. Sairang locality is on the approach road to Lengpui Airport, near the bank of the river Tlawng which is the longest river in Mizoram. Since this road forms the main system of transportation for travelers, the roadside forest is under threat due to anthropogenic activities, different kinds of developmental activities like road constructions and building constructions, farming and cultivations, resulted in the loss of roadside forest cover and consequent loss of soil fertility. The soil frequently shows high degree of pollution that can be attributed to road traffic movement and unscientific dumping of garbage on the roadside and dumping of soil.

CHAPTER-4

MATERIALS AND METHOD

4.1 Plant collection: Detail field survey and collection of bryophytes was done randomly in all the potential habitats within the study area, during the study period from 2015 - 2018. The plant specimens were collected by using a simple sharp knife sometimes collected even with bare hands. The collected specimens of Bryophytes were kept in polybags and the place and date of collection; ecological parameters were recorded in the field note book with collection number.

4.2 Herbarium method: The collected plant specimens were kept on a blotting paper and air dried at room temperature and then packed in the herbarium packets. Each one of the herbarium packet was tagged with full information like herbarium specimen number, date of collection and site of collection, altitude, habitat of plant, following to this process all the herbarium packets containing plant specimens were kept in the cabinet. The name of the plants and family were added on the herbarium packets after the identification of taxon.

4.3 Identification: Some Voucher specimens were brought to the National Botanical Research Institute (NBRI), Lucknow for identification. Some specimens were identified in the Research Laboratoy, Department of environmental Science Mizoram University.

For analysis, the plant specimens were soaked in water for about 20 - 30 minutes to make them completely stretch-out until they attain their original forms. The morphological structure of the plants has been observed by using Monocular

Compound Microscope (Barska AY13070) and the cellular details structure with microscopic structures were investigated with the help of Compound Biological Microscope (OMAX 40-2000X) and AmScope M500 monocular Compound Microscope. For dissecting the plant parts and also for anatomical analysis, temporary slides set in 70% aqueous glycerin and all the line drawing illustrations were made with the help of Camera Lucida. Measurements were made with the help of microscopic occulometer. Infrequently, the thalloid forms with thick epidermal layer have complexity and not attain its original forms. In such situation the specimens were soak in hot water with 70% lactic acid for about 5 – 10 minutes and rinse in water. And the specimens were kept for about 12 hours before investigation.

4.4 Description of plants: Detailed descriptions of plants were given after a careful examination of specimens with the help of Singh and Nath (2007); Singh and Singh (2009); Gangulee (1969-80) and Vohra (1983). Relevant literatures, monographs and publications were also consulted (Singh and Singh 2008).

4.5 Economic importance of bryophytes: The information on the economic importance of Bryophytes were generated and collected from the local people, knowledgeable persons and home gardeners. Literature search were also held from various secondary sources and also in consultation with local informants experts in the relevant field.

CHAPTER - 5

RESULTS AND DISCUSSIONS

During the study period (i.e. 2015 - 2018) the selected study areas were visited and recorded 40 species of Bryophytes, of which 21 species belongs to liverworts and 19 species belong to mosses. The recorded species were presented in a standard form of groups of bryophytes.

5.1 Plants Description:

5.1.1 Liverworts:-

Family: Aytoniaceae Cavers**.** in New Phytol. 10:42. 1911. Rebuliaceae A. Evans in Briton *et al.*, fl. 14: 39. 1923.

1. ***Asterella khasyana*** (Griff.) Pande, K.P. Srivast. and Sultan Khan, J. Hattori Bot. Lab. 11: 7. 1954 '*khasiana'; D.G. Long in Bryophyt.* Biblioth. 63: 169. 2006. *Octokepos khasyanum* Griff., Not. Pl. Asiat. 2: 343.1984. *Asterella blumeana* auct. Plur non (Nees) Kachroo in J. Hatorri Bot. Lab. 12: 36. 1954; Grolle in the flora of Eastern Himalaya, 3rd Rep.: 241. 1974; Kachroo in J. Indian Bot. Soc. 56: 73. 1977; Asha Gupta & Udar in Bryphyt. Biblioth. 29: 69. 1986. *Fimbriaria blumeana* auct. Plur non Nees; Steph., Sp. Hepat, 1:89. 1899; Kashyap, Liverw. W. Himal. 1: 62. 1929.

Thallus bright and yellowish green, found in medium sized, foetid, 2 mm wide and 6 -11 mm long, dichotomously branched; lobe linear margins entire or irregular, apex wide, base slender; Epidermal pores surrounded by 2 concentric rings

of 6 cells each. epidermal cells multilateral 27.1 - 44.1 x 27.0 - 40.6 µm, two concentric rings of six cells surrounding epidermal pores. Air chamber two layers without photosynthesis filaments. Ventral surface with top midrib; a small number of scales, distinct, purple; spores dark brown, globose, 60 - 80 µm. Male receptacle is present just at the back the female receptacle. Female receptacle disc almost flat to convex, translucent, 1 - 3 lobed. Both dorsal in position on main plant body; pseudoperianth hyaline, capsule brown in color, cell wall hexagonal 50.0 - 70.1 x 29.3 - 39.2 µm. (Fig. 6)

Distribution: Pakistan, Nepal, Indonesia, Thailand, China, Indo-China, Phillipines and Africa;

Darjeeling, Sikkim, Assam, Manipur, Meghalaya, Rajasthan, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Kerela, Madurai, W. Ghats, Himachal Pradesh, Mizoram.

Habitat: Plants grow on the bark in moist and damp place.

Specimens examined: India, Mizoram, Aizawl District; Hmuifang Sub - tropical forest, Tawi Wildlife sanctuary, 12th October 2017, Tlangthanpuii Tlangte, Altitude 1619 m, 950 m, 17 -00001 (MZU).

2. *Asterella mussuriensis* (Kashyap)Verd. in Ann. Bryol. 8: 156. 1935; D.G. Long in Cryptog. Bryol. 27: 120. 2006. *Fimbriaria mussuriensi*s Kashyap in J. Bombay Nat. Hist. Soc. 25: 345. 1916 & Liverw. W.Himal. 1: 64. 1992.

Thallus yellowish green, 8 – 13 mm long, 1 - 5 mm wide , branched typically undivided, pale purple margins seen. Ventral scales 1 – 3 linear,

appendages. Ventral shoots common, bear laterally, infrequently, apically on either side of the thallus, arise from midrib. Dorsal surface plane, epidermal cells thin walled, epidermal pores surrounded by 2 - 3 concentric rings of 6 - 8 cells each. Spore globose 87.3 – 120 µm in diameter. Male receptacles, forming a top oval cushion along midrib to the apex of ventral shoot. Female receptacle disc extremely convex, 4 lobed, with conical lanceolate pseudoperianth. Both male and female receptacles are dorsal on the small alternate ventral branches on the main plant body. Spores shady brown, globose, 70 – 79 µm. (Fig.7)

Distribution: Nepal, Bhutan, China and Pakistan; Himachal Pradesh, Uttarakhand, Sikkim, Darjeeling, Maharashtra, Mizoram.

Habitat: Plants grow on the bark in moist and damp place.

Specimen Examined: India, Mizoram, Aizawl District; Tawi Wildlife sanctuary Hmuifang Sub-tropical forest; altitude 650 m, 1400 m. 12th October 2017, 7th June 2016. Tlangthanpuii Tlangte; 17,16 - 00002 (MZU)

Family: Fossombroniaceae Hazsl. Amagyar birodalom moh- flórája: 20, 36.1885

3. *Fossombronia cristula* Aust., Acad. Philad. 1866, p.228. *F. joponica Schiffn*., Oest. Bot. Zeitschr., p. 389 (1899).

Plant pale or bright green leaves which are variously arched and crisped. Thallus 11 - 14 mm long and 2.3 mm wide including leaves, postrate ascending towards the apex; dorsoventrally flattened , ventrally curved with simple rhizoids.

Leaves succubous, on two bilateral rows, simple, quadrate, anterior margin decurrent and slightly undulate, somewhat unevenly lobed with mucilage papillae at the apex; Leaves 0.5 - 1.6 mm long and 1 - 1.70 mm wide, leaf marginal cells polygonal thin walled. Stem 0.15x0.20mm indiameter, periphery cells 22 x 32 µm, ventral 2 peripheral cells moderately thick walled, extended and probably extending for rhizoidal initials; medullary cells 22 - 38 x 35 - 40 µm, thin walled.

Distribution: America, New Jersey (Austin); East Khasi Hills Shillong, Mizoram

Habitat: Plants grows on moist and damp soil, also found growing on rocks.

Specimens examined: India: Mizoram: Aizawl District: Darlawn forest Division, Hmuifang Sub-tropical Forest, 12th May 2016, 9th June 2016. Tlangthanpuii Tlangte; Altitude 1150 m, 1619 m, 16 - 00005 (MZU).

Family: Jungermaniaceae Rchb. Bot. Damen: 256. 1828

4. Jungermania comata Nees, Hepat. Java. 78 (1830)**;** Jngermania stevensiana Steph., Spec. Hepat. 6: 93 (1924).

Plants pale yellowish green – pale brown, Dioecious, 8 - 15 mm long, 2.1 - 3.2 mm wide together with the leaves, horizontally flat, rising from procumbent base, branched. Stem greenish - yellowish brown, 1.25 x 1.50 in diameter, 10 – 15 cells across; cortical cells 17 - 25 x 19.5 - 37 µm, thin walled, no pigmentation; medullary cells thin walled, 17 x 29 – 40.0 µm, with no pigment. Rhizoids purple or almost brown, large beside the stem, typically constrained to leaf base. Leaves

imbricate, obliquely insert, diagonally scattering, sub-quadrate rotund, ovate, ovate-ligulate, 2.01 - 2.19 mm long and 1.80 - 1.86 mm wide, apex curved or somewhat truncate, dorsal edge a little decurrent at base; leaf edges cells 14.0 - 15.2 x 20.0 µm, walls thickened, small trigonous; median cells trigonous, thin walled, 17.5 - 20 x 25 - 27.5 µm; basal cells trigonous, slender walled, not often broad walled, 28.5 - 29 x 38 - 39.5 µm; cuticle smooth – little or not often roughly verrucose. Male inflorescence intercalary, bracts 6 - 8 pairs, ventricose. (Fig.8)

Distribution: Thailand, Sumatra, China, Philippines, Java, Japan and Taiwan; Sikkim, Meghalaya, Mizoram.

Habitat: Plant grows on soil and tree bark in association with other species of moses.

Specimen examined: India, Mizoram, Aizawl District; Tawi Wildlife Sanctuary, Darlawn forest division, 12th May 2016, 9th June 2016, Tlangthanpuii Tlangte, Altitude 1090 m, 1611 m, 16 - 000011 (MZU).

Family: Jubulaceae H. Klinggr. Höh. Crypt. Preuss.: 40.1858.

5. *Frullania ericoides* *(*Nees) Mont. Syn. Hepat. 417 (1846). *Frullania squarrosa* (Rein., Blume *et* Nees) Dum., Rec. d' obs. 13 (1835).

Plant green; unevenly pinnately branched shoots 4 - 40 mm long, 0.7 - 1.2 mm wide; leaf cells towards apex quadrate- sub quadrate 9 - 18.9 x 9 - 17.1 µm; median leaf cells subquadrate – hexagonal, 15.5 - 30.1 x 9.2 - 22.3 µm; basal leaf

cells a little extended, hexagonal 12.3 - 39 x 12.3 - 27 µm, with nodulose trigones and transitional thickenings ; leaf lobules a little curved in, lanceolate, 0.2 1 0.32 mm long, 0.14 mm wide complete at margins, acute at apex. Oil bodies 2 - 67 per cells. Under leaf 2 times as wide as stem, 0.45 - 0.47 mm long, 0.39 - 0.45 mm wide cross section of stem more or less spherical 129 - 243 µm, 7 - 10 µm celled in across diameter, cortex and medulla undifferentiated; cells polygonal, 13 - 20 x 15 - 25 µm significantly thick-walled. Leaves imbricate, diagonally spreading; leaf lobes squarrose, 0.6 - 0.7 mm long, 0.3 - 0.5 mm wide. (Fig.9)

Distribution: Nepal, Bhutan, China, Japan, Korea, Phillipines, Melanesia, Macronesia (Madeira) Indonesia; Himachal Pradesh, Uttarakhand, W.Bengal, Meghalaya, Madhya Pradesh, Karnataka, Tamilnadu, Andaman and Nicobar Island, Mizoram.

Habitat: Epiphytic, grows on the bark of tree in association with *Frullania retusa* and other epiphytic plants.

Specimens Examined: India, Mizoram, Aizawl District; Darlawn forest Division, Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 19th July 2017, Tlangthanpuii Tlangte, Altitude 1542 m,1619 m, 1000 m 16 - 00007 (MZU).

6. *Frullania retusa* Mitt. in J. Proc. Linn. Soc., Bot. %: 119. 1861; Steph., Sp. Hepat. 4: 448. 1910: Kashyap, Liverw. W. Himal. 2:13. 1932; Vidrendra Nath & Udar in Proc. India Natl. Sci. acad., B 50: 226

Plant Yellowish green - brown, dioecious, shoots 34 – 47.4 mm long, irregularly pinnately branched; leaf lobes ovate - spherical, with entire margins and rotundate apex; leaves imbricate, spreading; leaf lobes ovate0.5 – 0.9 mm long, 0.5 – 0.7 mm wide, rounded at apex with subrotund – subquadrate appendages at base, entire at margins; marginal leaf cells towards apex quadrate – subquadrate, 11 - 22 x 11 - 22 µm median leaf cells oval-subquadrate or polygonal 15.6 - 29.2 x 15.6 – 28 µm; basal leaf leaf cells slightly elongated, ovate – multilateral 20.1 - 33.2 x 17.1-29.5 µm cells with medium – large nodulose trigones and intermediate thickenings ; leaf lobule erect, parallel in the direction of stem, cocullate, 0.10 - 0.22 mm long, 0.10 – 0.22 mm wide, incurved at openings, with prominent beak at apex, when explanate or canaliculated – lanceolate with acuminate – acute apex. Under leaves contiguous, margin recurved, large, flat, appressed towards the stem, as wide as long, orbicular 0.5 - 0.8 mm long, 0.5 - 0.8 mm wide. (Fig.10)

Distribution: Nepal, China; Himachal Pradesh (Dalhousie, GHNP, Shimla), Uttarakhand, W. Bangal, Sikkim, Meghalaya, Mizoram.

Habitat: Plants, grows on wet and moist soil and rocks

Specimens Examined: India, Mizoram, Aizawl District; Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 18 July 2017, Tlangthanpuii Tlangte, Altitude 1150 m,1619 m, 16 - 00008 (MZU)

7. *Frullania tamarisci* (L.) Dumort. Sde. Lac. In Miquel, Ann. Mis. Lugd.-Bavati 1: 312 (1836).

Plants green 29 – 43 mm long, 2 mm wide together with leaves ; dioecious, irregularly branched ; Dioecious plant ; Stem yellowish to brownish, cylindrical, 0.22 - 0.23 x 1.24 mm in diameter and 12 cells crosswise; Cortical cells semiquadrate to pointed, 11 - 12.4 x 4 - 8.1 µm; Medullary cells superior to cortical cells, pointed to subquadrate, 18.2 - 24.4 x 9.5 - 13 µm. Leaf imbricate, somewhat leaning to transverse, extensively spreading, dorsal margin convex, ventral margin slight concave with base appendages, ovate with acute, acuminate, obtuse to apicualte apex, often incurved, 2 - 2.1 mm long and 0.87 - 1.6 mm wide ; ocelli in 1 row, 11 - 20 cells long. Leaf marginal cells quadrate, regular slightly trigonous, 10.1 - 13.0 x 10.1 - 13.0 µm; median cells huge, polyhedral, oblong trigonous, 21 - 28 x 11 - 15 µm. Under leaves wider than the length, recurved along margin, toothed appendages at base, lobe acute, 0.40 – 0.68 mm long and 0.59 - 0.90 mm wide.

Distribution: Europe, Asia, Ceylon, Malaysia, China, Formosa, Korea, Siberia, Japan, Vancourver and Orcas Island: Kerala, Tamil Nadu, Sikkim, Meghalaya, Mizoram.

Habitat: Plants, grows on wet and moist soil**.**

Spcimens Examined: India, Mizoram, Aizawl District; Darlawn forest Division, Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 19th September 2017, 17th July 2018, Tlangthanpuii Tlangte, Altitude 1074 m, 1670 m, 1200 m. 16 – 00009 (MZU)

8. ***Frullania wallichiana*** Mitt., Proc. Linn. Soc. 5: 118 (1861). *Frullania indica* Steph., Spec.Hepat. 4: 347 (1910); F. hosseana Steph., Spec. Hepat. 4: 348(1910).

Plant pale yellowish green to yellowish brown, 48 mm long 3.5 mm wide together with the leaves. Irregularly-branched. Primary branches 24 mm long and 3 mm wide together with leaves; secondary branches 14 mm long and 3.1 mm wide together with leaves, tertiary branches 8 – 9 mm long and 2.19 mm wide with leaves; quartery branches 3.49 mm long and 2.1 mm wide with leaves; Leaf lobe imbricate, elliptical to oblong, incurved margin whole, 1.37 mm - 1.70 mm long and 1.15 - 1.37 mm wide and apex curved; leaf marginal cells quadrate 16.6 - 24 x 14 - 18.2 µm. Median cells polyhedral, trigonous 21 - 28 x 16.9 - 27 µm basal cells trigonous, 34 - 39 x 20 - 28.2 µm. Stem dark green, cylindrical, 0.16 - 0.17 mm in diameter 6 - 7 cells across ; cortical cells smaller than medullary cells; Lobules large, helmet shaped, dorsal portion almost horizontal, elongated, arched, connate with the lobes, parallel to stem, 0.62 - 0.72 mm long and 0.28 - 0.48 mm wide. Under leaves freely imbricate, 0.79 - 1.23 mm long and 0.87 - 1.26 mm wide, oppressed to the stem; Female inflorescence on main axis, semi exerted, cylindrical 1.3 mm long and 0.9 mm wide; cross section of perianth 0.46 - 0.57 x 0.89 - 1. 15 mm in diameter, 6 - 10 keeled; bracts 1-4 pairs, 1.75 – 2 mm long and 1.3 - 1.4 mm wide, margin undulate – denticulate with apiculate - acute apex. Male inflorescence lateral on main axis, capiate, 2 - 3 pairs bracts, medium, stalked. (Fig.11)

Distribution: Himalaya, Sumatra, Java, Phillipines; Eastern Himalaya: Meghalaya, Mizoram

Habitat: Plants grows on the bark of tree, epiphytic, in association with other epiphytic plants.

Specimens Examined: India, Mizoram, Aizawl District: Darlawn forest Division, Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 16th September 2016, 17th June 2017, Tlangthanpuii Tlangte, Altitude 570 m,1200 m, 1700 m 16 – 000010 (MZU).

9. *Frullania muscicola* Steph., Hedwigia 33: 146 (1894). *Frullania gollani* Steph., Spec. Hepat. 4: 445 (1910).

Plants dark yellowish to dark brown size medium; Diocious medium plant; shoots 19 – 35 mm long and 1.91 mm wide together with leaves. Irregularly branched; bi-tripinnately branched; primary branches 5 – 7 mm long and 1.37 mm wide with leaves, secondary branches 6 mm long and 1.14 mm wide with laves, tertiary branches 4mm long and 0.47 mm wide with leaves. Stem brown to dark brown, 0.15 x 0.19 - 0.21 mm in diameter, 7 - 9 cells across; cortical cells subquadrate, 12.7 - 23.1 x 8.0 - 16 µm; medullary cells larger, 12.7 - 23.1 x 11 - 23.1 µm. Leaf lobe imbricate 0.59 - 1.02 mm long and 0.6 - 0.9 mm wide with obtuse apex and small appendages; leaf marginal cells distinct, transformed into gemme and new plantlets, semiquadrate, thick walled, 16 - 21 x 13.1 - 15 µm ; median cells trigonous, 16.9 - 26 x 15 - 23.1 µm. Stylus 3 - 6 cells long, lobules 0.40 - 0.42 mm long and 0.30 - 0.36 mm wide. Under leaves with 1 - 2 teeth on lateral margin, 0.34 - 0.50 mm long and 0.36 - 0.43 mm wide. Perianth terminal on the main or lateral branches, 1.25 mm long and 0.94 mm wide, exserted, 4 - keeled, smooth, apical beak small; bracts 2pairs oblong-ovate, entire, 0.65 - 0.73 x 1.20 - 1.26 mm.

Distribution: Nepal, China, Japan, Korea; Himachal Pradesh, Uttarakhand, Sikkim, Assam, Madhya Pradseh, Tamilnadu, Mizoram.

Habitat: Plants grows on wet and dump soil.

Specimens Examined: India, Mizoram, Aizawl District; Darlawn forest Division, Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 15th September 2017, Tlangthanpuii Tlangte, Altitude 1174 m,1300 m, 1000 m. 16 – 000012 (MZU).

Family: Lejeuneaceae Casares- Gil. Fl. Iber. Briof. 1: 703. 1919

10. *Lejunea obfusca* Mitt. In J. Proc. Linn. Soc., Bot. 5: 114.1861; S.K. Singh & D.K. Singh, Cryptog. Bryol. 28: 257. 2007.

Plants yellowish green, flattened on bark of tree, 16mm long and 1.1 - 1.4 mm wide together with leaves; unevenly branched, lateral floriferous; primary branches 3 mm long and 0.65 mm wide together with leaves . Stem 0.08 x 0.15 mm in diameter and 6 - 8 celled across; cortical cells 13.1 - 23 x 26.7 - 45.1 µm and in 7 longitudinal 19µm. Rhizoids colourless. Leaflobes elliptical 0.59 - 0.76 mm long and 0.51 – 0.59 mm wide, imbricate, slanting to transverse, antical margin convex, base arched, apex rounded; marginal cells 11.9 – 16 x 16 – 18.1 µm; median cells 19 - 21.9 x 26 - 28.1 µm; basal cells larger 20.5 - 29 x 28.1 - 39 µm; leaflobules 100 x 200 µm, first tooth one celled, obtuse, apex, truncate. Under leaves wider than length 0.27 - 0.32 mm long and 0.28 - 0.32 mm wide. Male inflorescence lateral on main stem with six pair of bracts. Female inflorescence lateral on sub-branches parianth terminal on lateral branches, clavate, 0.72 mm long and 0.41 mm wide. (Fig.12)

Distribution: Ceylon, Nepal, Sri Lanka; Eastern Himalayas: Meghalaya, Western Himalaya: Himachal Pradesh Himachal Pradesh, Pachmarhi, Kerala, Peninsular India

Habitat: Plants grows on tree bark epiphytically, it also grows on rocks (terrestrial) with other mosses in moist and damp place.

Specimen Examined: India, Mizoram, Aizawl District: Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 18September 2016, Tlangthanpuii Tlangte, Altitude 1560 m, 570 m 16 – 000014 (MZU).

11. ***Mastigolejeunea humillis*** (Gottsche)Schiffn., In Engl.& Prantl, Nat. Pfl.-fam. 1, 3: 129 (1895). *Phragmicoma humilis* Gott., in Gott., Lindenb. & Nees, Syn. Hepat. 299 (1845).

Plants pale green, 14 mm long and 2.9 mm wide together with leaves, branching irregularly by the intercalary branch. Stem 0.12 x 0.15 mm in diameter, cross section of stem about 7 - 9 cells across, cells thick walled, trigonous large; cortical cells in about 18 longitudinal rows, larger than the medullary cells. Rhizoids present. Leaves compactly imbricate, extensively spreading, lobes convex, slightly falcate, ovate or oblong, 0.88 - 0.97 mm long and 0.59 - 0.67 mm wide, margin entire, apex obtuse – apiculate; marginal cells 8.1 x 12.9 µm; median cells 11 - 13.1 x 18.2 – 24 µm ; basal cells 16 - 17 x 34 - 35 µm, trigones large and nodulose; leaf lobule typically 0.50 mm long and 0.29 mm wide, oblong, inflated, apex diagonally truncate, free margin with 1 - 2 teeth, first tooth 1 - 4 cells long and 1 - 2 cells wide at base, second tooth 2 celled long, keels straight; cuticle smooth. Under leaves robustly imbricate, sub-transversely sinuately inserted, obcordate or widely ovate, 0.38 - 0.39 mm long and 0.46 - 0.52 mm wide, apex truncate, margin entire.

Distribution: Japan, Oceania, Asia, Ryukyu and Formosa; South India, Mizoram.

Habitat: Plants grows on tree bark epiphytically.

Specimen Examined: India, Mizoram, Aizawl District: Darlawn forest Division and Aizawl to Sairang Road side, Hmuifang sub-tropical forest; 12th May 2016, 13th August 2017, Tlangthanpuii Tlangte, Altitude 1023 m, 350 m, 1560 m. 16,17 – 000015 (MZU)

12. *Trocholejeunea infustaca* (Mitt.) Verd., Ann. Bryol. Suppl. 4: 190 (1934) *Lejeunea infuscate* Mitt., Jour. Proc. Linn. Soc. London 5:111 (1861).*Dicramolejeunea birmensis* Steph. *ex* Bonner, Index Hepat. 5: 24 (1965).

Plants light - dark brown; shoots 21 - 30 mm long, 0.19 – 0.20 mm wide, unevenly branched. Leaves imbricate diagonally spreading; leaf lobes diagonally ovate, 0.9 - 1.0 mm long, 0.7 - 0.8 mm wide, obtuse, entire at margin; marginal leaf cells towards apex sub-quadrate, 12.5 - 17.1 x 12.5 - 21.4 µm; median leaf cells multilateral, 23.9 - 37.1 x 17.0 - 30.1 µm; basal leaf cells slightly elongated, polygonal, 23.9 - 39.5 x 20.9 - 30.6 µm, thin walled, with large nodulose trigones; cuticle smooth; leaf lobules triangular or ovate, 0.39 - 0.41 mm long, 0.25 - 0.34 mm wide, obliquely truncate with 2, small one celled tooth at margins. Under leaves imbricate or approximate, rotund, 0.39 - 0.51 mm long and 0.58 - 0.75 mm wide, recurved at margins, sinuately inserted. Stem in cross section orbicular, 7 - 10 celled across diameter; cortical cells sub-quadrate – polygonal, 17 - 34 x 17 - 27 µm, slightly thick walled; medulary cells multilateral, 17 - 27.1 x 17 - 22 µm, slightly thick walled. Rhizoids pale-brown in colour. (Fig.13)

Distribution: Nepal, Bhutan, China, Sri Lanka, Myanmar; Himachal Pradesh, Eastern Himalaya, Darjeeling, Sikkim, Meghalaya, Mozoram.

Habitat: Plants grows on tree bark, also found on wet rocks.

Specimen Examined: India, Mizoram, Aizawl District: Darlawn forest Division, Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 18th September 2016 Tlangthanpuii Tlangte ,Altitude 1500 m,1619 m, 1172 m 16 – 000016 (MZU)

13. ***Trocholejeunea sandvicensis*** (Gottsche) Mizut. In Misc. Bryol. Linchenol. 2: 169. 1962; Mizut. In J. Hattori Bot. Lab. 66: 275. 1989. Awasthi & S.C. Srivast. in Proc. Indian acad. Sci., Pl. Sci. 98: 7. 1988.

Plant yellowish green – brownish green; shoots 16 - 30 mm long, 1.7 - 2.5 mm wide, irregularly branched;. Leaves closely imbricate, broadly spreading; leaf lobes squarrose , ovate 0.79 - 1.27 mm long, 0.71 - 1.12 mm wide, rounded at apex, entire at margins; marginal leaf cells towards apex sub-quadrate, 20.5 - 29.1 x 17.1 - 20.5 µm; median leaf cells hexagonal – polygonal, 27.1 - 47.5 x 27.1 - 38.5 µm; basal leaf cells polygonal, 38.1 - 59.5 x 30.1 - 45.8 µm, with triradiate – subnodulose trigones and in-between thickenings; leaf lobules sub-orbicular or ovate, 0.40 - 0.45 mm long, 0.4 - 0.5 mm wide, margins with 4 - 5 teeth; teeth small, 1 - 2 celled. Under leaves closely imbricate, obliquely widely spreading 0.35 - 0.61 mm long, 0.45 - 0.79 mm wide, narrowly recurved, flat at margins. Stem in cross section orbicular, 150 - 220 µm, 5 - 9 celled across diameter; cortical cells sub-quadrate – multilateral, 17.1 - 29.0 x 17.1 - 25.4 µm, thin walled; medullary cells slightly

smaller than cortical cells, multilateral, 13.0 - 20.4 x 17.0 - 20.4 µm, thin walled. Rhizoids pale brown in colour. (Fig.14)

Distribution: Pakistan, Nepal, Bhutan, China, Sri Lanka, Myanmar, Japan, Korea, Malaysia, Vietnam, Polynesia (Hawaiian Island), Melanesia (New Caledonia); W. Himalaya, Uttarakhand, Sikkim, Tamil Nadu, Mizoram.

Habitat: Plants grows epiphytically on the tree bark, it also found on the wall of rocks in moist and damp place.

Specimens Examined: India, Mizoram, Aizawl District; Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016, 9th June 2016, 18September 2016 Tlangthanpuii Tlangte, Altitude 1150 m,1000 mm, 16 – 000017 (MZU)

Family: Lepidoziaceae Limpr. Lepidoziaceae Limpr., in Cohn, Krypotgamen- Flora von Schlesien,p. 310, 1857.

14. *Bazzania hainanensis* L.-P. Zhou & Zhang, sp.nov. 1977

Plants green – pale green; shoots 19 – 30 mm long, 2 - 4 mm wide; branching recurrent, side pseudodichotomous; branches abundant on ventral surface with reduced leaves and under leaves; rhizoids present.Cross section of stem oval, 0.25 - 0.28 mm × 0.25 - 0.37 mm, 9 - 12 cells across diameter; cortical cells sub-quadrate or multilateral, 18. 2 - 37.0 × 24 - 55 µm, hyaline, thick walled; medullary cells multilateral to rectangular, yellow to hyaline, trigones present. Leaves imbricate to adjacent, alternating, scattering, diagonally inserted, oblong, 1.7 - 2.0 mm long, 0.6

- 0.9 mm broad, longer than wide, apex narrow, obliquely truncate, typically entire, irregularly 3 – 4 lobe, lobes small, tooth-like, one to three cells long, one to three cells wide, sinus almost absent, dorsal margin arched, base curved; apical to subapical leaf cells rectangular or multilateral, 9.0 - 23.2× 8.0 - 23.2 μm, trigones indistinct; median leaf cells subquadrate or multilateral, 19.1 - 44.1 × 17.1 - 44.3 μm, nodulose trigones, basal leaf cells subquadrate to multilateral, 27.3 - 57.5 × 24.2 - 48.4 μm, thick walled with nodulose trigones; leaves near branch 1.3 - 1.5 mm long, 0.7 - 0.9 mm wide at base, apexacute; Underleaves distant, one or two times as wide as stem,unevenly lobed, 0.45 - 0.66 mm long, 0.43 - 0.65 mm wide, widest at apex ; apical underleaf cells subquadrate to multilateral, margin entire; median leaf cells subquadrate to multilateral, 16.1 - 45.1 × 8.1 - 24.2 μm, thin walled; basal underleaf cells smaller, rectangulate or multilateral, 13.1 - 33.3 × 7.1 - 23.5 μm, trigonous. (Fig.15)

Distribution: China, Bhutan and Nepal; Endemic to Mizoram.

Habiat: Plants grow on the bark in moist and damp place.

Specimens Examined: India: Mizoram: Aizawl District: Tawi Wildlife sanctuary, Darlawn Forest Division, Hmuifang sub-tropical forest. 12th October 2017, 8th May 2016 Tlangthanpuii Tlangte, Altitude 1050 m, 774 m 1000m, 17,16 - 00003 (MZU)

15. *Bazzania pearsonii Steph.*, Hedwigia 32: 212 (1893).

Mastigobryum pearsonii (Steph.) Steph., Sp. Hep. 3: 476 (1908); *Bazzania ampliata* Steph. Ex Herz., Ann. Bryol. 12: 78 (1939).

Plants pale green to yellowish green, small to average in size, shoots 1.5 - 3 cm long, 11.5 mm wide including leaves; Leaves alternating, closely imbricating, incubous, delicate, leaves broader at middle than base and apex. Stem 0.171 - 0.22 mm wide. Basal leaves are smaller, leaves at tip 0.31 - 0.35 mm long and 0.17 - 0.25 mm wide, middle leaves 0.55 - 0.72 mm long and 0.35 - 0.42 mm wide and basal leaves 0.29 - 0.38 mm long and 0.29 - 0.38 mm wide. Leaf cells oval. Under leaves broader than stem, oblong to sub-orbicular cross wisely inserted .Spines are present but very rarely absent, commonly 2 - 3 spines, number of spines reduces at the base, 2 - 5 series of cells in spines and one or two cells of tip, basal multiseriate.

Distribution: Sri Lanka, Bhutan, China, Japan, Borneo, Korea, Java, Myanmar, Philippines, Samoa, Sumatra, Taiwan, Thailand, Vietnam; Assam, Shillong, West-Bengal, Tamil Nadu, Kerala, Mizoram

Habitat: Plants grows on the tree bark.

Specimens examined: India, Mizoram, Aizawl District; Tawi Wildlife sanctuary, Aizawl to Sairang road side, Hmuifan sub - tropical forest. 12th October 2017, 9th August 2016, Tlangthanpuii Tlangte, Altitude 960 m, 360 m, 1612 m, 17,16 - 00004 (MZU)

Family: Marchantiaceae (Bisch.) Lindl. Nat. Syst. Bot. 2: 24, 412. 1836. Marchantieae Bisch.Bem. Leberm.: 53: 1835

16. *Dumortiera hirsuta* (Sw.) Reinw. Bl. Et Nees., Nov. Act. Leop. Carol. VII p. 410 (1824).Syn.:*Marchantia hirsute* SW. Fl. Ind. Occ. Prodr. 145 (1788)

Plant dark green up to 30 – 65 mm long 16mm wide aromatic, with wide, flat, semi-translucent, dichotomously branched; the thallus margins and undersides bear scattered, firm bristles. It lacks air pores, a few indistinct pores close to the tip and has no network of lines on upper surface. Dorsal surface flat with a faded network, covered with papilate cells. Ventral surface green, scales not present, hyaline occurring in older part as narrow in one row on each of the midrib. Midrib prominent, about 16 - 19 cells thick in the middle, formed of 4 - 7 angled cells. Midrib cells exhibit fungal hyphae. The male receptacles are bristly and borne on a very short stalk upper surface smooth or with a few bristles. Female plants have long-stalked up to 42mm, stalk thick, brown in colour with rhizoidal furrows. (Fig.29)

Distribution: West Indies, Mexico, Central America, Hawaii, Borneo, Asia, New Caledonia and Samoa; Uttarakhand, Sikkim, W. Bangal, Assam, Arunachal Pradesh, Madhya Pradesh, Tamilnadu, Nepal, Mizoram

Habitat: Plants was found growing on moist and damp soil.

Specimens examined : India, Mizoram, Aizawl District; Darlawn forest Division, Hmuifang Sub-tropical Forest, Tawi Wildlife Sanctuary 12th May 2016 - 9th June

2016, 18th September 2016 Tlangthanpuii Tlangte, Altitude 1162 m,1619 m, 950 m. 16 - 00006 (MZU)

17. *Marchantia paleacea* Bertol. In Opusc. Sci. 1: 242. 1817; Bischl. In Bryophyt. Biblioth. 38:91. 1989. *Marchantia nepalensis* Lehm. & Lindenb. In Lehm., Nov. strip. Pug. 4: 91 1832; V.B. Singh in Bull. Lucknow Natl. Bot. Gard. 156: 15.1966. subsp. Paleacea

Plants dichotomously branched. Thallus small to medium in size, 45 mm long and 9 mm wide, greenish brown to purplish. Dorsal surface green with a dark medium streak, convex abruptly ending near the growing tip. Pores noticeable, medium cylindrical shaped, prominent with 5 – 8 superimposed concentric rings of cells, each ring with four cells, 2 – 3 ring of cells above epidermis level, 2 – 3 ring of cells projecting below into the air cavity; inside pore cruciate surrounded by a four cells, convexities of the inside walls reaching nearly up to the central region of the pore. Ventral surface brownish, scales noticeable in two rows on each of the midrib, median scales superior, fixed by a long slanting decurrent based, appendaged. Midrib is not very prominent underneath, regularly passing into the margins. Gemmae cups profuse dorsally underneath the apex. Rhizoids present.

Distribution: Nepal, China, Java, Phillipines; Assam and Southern India, Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Darjeeling, Sikkim, Meghalaya, Madhya Pradesh, Tamil Nadu

Habitat: It was found on the moist soil during the rainy season.

Specimen Examined: India, Mizoram, Aizawl District: Darlawn forest Division, Tawi Wildlife Sanctuary 12th July 2016, 18th September 2016 Tlangthanpuii Tlangte, Altitude 989 m,1101 m, 16 - 000018 (MZU)

18. ***Marchantia Polymorpha*** Subsp. L., Sp. Pl: 1137. 1753; Mitt. In J. Proc. Linn. Soc., Bot. 5: 125. 1861; Kashyap, Liverw. W. Himal. 1: 32. 1929; Bischl. In Bryophyt. Biblioth. 38: 74. 1989.

Plants/thallus dark green, thick and large: 30 – 70 mm long 7 – 18 mm wide, dichotomously branched, flattened, margin undulate or wavy, lobed prominent in older thallus, apex emarginated. Dorsal surface flat or concave with dark line along the middle; epidermal cells 5 – 6 angled, 22.2 – 40.2 x 18.9 – 40.2 µm, thin walled, angles not thickened; pores not visible, very small, barrele shaped, elevated slightly surrounded by 4 - 8 superimposed concentric rings each with 4 - 6 cells, 2 - 4 rings of cells projecting into the air chamber region, innermost rings cruciate or even papillate with extended finger like projections, bounded by 4 – 6 cells. Air chambers are one layered with 3 – 5 cells high chlorophyllose filaments. Ventral surface brownish, scales in six rows on each side of the midrib; median scales are large, attached with a long oblique decurrent base, appendiculate, margins with short irrigulate teeth; laminar scales partly way of the thallus from the midrib region, margin entire. Midrib prominent below, very regularly passing into the lamina, ending in a one celled margin. Gammae cups abundant on the dorsal side of the thallus, slightly horizontal, margin lobed, lobes triangular, acuminate with a spinous margins. Gammae pear shaped 0.5 – 0.79 mm long and wide in diameter. (Fig.16)

Distribution: Bhutan, Australia, China, Japan, Korea, Nepal, New Guinea, New Zealand, Pakistan, Phillipines, Asiatic and Oceania, Afghanistan, Borneo, Java**;** Tamil Nadu, Kotagiri, Garhwal, Kedar Nath, Kashmir, Himachal Pradesh, Jammu and Kashmir, Darjeeling, Sikkim, Assam, Meghalaya, Uttar Pradesh, Punjab, Rajasthan, Nagaland.

Habitat: It was found on the moist soil during the rainy season.

Specimen Examined: India, Mizoram, Aizawl District: Hmuifang Sub- tropical forest, Tawi Wildlife Sanctuary 12th July 2016, 20th October 2016 Tlangthanpuii Tlangte, Altitude 700 m, 1290 m, 16 - 000019 (MZU)

Family: Metzgeriaceae Klinggt. Höh. Crypt. Preuss.: 10, Kongnigsberg 1858

19. ***Metzgeria furcata*** (L.) Dumort. Var. uvula, Nees in Noturg. Eur. Leburm 3: 489. 183.

Plants pale green to yellowish green, small in size, 1.5 – 7 mm long, 0.31 – 0.57 mm wide, pinnulate; Ventral adventitious roots not present. Dorsal epidermal cells in two rows, multilateral, 35.7 - 63.4 x 11.9 - 22.5 µm; ventral epidermal cells in two rows, multilateral, 35 - 40.1 x 13.2 - 23.1 µm, inner cells 2 – 6 in number, in 1 or 2 tiers; wing 6 – 8 cells broad on either side of midrib; marginal wing cells multilateral, 25.1 - 36.7 x 25.1 - 32.4 µm; median wing cells multilateral, 25.1 - 34.2 x 25.1 - 38.2 µm; cells thin walled with minute trigones, transitional thickening not present; mucilage papillae cylindrical – to some extent cup-shaped, present on apical

ventral surface; Midrib faintly developed, discontinuous, 30.1 - 45.1µm wide ; hairs minute, straight 50 -110 µm long, 15.1 – 16.6 µm wide, comparatively meager, disposed individually at the margins, infrequently on the ventral surface of midrib. Gammae marginal, linear – lingulate, 2 - 6 cells wide. (Fig.17)

Distribution: Japan, Oceania, Asia, Ryukyu and Formosa; Kashmir, Sikkim, Meghalaya, Drjeeling, Arunachal Pradesh, Mizoram.

Habitat: It grows epiphytically on the bark of tree.

Specimen Examined: India, Mizoram, Aizawl District: Hmuifang Sub- tropical forest, Darlawn Forest Division, 12th July 2016, 24th October 2016 Tlangthanpuii Tlangte, Altitude 1102 m, 990 m, 16 - 000020 (MZU).

Family: Ricciaceae Rchb. Bot. Damen: 255. 1828

20. *Riccia Fluitans* Linn., Spec. Plants. 1139, 1753.

Plants body, yellowish green - brownish, typically sterile or not often monoecious. Terrestrial forms thick with rhizoids and scales restrained near apex. Thallus 40 - 60 mm long and 1.5 mm broad, long band shaped, dichotomously branched. Segments divergent, linear, dorsal narrow channel next to apex. Scales and rhizoids absent on ventral side in aquatic froms. Air chamber present, large and in numerous layers.

Distribution: America, Japan, Siberia, Himalaya, Samoa, New Zealand, Argentina, Brazil, Nepal; Garhwal, Kashmir, Bombay, Assam, Himalayas, Kumaon, Pachmarhi, Tamil Nadu, Nilgiri, Chennai, Mount Abu, Himachal Pradesh, W. Ghats, Tirunelveli district.

Habitat: It was found on growing tangled with mosses on rocks just underneath the stagnant water.

Specimen Examined: India, Mizoram, Aizawl District: Darlawn Forest Division, Hmuifang sub-tropical forest, 12th July 2016, 14th May 2017, Tlangthanpuii Tlangte, Altitude 1014 m,1200 m. 16, 17 – 000021 (MZU).

21. *Riccia glauca* L., Sp. Pl.1139.1753. K. Mull., Rabenh. Krypt. Fl. 183.f.97.1907; Hatt., Nat. Sci. Mus. Tokyo 14: 142 f.1.g.h.z.1943; Kachroo, J. Univ. Gauhati 5:131.f. 6A-B.1954.

Plants body, bluish - green, thalloid thick, forming complete rosettes, 10 – 17 mm in diameter. The branches are dichotomous, 4 – 9 mm long and 2 – 3 mm wide, 4 times broader than long, and bright green or yellowish-green, rarely with reddish pigment. The median groove of the branches is very short, shallow and flat; the thallus spreads and curves downwards to a sharp margin and is not swollen, and is with or without scattered, colourless hairs. The ventral scales are ephemeral, transparent and colourless. Always forms sporophytes. The spores are dark brown, with angular shaped on the surface 65 – 89 µm. Rhizoids simple and tubeculate.Bisexual. Capsules are commonly produced in older parts of the rosettes.

Distribution: Balkan Peninsula, Europe, North Africa, Siberia, Far East-West and East Asia, China, New Zealand, North America, NW Pacific; Meghalaya, Assam, Odhisha, Maharastra.

Habitat: It was found on rock just beneath the stagnant water

Specimens Examined: India, Mizoram, Aizawl District: Darlawn Forest Division, Tawi Wildlife sanctuary 12th July 2016, 14thMay 2017 Tlangthanpuii Tlangte, Altitude 950 m, 1174 m. 16,17 – 000022 (MZU).

5.1.2 Mosses:-

Family: Bartramiaceae Schwägr. Bartramiaceae Schwägr. In Willd., Sp. Pl. ed. 4. 5(2): 90. 1830.

22. Philonotis falcata (Hook.) Mitt. Philonotis falcata (Hook.) Mitt., J. Linn. Soc. Bot. Suppl. 1: 62. 1859.

Plants epiphytic, pale green to deep greenish, acrocarpous, epiphytic, 3 - 5 cm long and 1.5 – 3.0 mm wide including leaves; stem 0.19 - 0.25 mm in diameter, 3 rows of outer cortical cells, a little thick walled, tiny, yellowish-brown in colour, inside cortical cells thin walled, large, 17 - 30 x 12 - 17 μm, central strand present; leaves spirally arranged, erecto-patent, triangular-ovate with wide base, 2.0 - 2.1 x 0.3 - 0.4 mm, margin stridently denticulate; costa single, sturdy, excurrent; leaf-cells tapering, ovate - hexagonal 20 - 40 x 5 - 9 μm at apex, middle cells a little thick walled, elongated with mamillose at distal end, 23 – 50 x 4 - 10 μm, basal cells thin walled, rectangular,21 - 53 x 6 - 20 μm. (Fig.18)

Distribution: India, Bhutan, Tonkin, Russia, Java, Philippines, Taiwan, China, Korea, Japan, South Africa, Europe, North America and Hawaii; Sikkim, Darjeeling, Meghalaya.Kashmir, Uttarakhand, Tamil Nadu, Mizoram.

Habitat: Plant was found growing epiphytically on the bark of tree.

Specimens Examined: India, Mizoram, Aizawl District: Aizawl to Sairang road side, Darlawn Forest Division, Tawi Wildlife sanctuary 11th July 2017, 14thMay 2017, 3rd August 2017, Tlangthanpuii Tlangte, Altitude 290 m, 1600 m, 1500 m. 16,17 – 000023 (MZU).

Family: Bryaceae Schwägr. Bryaceae Schwägr. in Willd., Sp. Pl. ed. 4. 5(2): 47.1830.

23. *Brachymenium bryoides* Hook. ex. Schwagr., Spec. Musc. Suppl. 2(1): 134. 135. 1824.

Plants deep green, gregarious. Stem erect or partly prostrate, reddish, less than 5 mm and branched by several whorl of sub-floral innovations leaves erectopatent, dense, ovate – lanceolate, 0.49 mm – 0.55 mm, acuminate with entire margin. Costa strong, excurrent in a 0.31 mm long arista. Apical leaf cells thin walled, elongated, hexagonal to rhomboid, 6.7 – 8.9 mm and middle leaf cells 6 – 10 mm. Basal cells sub-quadrate to rectangular, 14 – 19 mm wide at base. Leaf margin bordered by one row of small, narrower marginal cells. (Fig.19)

Distribution: Papua New Guinea, Phillipines, Sri Lanka, Nepal; Manipur, Nilgiri hills, Pachmarhi, Khasi Hills, Darjeeling, Uttarakhand and Shimla, Mizoram.

Habitat: Plants, growing on the soil.

Specimens examined: India: Mizoram: Aizawl District: Hmifang Sub-tropical forest, Tawi Wildlife sanctuary 11th July 2017, 14thMay 2017, 17rd August 2016, Tlangthanpuii Tlangte; Altitude 1599 m, 980 m. 16, 17 – 000024 (MZU).

24. *Bryum alpinum* Huds. ex. With. *Bryum alpinum* Huds. ex With., Syst. Arr. Brit. Pl. ed. 4, 3: 824. 1801.

Plants Purplish – brown, acrocarpous, terrestrial, densely turfs, little branched, 1.5 – 2.1 cm long and 0.1 - 2 mm wide including the leaves, main stem erect with 2 to 3 sub-floral innovations; cross-section of stem circular, compressed

slightly in outline, 10 - 20 mm in diameter, 2 rows of outer cortical cells thick walled, tiny in size, inner cortical cells thin walled, large, 35 - 48 μm large; leaves tiny, erect scarcely lanceolate, acuminate,2 - 2.5 x 0.4 - 0.6 mm, margin entire; costa excurrent in to short arista; leaf-cells stretched out, rhomboidal, 40 – 67 x 8 - 16 μm at apex, middle cells 64 – 102 x 8 - 13 μm, basal cells rectangular, 29 – 57 x 11 - 17 μm. Seta brown in color, smooth, erect, bent at apex, 1.0 - 1.5 cm long; capsule pendulous, brown, 1.5-4.5 x 1.5 - 2.10 mm; peristome teeth present, exostome 350 - 590 μm high and 80 - 100 μm wide at base, endostome transparent yellow, basal membrane with 2-3 apendiculate cilia; spores small, finely papillose, 9-14 μm in diameter. (Fig.20)

Distribution: West Tibbet, Nepal, Caucasus, Asia Minor, Central Asia, Europe, Africa and North America; West Bengal: Darjeeling, Sikkim and Meghalaya: Khasia Hills. Western Himalaya: Himachal Pradesh: Shimla and Kashmir. South India: Kerala, Tamil Nadu: Nilgiri hills: Ootacamund, Mizoram.

Habitat: Plants grow on soil as a unadulterated population.

Specimens Examined: India: Mizoram: Aizawl District: Hmifang Sub-tropical forest, Darlawn Forest Division, Tawi Wildlife sanctuary, Darlawn forest division; 11th July 2017, 15th September 2016, 14thMay 2017, 17rd August 2016, Tlangthanpuii Tlangte; Altitude 1500 m, 870 m,1200 m; 16,17 – 000025 (MZU).

25. *Bryum auratum* Mitt., *Linn. Soc. Bot. Suppl*. 1: 67 (1859)

Plants small, in dense population, yellowish – brown, densly tufted. Stems julaceous, branching by numerous subperichaetial innovations. Leaves imbricate,

broadly ovate, concave, 0.5 – 0.9mm long, with apiculate to obtuse apices; upper part of lamina green; margin smooth; costa weak, 50–67% the length of the leaf; upper and middle laminal cells elongated 37 – 48µm long (at least 6: 1), thick-walled; inferior cells lax, quadrate to short-rectangular. Setae short. Capsules short-ovate, horizontal to suberect, red when mature. Endostome and cilia rudimentary. Spores 11–13 µm in diameter. (Fig.21)

Distribution: Australia, Africa, SE Asia and the Philippines; Kerela, Karnataka, Tamilnadu, Darjeeling, Western Himalayas, Kashmir, Meghalaya, Naga hills, Sikkim. Mizoram.

Habitat: Plants grows epiphytically on the bark and also on rock.

Specimens Examined: India: Mizoram: Aizawl District: Darlawn Forest Division, Hmuifang sub-tropical forest;11th July 2017, 15th September 2016, 17rd August 2016;Tlangthanpuii Tlangte; Altitude 1280 m,1250 m 16,17 – 000026 (MZU).

26. *Bryum argenteum* Hewd. Bryum argenteum Hedw., Spec. Musc.181.1801. Synonym:Bryum argenteum Hedw. var. lanatum (P.Beauv) Hamp. (Ross et al. 2013).

Plants small, in dense turfs, silky greenish white when moist, silvery-hyaline when dry. Stems julaceous, fragile, crowded, 8 – 17 mm tall, branching by numerously, subperichaetial innovations. Leaves ovate to ovate-lanceolate, 0.7 – 1.8 mm long, concave, imbricate, tapered somewhat abruptly to an obtuse apex; margin plane, typically un surrounded; costa feeble, percurrent or not reaching the apex, in cross-section lacking guide cells and with a condensed stereid band; upper and mid-

laminal cells rhomboidalhexagonal, 40 – 70 µm long, 2 – 4: 1, thin or firm-walled; basal laminal cells predominantly quadrate, thin-walled. Gemmae (bulbils) often present in leaf axils of sterile stems. Perichaetia on short stems; perichaetial leaves apiculate. Setae red, 12 – 20 mm long. Capsules short, to 2 mm long, pendulous, ovate, with a thick and often wrinkled neck, abruptly contracted to the seta, bright red at maturity; operculum convex, apiculate. Peristome double; exostome teeth 16, with a narrow border, tapering to a pale tip; outer face finely papillose; endostome segments 16, with narrow gaps; basal membrane half the height of the exostome teeth; cilia 1 – 3, short-appendiculate. Spores small, 8 – 15 µm diameter. (Fig.22)

Distribution: New Zealand and Islands of the South Pacific Ocean; Sikkim, West Bengal:Darjeeling, Arunachal Pradesh and Meghalaya: Khasia Hills. Kashmir. South India: Karnataka: Kabbinakad, Kerala, Tamil Nadu: Palni hills and Nilgiri hills: Kotagiri, Ootacamund, Mizoram.

Habitat: Plants are growing on rock and soil as pure population.

Specimens Examnined : India, Mizoram, Aizawl District: Aizawl to Sairang road side, Darlawn Forest Division, 11th July 2017, 15th September 2016, Tlangthanpuii Tlangte, Altitude 400 m, 1101 m; 16,17 – 000027 (MZU).

27. *Bryum coronatum* Schwagr. Sp. Musc. Frond., Suppl. 1(2): 103. Pl. 71. 1816.

Plants bright to pale- greenish, slender, densely and closely turfted, 3.1 – 3.5 cm high, tomentose at base.Stem branched at base, central strand present, erect, Branche from base, tomentose at base; Leaves ovate to oblong – lanceolate, long acuminate, lower leaves smaller than upper leaves,4 x 1 mm, erect spreading when

moist, twisted when dry, margin entire except the arista; costa strong, reddish, excurrent at base; Lamina cells narrow, cells at upper part thin, rhomboid to hexagonal, 50 – 58 x 8 µmm basal cells sahorter, rectangular, thin walled, 35 – 40 x 15 – 19 µm, one layer of elongated cells at marginal border, tip serrated; seta apical, erect, reddish, 3.1 - 4.0 cm long; capsule pendulous, shaped like a cup in another cup, red to purple when matured, up to 2 mm long, apophysis thick, spongy, peristome reddish. (Fig.23)

Distribution: China, Borneo, Philippines, Thailand, Brazil, Bolivia, Peru and Mexico; Sikkim, Manipur, Darjeeling, Rajasthan, Calcutta, Orissa, Tamilnadu, Mizoram.

Habitat: Plants grows on soil in moist and damp place.

Specimens Examined: India, Mizoram, Aizawl District: Darlawn Forest Division, Hmuifang Sub- Tropical Forest 11th July 2017, 15th September 2016, 15th October 2016, Tlangthanpuii Tlangte, Altitude 1200 m, 990 m; 16,17 – 000028 (MZU).

Family: Dicranaceae Schimp. Dicranaceae Schimp., Coroll. Bryol. Eur.11.1855-56.

28. *Campylopus ericoides* (Griff.) A. Jaeger *Campylopus ericoides* (Griff.)A. Jaeger, Ber. S. Gall. Naturw. Ges.1870-71. 424. 1872. Synonym: Campylopus involutus (Müll. Hal.) A. Jaeger, Ber. S. Gall. Naturw.Ges. 1870-71:418. 1872 (Frahm 1999).

Plants yellowish brown, 3 - 4 cm long and 2 - 3 mm wide with leaves, cross-section of stem circular, 0.2 - 0.3 mm in diameter, two rows of outer cortical cells

thick walled, brown, small, inner cortical cells thin walled, large, 19 - 30 x 15 - 22 µm, central strand well developed with very thin, hyaline cells; leaf erect, lanceolate, 4.0 - 6.0 x 0.7 - 0.8 mm wide with denticulate tip; bunch of rhizoids present at the base of leaf on the dorsal side of costa; costa covering about 1/3 of leaf width, stereids present on the both sides of median guide cells; leaf cells rhomboidal, incrassate, 20 - 35 x 4 - 8 µm, basal cells rectangular, 25 - 45 x 11 - 22 µm, alar cells slightly inflated, reddish brown, thin walled. Diocious, antheridia intermixed with paraphyses. Sporophytes not seen.

Distribution: Nepal, Ceylon, Burma, Java, Thailand, Vietnam and Philippines; West Bengal, Meghalaya, Manipur, Tamil Nadu, Nepal, Mizoram.

Habitat: Plants are terrestrial and epiphytic, growing on soil as pure population and on bark of tree.

Specimens Examined: India, Mizoram, Aizawl District; Darlawn Forest Division, Tawi wildlife sanctuary 11th July 2017, 15th September 2016, 15th October 2016, Tlangthanpuii Tlangte; Altitude 1600 m, 790 m; 16,17 – 000029 (MZU).

29. *Campylopus pilifer* Brid.*Campylopus pilifer* Brid. Mant. Musc.72, 1819.

Plants vegetative ,green - yellowish, rising in free tuft, 4 – 5 cm long and 2 - 4 mm wide; cross-section of stem rounded, 0.4 - 0.6 mm in diameter, 2 - 3 rows of outer cortical cells thick walled, brown in colour and tiny, inner cortex cells thin walled, big, 23.2 - 40.1 x 10.3 – 20.3 µm, central strand well developed with thin, hyaline cells; leaf erect, lanceolate 6.1 - 8.0 x 0.7 - 0.9 mm and gradually tapering from base to the apex finish with a serrate; costa covering 1/4 of leaf width, stereids

near on dorsal side with fine developed dorsal lamellae, 2 - 6 cells high; leaf-cells rhomboidal, incrassate 40 - 60 x 4 -8 µm, basal cells thin walled, rectangular, 45 - 60 x 12 - 17 µm; alar cells not differentiated, brown in colour. (Fig.24)

Distribution: Srilanka, Medagascar, Central and South America, South West Europe and Africa; Kerala, Tamil Nadu, Mizoram.

Habitat: Plants are growing on soil as a pure population.

Specimens Examined: India, Mizoram, Aizawl District; Darlawn Tawi wildlife Sanctuary, 11th July 2017, Tlangthanpuii Tlangte, Altitude 970 m; 16,17 – 000030 (MZU).

Family: Ditrichaceae Limpr. Ditrichaceae Limpr. in Rabenh., Kryptogamen - Fl. ed. 2. 4:482. 1887.

30. *Dicranum lorifolium* Mitt.,J.Linn. Ihsiba (1935) 199.

Plants dark green to yellowish, shiny, in thick tufts, medium sized up to 7 cm high. Stems rising, or erect, dichotomously branched, densely fliate, tomentose beneath. Leaves uniformly curving at one side, fulcate – secund when dry, erect patent scarcely lanceolate, up to 1.6 cm long, increasingly narrowed from an ovate base to a long, canaliculated acumen; margins plane, entire below, stridently serrate near the apex; costa slender, brownish, percurrent, serrate at rear above; upper cells rhomboidal to short-rectangular, 45 – 60 µm x 12-14 µm; basal cells lengthened, rectangular 77 – 89 µm x 11 – 13 µm, thick walled, porose; alar cells somewhat

bulging out, bistratose, reddish brown at the margins, hyaline inside. Diocious. Perichetial leaves with s high convolute – sheathing base, abruptly tapering to a short point. Satae single, in a straight line, up to 5 cm long, brownish; capsules erect to sub-erect, cylindric, ca. 7 mm long, reddish brown; opercula erect, conic – rostrate; peristome teeth typically dicranoid. Spores 20.1 – 25.2 µm in diameter, light brownish.

Distribution: China, Bhutan, Nepal; Darjeeling, Sikkim, Meghalaya, Nagaland, Kashmir, Mizoram.

Habitat: Plants grows on tree bark, and sometimes growing on soil.

Specimens Examined: India, Mizoram, Aizawl District; Tawi Wildlife Sanctuary, Hmuifang sub tropical forest, Darlawn forest division; 15th August 2016, 11th July, 2017, 14th August 2017, Tlangthanpuii Tlangte, Altitude 1501 m, 1000 m, 990 m, 16,17 – 000031 (MZU).

31. ***Ditrichum heteromallum*** var. emodi Gangulee Ditrichum heteromallumvar. emodi Gangulee, in Bull. Bot. Soc. Beng. 13:3. 1959.

Plants yellowish to pale green, unbranched, 1.5 - 1.1 cm long and 2.3 - 2.7 mm wide including leaves; cross-section of stem triangular, 0.14 - 0.17 mm in diameter, one row of outer cortical cells thick walled, small, brown, inside cortical cells thin walled, large, 12 - 23 x 8 - 12 µm, central strand well developed with very thin, hyaline cells; leaves erect, lanceolate, 3.5 - 4.5 x 0.13 - 0.5 mm, steadily tapering from broader oval base to a long narrow subula with weakly denticulate tip; costa well developed; leaf-cells long, thin 20 - 40 x 8 - 12 µm, basal cells

rectangular 40 - 75 x 16 - 20 µm wide. Sporophytes present at apical part of the main axis. Seta erect, 0.6 - 1.8 cm long; capsule ovate-cylindrical, 2.3 - 3.1 x 0.6 - 0.8 mm; peristome teeth disintegrated; spores tiny, papillose, 12 - 16 µm. (Fig.25)

Distribution: Endemic to India. Eastern Himalaya: Sikkim, West Bengal: Darjeeling. South India: Tamil Nadu: Nilgiri hill : Kotagiri, Ootacamund, Mizoram

Habitat: Plants grow on rocky soil as a pure population and it was also found on the tree bark.

Specimens examined: India, Mizoram, Aizawl District: Hmuifang Sub- Tropical Forest 11th July 2017, Tawi Wildlife Sanctuary 15thAugust 2016, Tlangthanpuii Tlangte, Altitude 1501 m, 1000 m; 16,17 – 000032 (MZU).

Family: Leucobryaceae Schimper**.** Paul L. Redfearn Jr.

32. *Leucobryum candidium* Brid.ex P. (Beauv.)Wilson, *in* J.D.Hooker, *FL.Nov*.-Zel.2:64 (1854)

Plants medium-sized to vigorous. Stem deficient a central strand. Leaves imbricate, spirally set, uniformly curving to one side to falcate-secund, ovate-lanceolate, 3.9 – 5.5 mm long, 0.7 – 1.3 mm wide, canaliculated below, base slightly lessened; costa abaxially undulate in the distal 25 - 33%, toothed at the apex only; at the base with 1 – 2 layers of leucocysts adaxially and 2 layers abaxially, higher up with a single layer of leucocysts at either side; basal superficial abaxial cells gradually shortened, short-rectangular to quadrate; lamina contracted, consisting of 3

– 5 cell rows throughout. Perichaetial leaves shorter and narrower than adjacent stem leaves.

Distribution: Lord Howe Island, New Zealand and New Caledonia, Australia; Tamilnadu, Mizoram.

Habitat: Plants grows on moist and wet soil.

Specimens examined: India, Mizoram, Aizawl District; Hmuifang Sub-Tropical Forest 11th July 2017, Tawi Wildlife Sanctuary 15thAugust 2016, Tlangthanpuii Tlangte; Altitude1000 m, 1200 m; 16,17 – 000033 (MZU).

Family: Meteoriaceae Kind. Meteoriaceae Kindb., Gen. Eur. Northamar. Bry.7, 1897.

33. *Meteoriopsis reclinata* (Müll. Hal.) M. Fleisch. *Meteoriopsis reclinata* (Müll. Hal.) M. Fleisch. In Broth., Nat. Pfl. 1(3): 826. 1906.

Plants epiphytic, pale yellow - green, Plants vegetative. sleek, 1 - 5 cm long, 1 - 4 mm together with leaves, pinnately branched; cross section of stem rounded, 0.1 - 0.3 mm in diameter, 2 - 3 rows of external cortical cells thick walled, inside cortical cells thin, larger, 12 - 21 x 9 - 15 µm, central strand not seen; leaves compressed, thick, spirally set, ovate-lanceolate with outer layer base, 3 -4 x 1.0 - 1.5 mm, frequently totally fold, canaliculate, margin minutely denticulate, apex barely acute, elongated; costa single, typically end at mid-leaf area; apical leaf cells

linear, 20.5 - 40 x 4 5 – 6 µm, middle cells rhomboidal with 1 - 3 minute papillae, 48 - 64 x 4 - 8 µm, basal cells rectanguar 19 - 33 x 9 - 10 µm.

Habitat: Plants are found growing on bark of tree epiphytically, and are also terrestrial, growing on soil as pure population.

Distribution: Nepal, Myanmar, Thailand, Indonesia, Malalaya, Srilanka, Vietnam, Java, Moluccas, New Guinea, Philippines, Australia, Tasmania, Taiwan, Yunnan, Szechuan, Kweichow, Riukiu, Celebes, China, Mangolia, Formosa, Japan, Korea and Australia**:** Eastern Himalaya: Arunachal Pradesh, Sikkim, West Bengal: Darjeeling, Manipur, Meghalaya: Khasia hills, Nagaland: Naga hills, Assam. Western Himalaya: Uttarakhand: Gharawal-Mussoorie, Kumaon, Himachal Pradesh: Shimala. South India: Karnataka: Coorg, Kerala, Tamil Nadu: Palni and Nilgiri hills: Kotagiri, Gudalur, Mizoram.

Specimens examined: India, Mizoram, Aizawl District; Hmuifang Sub-Tropical Forest, Tawi Wildlife Sanctuary, 11th July 2017, 15th August2016, Tlangthanpuii Tlangte; Altitude 1700 m, 229 m;16,17 - 000034(MZU).

34. ***Cryptopapillaria fuscescens*** (Hook.) M. Menzel, Willdenowia, Bd. 22, H. ½: 171-196. 1992.

Plants yellowish to pale green, Plants vegetative, sleek and epiphytic, 7 - 13 cm long and 1 - 4 cm wide together with the leaves; cross-section of stem rounded, 0.2 - 0.5 mm in diameter, 2 - 4 rows of external cortical cells thick walled, tiny, interior cortical cells slender walled, larger, 12 - 24 x 8 -13 µm, central strand not seen; leaves imbricate, compactly set, oblong - lanceolate, plicate auriculate, 2.0 - 2.5

x 0.4 - 0.8 mm, margin denticulate all through; costa solitary, ending midleaf; leaf - cells linear - lengthened to rhomboidal, multi-papillate except juxta-costal cells; median leaf-cells thin walled, rhomboidal, 23 - 45 x 2 - 7 µm, basal costal cells rectangular, flat, porose, 40 - 55 x 7 - 12 µm.

Distribution: Nepal, Bhutan, Ceylon, Myanmar, Thailand, Laos, Yunnan, Tonkin, Java, Sumatra, Celebes, Borneo, and Philippines**;** Sikkim, West Bengal, Karnataka, Kerala, Tamil Nadu , Mizoram.

Habitat: Plants are epiphytic, growing on the tree bark and hanging on rocks, in association with other species of epiphytic plants.

Specimens examined: India, Mizoram, Aizawl District; Hmuifang Sub-Tropical Forest, Tawi Wildlife Sanctuary, 11th July 2017, 15th August2015, Tlangthanpuii Tlangte; Altitude 1200 m, 2000 m; 15,17 – 000035 (MZU).

Family: Funariaceae Schwägr. Funariaceae Schwägr. in Willd., Sp. Pl. ed. 4. 5(2): 43.1830. Neckraceae Schimp., Coroll. Bryol.Eur. 99.1855-56.

35. ***Funaria hygrometrica*** var. calvescens (Schwägr.) Mont. Funaria hygrometrica var. calvescens (Schwägr.) Mont., Ann. Sc. Nat. Bot. Ser. 2, 12: 54. 1839.

Plants yellowish green, acrocarpous, epiphytic, 1.5 – 2.7 cm long and 2.1 – 3.4 mm wide with leaves; cross-section of stem spherical, 0.5 - 0.6 mm in diameter, 2 rows of outer cortical cells thick walled, tiny, internal cortical cells thin walled, large, 28 - 40 x 16 - 27 µm, central strand well developed with hyaline thin walled cells; lower leaves minute, thinly display, upper leaves oblong - lanceolate, 3.1 - 3.7 x 0.9 - 1.5 mm, margin entire; costa single, percurrent; leaf-cells smooth, elongated

rectangular, apical cells 37 – 60 x 18 - 25 μm, middle cells 80 - 98 x 15 - 26 μm, basal cells 112 – 135 x 17 - 35 μm. Seta elongated, arcuate; capsule straight, irregular, 2.8 -4.1 x 1.5 - 1.9 mm; peristome teeth double; external teeth, 540 - 585 x 90 - 95 μm, internal teeth hyaline, 520-565 μm; spores smooth, small, 7-11 μm. (Fig.26)

Distribution: Nepal, Bhutan, Pakistan, China, Ceylon, Burma, Thailand, Japan, Taiwan, Korea, Siberia, Europe, sub Saharan Africa, North and S. America, Australia and New Zealand**;** Arunachal Pradesh, Manipur.Western Himalaya: Kashmir. South India: Karnataka: Agumbe. Kerala, Tamil Nadu, Mizoram.

Habitat: Plants are terrestrial, growing on soil as well as on the bark of tree.

Specimens Examined : India, Mizoram, Aizawl District; Hmuifang Sub-Tropical Forest, Tawi wildlife Sanctuary 11th July 2015, 17th August 2016, Tlangthanpuii Tlangte, Altitude 1501 m ,959 m; 16,17 – 000037 (MZU).

Family: Neckraceae Schimp. Neckraceae Schimp., Coroll. Bryol.Eur. 99.1855-56.

36. ***Homaliodendron scalpellifolium*** (Mitt.) M. Fleisch. Homaliodendron scalpellifolium (Mitt.) M. Fleisch. in Hedwigia, 45: 75 (1906).

Plants yellowish- green, vegetative , pleurocarpous, epiphytic, dendroid, 5 - 9cm long, main stem erect, bi- or tripinnately branched, crosssection of stem oval in shape, 0.8 - 0.9 x 0.6 - 0.7 mm in diameter, 5 - 8 rows of outer cortical cells thick walled, tiny, yellowish in color, inner cortical cells thin walled, large, 21.1 – 29.9 x

12.1 - 17.1μm; central strand absent; stipe leaves broadly triangular, appressed, gradually tapering to a long apiculus; upper leaves horizontally scattering, ovate-spathulate, 4 - 5 x 2 - 3 mm; apex obtuse bearing 12 - 20 teeth, terminal teeth prominent, 0.5 - 0.6 mm; costa singly present, covering about 1/2 of leaf length; leaf-cells rhomboidal, apical cells 13 - 24 x 4 - 9 μm, middle cells 35 - 49 x 5 - 8 μm, basal coastal cells rectangular 60 - 78 x 4 – 8 μm with porose walls. (Fig.27)

Distribution in India: Nepal, Ceylon, Thailand, Laos, Vietnam, China Taiwan, Japan, Malaysia, Indonesia, Philippines, New Guinea, New Caledonia and East Africa; Meghalaya, West Bengal, Arunachal Pradesh, Tamil Nadu, Mizoram.

Habitat: Plants are growing on the soil and tree bark in association with other epiphytic plants.

Specimens Examined: India, Mizoram, Aizawl District; Hmuifang Sub-Tropical Forest, Tawi wildlife Sanctuary 11th July 2015, 17th August 2016, Tlangthanpuii Tlangte ,Altitude 800m,2100m, 15,17 – 000039 (MZU).

Family: Orthotrichaceae Arn. Orthotrichaceae Arn. Disp. Meth. Mousses 13. 1825.

37. *Macromitrium nepalense* (Hook. & Grev.) Schwägr., Spec. Musc. Suppl. 2(2):134. 192. 1827

Plants pleurocarpous, epiphytic, brownish green in colour, 4 - 5 cm long and 3 - 4 mm wide with leaves, branched; cross-section of stem circular, 0.1 - 0.2 mm in diameter, two rows of outer cortical cell slightly thick walled, small, brown in colour,

inner cortical cells thin walled, large, 19-23 x 11-19 μm, central strand absent; leaves densely arranged on stem, erect, lanceolate, often with hook-like incurving of tip, 2.3 - 2.8 x 0.4 - 0.6 mm; costa single, percurrent; leaf-cells thick walled, papillose, apical cells rounded, 7 - 12 x 4 - 9 μm, middle cells 8 - 12 x 3 - 9 μm, mid-laminar cells with 1 - 2 small papillae, basal cells rectangular with single papilla, 15 - 22 x 7-11 μm.

Distribution: Nepal, Burma, Thailand, North Vietnam, Yunan, Hongkong, Philippines; Meghalaya, Nagaland, Arunachal Pradesh, West Bengal, Assam, Kerala, Tamil Nadu, Mizoram

Habitat: Plants are found growing on soil.

Specimens Examined: India, Mizoram, Aizawl District; Tawi wildlife sanctuary, Hmuifang Sub-Tropical Forest, 11th June 2016, 17th August 2016, Tlangthanpuii Tlangte; Altitude 1000 m, 1612 m; 15,17 – 000040 (MZU).

Family: Polytrichaceae Schwägr. Polytrichaceae Schwägr., in Willd., Sp. Pl. ed. 4. 5(2): 1.1830.

38. *Artrichum undulatum* (Hedw.) P.Beauv. var. *selwynii* (Aust.) Frye in Gourt, in Moss Fl. N. Amer. 1 :103. 1837

Plants small, usually dark green or yellowish, robust and acrocarpous, forms widespread patches, loosely tufted,. The erect stems unbranched, 6 – 7 cm, together with extended and slender pointed leaves up to 1 cm in length and are strongly

crisped when they are dry. Each leaf is noticeably transversely undulate when moist and crisp when dry. Leaves are meager below, more crowded above, with toothed leaf adges, The nerve ends in the leaf tip. Seta redish - brown grasp the brown capsule, Capsule recurrent, cylindrical and curved - horizontal, with a long beak on the lid. Capsules mature spring – summer. Cynlindrical capsules are recurrent, 4 – 5 mm long with a long beak of similar length, on a 3 – 4 cm long reddish seta.

Distribution: Wide spread in Europe, North America and Asia: China, Japan, Kazachstan, Phillipines, Russia, Taiwan; Himalayas, West Bengal, Sikkim**,** Mizoram

Habitat: Plants was found on the wall of rock near the steam and also on the damp soil

Specimens Examined: India, Mizoram, Aizawl District; Darlawn forest division, Hmuifang Sub-Tropical Forest, 11th June 2016, 18th August 2015, Tlangthanpuii Tlangte, Altitude 1000 m, 1300 m, 15,17 – 000045 (MZU).

39. *Pogonatum aloides* (Hedw.) P. Beauv., 1805

Plants Green to reddish, robust, 3.0 – 4.5 cm in lax tuft. Stem branched slightly, with pale tomenta at the basal rhizomatous region. Leaves lanceolate, broader sheathing base; 7.0 – 12.0 mm long; apex stridently acute; margin also stridently toothed roughly up to the base of the lamina. Costa reddish brown, toothed at the backside towards apex. Longitudinal lamellae abundant, casing most of the ventral face. Basal cells of the lamina almost quadrate, 10.0 – 11.2 µm diagonally, end cells of the lamellae curved. Seta 1.4 – 1.6 cm long; capsule erect, reddish brown, 4.2 – 5.7 mm long, ovate cylindrical, surface roughed; calyptras covers whole

capsule, flatly, silvery white; operculum convex, shortly rostrate; peristome teeth 34, solid with brown striation, 72.0 – 78.0 µ long; spores rounded, 13.5 – 15.0 µ in diameter.

Distribution: Darjeeling, Sikkim, Shimla, Mussoorie, Garhwal, Kumaon, Assam, Nilgiri hills, Palni hills, Tamil Nadu, Mizoram

Habitat: Plants are terrestrial, growing on moist and damp rocks.

Specimens Examined: India, Mizoram, Aizawl District; Darlawn forest division, Hmuifang Sub- Tropical Forest, 11th June 2016, 18th August 2015, Tlangthanpuii Tlangte, Altitude 1174 m, 1619 m, 15,17 – 000045 (MZU).

40. *Pogonatum neesii* (Müll. Hal.) Dozy Pogonatum neesii (Müll. Hal.) Dozy, Ned. Kruidk. Arch. 4(1):75. 1856.

Plants small, green – Pale green, 1 - 4 cm long and 5 - 12 mm wide together with leaves; cross-section of stem round, 0.4 - 0.5 mm in diameter, two row of external cortical cell thick walled, small, brown in color, inner cortical cells thin walled, large, 17 – 27 x 12 - 16 µm, central strand finely developed; leaves with wide sheathing base and spreading elongated limb region, erect when moist, curled when dry, lanceolate, 5.0 - 7.0 x 0.6 - 2.0 mm, margin denticulate at apex, photosynthetic lamellae numerous, present on ventral surface on costa, lamellae 5-7 cells high, apical cells uneven and to some extent larger than adjacent cells; costa broad, reddish brown, spinose on dorsal side; leaf-cells rounded-quadrate to hexagonal, apical cells 16 - 27 x 9-13 µm, middle cells 12-14 x 4 -7 µm, basal cells rectangular 35 - 64 x 11-20 µm. Seta erect, 1.0-2.5 cm long; capsule a little inclined,

cylindrical, smooth; peristome teeth solid, 20; spores spherical, smooth 6-13 μm. (Fig.28)

Distribution: Nepal, China, Ceylon, Burma, Thailand, Sumatra, Vietnam, Russia, Java, Borneo, Celebes, New Guinea, Philippines, Formosa, East Europe and North Asia Sikkim; West Bengal, Tripura, Meghalaya, Uttarakhand, Himachal Pradesh, Maharastra, Karnataka, Kerala, Tamil Nadu, Mizoram.

Habitat: Plants are found, growing on rock in pure population.

Specimens Examined: India: Mizoram: Aizawl District: Hmuifang Sub-Tropical Forest, Aizawl to Sairang roadside 11th June 2016, 18th August 2015, Tlangthanpuii Tlangte ; Altitude 1619 m, 280 m;15,17 – 00004 5(MZU).

5.2 ECONOMIC IMPORTANCE OF BRYOPHYTES

According to the ethobotanical survey of Flowers (1957) species of *Bryum* Hedew., *Mnium* L. and *Philonotis* Brid.were used by the Gasuite Insians tribes in Utah for relief of pain burn. The bryophytes pastes were directly applied on the burn, cut and wounds. In India the tribal people of Himalayan region used the burned moss ash mixed with honey and fat as ointment for wounds, cuts and burn (Pant *et al.,* 1986; Pant and Tewari, 1989). The *Plagiochasma appendiculatum* L. et L. is used by the Gaddi tribes of Kangra Valley, Himachal Pradesh, India for the cure of burns, boils and blisters of skin (Kumar *et al.,* 2000). *Spagnum* has been used for various medicinal purposes, having better absorbing and antimicrobial activity has been used for surgical dressing by Allied Armies, Canadian Red Cross and American Red Cross (Thieret, 1954). Dried Sphagnum is, therefore, an excellent surgical dressing because of its absorptive qualities, absorbing more liquid than cotton pads (Richardson 1981), and its ability to prevent infection. Because of these properties, it was used extensively during World War I. *Bryum* sp., are used for padding in bone fracture (Flowers 1957). Calcified peat is very effective as germicide. Adamek (1976) found that peat had a retarding effect on the growth of human cancer tissue cultures. Many other bryophytes, notably the liverworts, contain biologically active substances and research in the United States on the anti-cancer properties of bryophytes has been rewarding. Some of the results of this research can be found in Spjut *et al.,* (1986, 1988). Peat water has antiseptic and astringent properties. Sphagnol is a distillate of peat tar and highly valuable in treating eczema, psoriasis,

hermorrhoids, scabies, insect bites, acne and other skin diseases. Dried *Sphagnum* is sold in China to treat hemorrhages (Bland, 1971). *Marchantia Poly morpha* and *Conocephalum conicum was* widely used to treat liver ailments (Miller and Miller, 1979). According to Bland (1971), it "cools and cleanses the liver, removes yellow jaundice, and removes inflammation". It is also used to treat pulmonary tuberculosis in some parts of Europe. It is still used in China to treat jaundice of hepatitis and as an external slave to reduce inflammation. *Polytrichum commune* is used to reduce inflammation and fever as a detergent diuretic, laxative and hemostatic agent and plant of this species are boiled to make a tea to treat common cold It also dissolves stones of the kidney and gall bladder (Gulabani, 1974). Certain compounds are effective against leukemia which have been isolated from *Plagiochila fasciculate.* Diplophyllin, a compound isolated from some species of the liverwort *Diplophyllum*, is significantly effective against human epidermoid carcinoma. *Spagnum* is extensively used for dressing wounds. Chemical analysis has revealed that most bryophytes, including Sphagnum, have antibiotic properties (Banerjee, 1974). Extracts of many species of mosses and liverworts contain phenolic compounds that inhibit growth of pathogenic fungi and bacteria. Its pads are preferred in place of cotton, because they easily absorb liquids as much as four times than cotton, and are cooler, softer and less irritating to skin than cotton. *Haplocladium microphyllum* is used to treat bronchitis, cystitis and tympanitis (Sharma, 2014). North American Indians have used various bryophytes as herbal medicines (Flowers, 1957), and the Chinese still use some species for the treatment of cardiovascular diseases, boils, eczema, cuts, bites, wounds, and burns (Wu 1977, Ding 1982, Ando 1983). *Bryum*, *Mnium*, *Philonotis spp.* and *Poltrichum juniperinum*for healing burns, bruises and

wounds. *Marchantia polymorpha* are used to cure fresh wounds and cuts, poisonous snake bite and insects bites. The species *Frullania tamarici* are used for anticeptic activity, *Frullania ericoides* are used for nourishment of hair. Some dried mosses were used as a fire starter in some villages of the study area Aizawl district. in some villages of Mizoram. Bryophytes are mainly accepted soil additives because of their remarkably high water holding capacity and high water retention capacity they are widely used by home gardener for moisture retention in their garden. Bryophytes have also been used for green house crops, potted ornamental plants and seedlings, and in garden soil.

Showing signs of diverse chemical compounds, bryophytes tends to prove antimicrobial activity against various microorganisms. The lipophilic extract of *Frullania, Marchantia, Bazzania, Radula, Porella* and *Plagoichila* species show antimicrobial activity. The extract of *Artrichum undulatum, Artrichum angustatumm, Anomodon rostratus, Barbula* sp., *Dumortiera hirsute, Dicranum* Sp. Show action against *Gifka tetragona, Staphylococcus aureus, Candida albicans* (Madsen and Pates, 1952); *Salmonella pullorum, Phytomonas phaseoli, Salmonella paratyphi, Micrcoccus flavus, shigella flexneri, Micrococcus rubens* and *Straptococcus pyogenes* (Mc Cleary *et al.,* 1960). Antimicrobial activity of the extracts of *Porella, Pallavicinia* and *Reboulia* has also been confirmed by workers like Belcik and Weigner (1980). Antibiotic properties in over a dozen mosses eg. *Atrichum, Polytrichum and Spagnum* has also been investigated; these mosses strongly inhibited either or both Gram-positive bacteria. *Ditrichum scoparium* strongly inhibit all bacteria except *Escherichia coli* (Mc. Clearly *et al.,* 1960).

The bryophytes are recognized as the basal or first diversity lineage of the land plants (Chaudhary and kumar 2011; Forrest *et al.,* 2006) which includes morphologically and biochemically diverse groups like liverworts, hornworts and mosses. They may expect interesting bioactivities (Dulger *et al*., 2005; Chobot *et al.*, 2006; Sabovljevic *et al.*, 2006). Traditional medicinal use was started around 400 years back in China (Chaudhary and kumar, 2011). According to Umadevi *et al*.,(2013), plants growing at high altitudes are subjected to a variety of stressful environments and hence they may produce a spectrum of secondary metabolites.

The results of phytochemical screening indicate the presence of some secondary metabolites that may be responsible for the antibacterial activity of the bryophytes. It reveals the presence of alkaloides, coumarins, steroides, tannins, saponins, resins, phenols and sugars. But quinones are absent in the bryophyte extracts. The phytochemical compounds are responsible for the antimicrobial activity. The activity may be due to the presence of various secondary metabolites. The antibacterial activities of the bryophytes collected from the high altitude areas are remarkable and results are comparable with standard commercial antibiotics. These may be due to the stressful environment where the plants are inhabited. It is already reported that the Plants interact with stressful environments by physiological adaptation and altering the biochemical profile of plant tissues and producing a spectrum of secondary metabolites. (Williams *et al.,* 2016). Wakuli *et al.,* (2003) the extracted pigments of bryophytes exhibited antibiotic properties against gram positive bacteria (*Aureobacterium liquefaciens, Arthrobacter globiformis, Bacillus brevis, B. cirulans, B. subtilis and Curlobacterium plantanum*). Catenarin also inhibited the growth of fungi accompanying P. tritici-repentis during the saprophytic

phase of development. The most sensitive species was Epicouim nigrum, whose growth was inhibited upto 90 per cent Wakuli *et al.,* (2003).

The ethnobotanical screening tests of *Targionia hypophylla* L. and species of *Bryum* such as B. *argenteum*, B. *cellular*, B.*coronatum*, B. *plumosum*, B. *pseudotriquertum* and B. *capillare* in different solvents against both human and plant pathogenic bacteria and fungi using micro-dilution technique. The extracts of different species show differential response against bacteria and fungi. Both benzene and chloroform extracts were found to be ineffective or showed poor inhibition of bacterial and fungal growth (Krishnan *et al.*, 2012).

They are very widely used to measure heavy metal air pollution, especially in large cities and in areas surrounding power stations and metallurgical works (Maschke 1981, Mäkinen 1987). Heavy metals, such as lead, chromium, copper, cadmium, nickel, and vanadium, accumulate in the cell walls. Bryophytes are also suitable as bio-indicators of water pollution (Glime and Saxena 1991), and for the monitoring of radioactive caesium (Isomura *et al.,* 1993). Other species may indicate specific ecological conditions, such as pH levels in soil and water. Bryophytes are, in general, considered to be just as sensitive to air pollution as lichen (Dässler and Ranft 1969).

Other species may indicate specific ecological conditions, such as pH levels in soil and water. Bryophytes are, in general, considered to be just as sensitive to air pollution as lichen (Dässler and Ranft 1969). The bryophytes which are the simplest green plants grow in a variety of habitats but especially in cool and moist places on rocks, barks, soil, tree trunks, leaves and fallen logs. They absorbed the nutrients and

many other substances from ambient moisture. Some substances and nutrients are directly absorbed throughout the gametophyte by diffusion. There are number of bryophytes species which are more specific to particular habitat and their presence reveals particular ecological conditions. The Cuprophile communities or copper mosses *Mielichhoferia, Dryptodon* and *Merceya* species on substances in rich copper. *Leskea polycarpa, Leskea nervosa* on the tree bark subjected to flood water; *Funaria hygrometrica* for high soil pH and high nutrient content of potash. The *Amblystegium* sp., *Cinclidotus* sp., *Cratoneuron* sp., *Fissidens* sp., *Hygrohypnum* sp., *Octodiceras* sp. and *Rhynchostegium* species of aquatic bryophytes have been used for spatio-monitoring of the water pollution of the rivers in Belgium. Thus bryophytes can be used as bryo-meters, instruments for measuring phytotoxic air pollutants (Singh and Nath 2007). Taoda (1972) first demonstrated the use of bryophytes in assessing the impact of air pollution in Japan, and bryophytes have long been used for air pollution monitoring in both Europe (Greven 1992) and North America (Rao 1982). As bryophytes lack a protective layer or cuticle, they are extremely sensitive to pollutants in the immediate environment. Bryophytes can be used as indicator species, as the presence of pollution-sensitive species can help indicate low levels of air pollution. Air pollution can also create "moss deserts" and force many sensitive species to retreat.

Bryophytes are also sensitive to natural fluctuations in humidity. Many species are, therefore, restricted to microhabitats with specific microclimates (Jeglum, 1971). Multiple characteristics exist that make bryophytes effective bio-monitors including their ability grow on many different substrates in varying environmental conditions and rapid reproduction cycle which makes them easily

accessible and able to be propagated quickly (Vanderpoorten and Goffinet, 2009). Unlike flowering plants, bryophytes lack a leaf cuticle and are, therefore, capable of gaining and losing water more quickly. This means that bryophytes dry out very quickly, but they can also absorb minute quantities of available moisture from fog, mist, and dew – sources of water that other plants cannot utilize. However, during dry days there may be little physiological activity, and during droughts all physiological processes are quickly reduced to a minimum. Reproduction is highly dependable on water availability as the spermatozoids (male gametes) must swim from the antheridia to the archegonia in order to fuse with egg cells, initiating the spore-producing capsule generation; drought hampers this process. Plants in a dry state are also more vulnerable to disturbance, and since most bryophytes are not firmly attached to the substrate, a severe drought can eradicate these plants by desiccating their anchoring appendages. Activities that lead to a drier environment can, therefore, be considered potential threats to bryophytes (Hallingback and Hodgets, 2000). As minerals are obtained primarily from depositions of soluble salts and particles in the air, the substratum has little or no relevance in this respect. There are exceptions, however. It would appear that some mosses absorb metals and other contaminants from the soil, mainly through the capillary rise of water, making them inadequate for bio-monitoring. They tend to have neither a protective cuticle nor thick cell walls, as a result of which their tissues are readily permeable to water and minerals, including metal ions. The tissue making up the cell walls features numerous active sites (negatively charged groups), which act as efficient cationic exchanges (Brown, 1982). High metal accumulation capacities and specific sensitivities to pollutants also make bryophytes useful for air quality monitoring.

There are different effects on bryophytes in the presence of pollution particles. Even small traces of pollutants can cause a physical change in the bryophyte such as species abundance within the ecosystem, percent cover, and discoloration that can be seen and recorded (Govindapyari *et al.*, 2010). Changes in frequency of occurrence, reproductive formation, and color can be seen when bryophytes are exposed to atmospheric pollution.

The genus *Fontinalis* Hedw. has been used frequently in physiological studies as a representative aquatic plant; including many pollution studies. It is widely distributed through the world's temperate regions (Glime, 1984). Its large size and relative abundance further support its choice for detailed biological study. *Fontinalis sullivantii*, a species found in the Northeast Cape Fear River, is subjected to daily tides exposing it to dissolved sea salts as well as flooding and desiccation. Any change in either of these variables outside of what is experienced during a regular tidal cycle may cause immediate alterations in metabolism and physiology (Carol, 2003).

Epiphytic lichens and bryophytes are well known as indicators of air pollution and widely used to assess air quality (Nimis *et al*., 2002) In Ukraine lichen mapping studies have been carried out in many cities, for example Aviv. To estimate the air pollution in Kyiv we recommend using only the corticolous lichens and the modified index of atmospheric purity (IAPm). Indicator species of epiphytic lichens for zones with different air quality were proposed and can be used for further monitoring. It was established that air pollution in Kyiv was influenced by factories

(especially power and construction industries) and exhaust fumes of vehicles (Dymytrova , 2009).

Heavy metals originate from both natural and anthropogenic sources in the environment. In the atmosphere, natural sources of these elements are volcanic eruptions, cosmic and terrestrial dusts, vegetation fires, and salt spray from the oceans. Anthropogenic sources include emissions from different industrial plants (steel and non-ferrous metallurgy, smelters, alloying plants, petrochemical industry, fertilizer plants, coal power plants, industrial and home furnaces) and motor traffic. The amount of heavy metals originating from natural sources in the atmosphere is small as compared with the anthropogenic flux of these elements. Airborne heavy metals enter the ecosystems where they circulate and, depending on their concentration and toxicity, pose a greater or smaller threat to the components of these ecosystems (Zechmeister *et al*., 2003). The accumulation of heavy metals in the soil and living organisms may have a damaging effect on the environment. In the 1950s and 1960s, the quick development of industry and motor transport caused a dramatic increase in dust emissions containing heavy metals. It is only natural that ecologists focused their attention on threats posed by heavy metals to the biotic and abiotic environment. They began to look for sensitive and, cheap biological methods for assessing the environmental level of heavy metals, above all the most toxic ones (Cd, Pb, Hg). In the late 1960s, two Swedish ecologists, Rühling and Tyler (1968; 1969), first used mosses as indicators of heavy metals pollution. They recognised these plants to have many features of good bio-indicators. The suitability of bryophytes for the indication of heavy metal depositions is based on their accumulation which is a result of a series of morphological and physiological

properties which have already been given in Section 1 (e.g. cationic exchange properties) (Zechmeister *et al*., 2003).

In horticulture practice bryophytes are being used as soil additives since long time. Bryophytes are predominantly accepted soil additives because of their remarkably high water holding capacity and permeability to atmospheric air. Peats is one of the important soil conditioner and is frequently used for various horticulture purposes around the world. Numerous taxa of Bryophytes have also been used for green house plants, potted decorative plants, and in garden soil. In air layering, a method of propagating plants, uses of *Sphagnum* is very common. Fresh plants of *Sphagnum* spp. Are also mixed with topsoil or put on the soil as mulch. It helps to upholds wetness and prevent redundant growth of weeds. It is permeable to atmosphere and has flexibility, making it an ultimate growth medium. In Japan, use of mosses as ornamental plants for culture is very trendy. Landscape tray is another horticulture skill of Japan in which a number of mosses like *Bartramia pomiformis, Leucobryum neilgherrense* and *Polytrichhum commune* are used. Mosses also offer an imperative component for bonsai, where they help in the stabilization of soil and in preserving moisture. Moreover, the moss seems to be stylish and provides green cooling feel. Moss garden are also one of the aspects of daily life in Japan, where mosses have high commonly been used in moss gardens as they bestow a calm splendor and olden gaze to gardens by covering tree trunks, rocks and stone. Buddhist temple in Kyoto, an ancient capital of Japan holds a much admired moss garden. Horticulture benefits from extensive practice involving bryophytes as additives to the soil, soil cover, undersized plants, greenhouse crops, potted ornamental plants, and for seedling beds. *Spagnum* (Moss) is used in making totem

poles to support climbers and moss-filled garlands, admired in South Eastern U.S. Other pretty horticultural uses comprise floral arrangements, making flower baskets and covering flower container etc. Gardeners typically employ soggy *Sphagnum* for transportation of life plants. Occasional burning of *Sphagnum* is also used to create a smoke screen against frostiness (Glime, 2007). Bryophytes play role as maker for specific sites. The soil binding habitat of bryophytes may be exemplified by *Politrichum piliferum, Politrichum juniperinum, Ceratodon purpureum,* if we try to free it from the soil mechanically or by washing (Nath *et al.*, 2000). Some mosses e.g *Physicomitrium, Polytrichum,* Thalloid liverworts *Lunularia cruciata, Conocephalum conicum* and leafy liverworts *Chiloscyphus argutus, Scapania parva* etc. luxuriously grow on rock cover and protect them from physical and mechanical weathering, which are fast growing process. On the other hand, these plants also promotes slow weathering and soil formation by secretion of specific acids like Lunularic acid by *Lunularic criciata* (Nath *et al.*, 2000).

Bryophytes especially mosses, are used for decorative purposes in many countries including Finland, England, France, Japan and USA. Because of the absorbent and insulating properties, *Sphagnum* is the most useful household moss. Dry plants of *Clemacium japonicum* are used in Japan for making ornamental white flowers. Mats are prepared and sold in the market in many parts of India. Beddings, mattresses, cushions and pillows are prepared by stuffing mosses in many parts of India. In some parts of Himalayas, mosses are used as insecticides and insect repellants while storing grains. A cheap kind of clothing is prepared by mixing *Sphagnum* with wool in Germany. Head cushion for carrying vessels of water and other heavy articles are prepared by several mosses including *Hylocomium, Hypnum*

and *Trachypodopsis.* Several bryophytes e.g *Hypnum macrothamnium, Nichera, Sphagnum etc.* are used for packing apples, plums and other fruits in India (Sharma, 2014).

5.3 DISCUSSION:

The present study was carried out during 2015 to 2018, in the selected study area within Aizawl District, Mizoram which is located at latitude 23.7, longitude 92.7. Owing to its representation on tropical, sub-tropical and temperate climatic conditions, these different combinations of forest types, adaphic factor and climatic factor, temperature and altitude are expected to have the influenced on bryophytes diversity and abundant. The District is bounded on the North by Kolasib district, on the west by Mamit district, on the south by Serchhip district and on the east by Champhai district. The total forest cover is 86.5 % of the total geographical area including very dense forest (18 Sq.Km), moderately dense forest (1092 Sq.Km) and open forest (1984 Sq.Km). The average annual rainfall ranges from 2179 mm – 2712 mm during the year of 2015 - 2017, the state of Mizoram receives an adequate amount of rainfall since the area falls under the influence of the south – west monsoon, the highest rainfall occurs during the month of June to September (Fig. 30). The specimens were collected during the Month of June – September, since they are most abundant during the rainy season. During winter and summer, the specimens were all dried up and the best collecting season is the rainy season.

During the study period from 2015 to 2018, a total of 40 specimens were identified and collected, of which 21 species of 12 genera and 10 families are under liverworts and 19 species of 14 genera and 10 families are under mosses. The present reports on the study of bryophytes in Aizawl district, Mizoram shows the occurrence of 40 taxa belonging to 10 orders i.e Marchantiales, Jungermaniales, Metzgeriales, Porellales, Polytrichales, Bryales, Dicranales, Funariales, Hypnales and

Orthotrichales. The study revealed that, *Frullania* and *Bryum* are the most dominant genus and Jubulaceae and Bryaceae are the most dominant family. In the group of Liverworts, the order Marchantiales (4 genera and 6 species) and Jungermaniales (3 genera and 8 species) are the largest family, followed by order Metzgeriales (2genera and 2 species) and Porellales (1genera and 2 species). In the group of mosses the order Dicranales (4 genera and 5species) followed by Bryales (2 genera and 6 species), Hypnales (3genera and 3 species), Polytrichales (2 genera and 3 species), Funariales (1genera and 1species), Orthotrichales (1 genera and 1 species).

Table 3 Shows that Hmuifang reserved forest account for the highest diversity of the plant species, the temperature ranges between 20°C - 29°C during summer and winter temperature ranges from 7°C - 21°C and the area have the highest altitude (1619 m) among selected study sites. Aizawl to Sairang roadside (Table 5) have the lowest number of species, where temperature ranges between 11℃ - 32℃ with an altitude of 200 – 600 m. Since the roadside soil frequently shows high degree of pollution attributed to road traffic movement, unscientific dumping of garbage on roadside, road construction and other developmental activities which do not support luxuriant growth of the plant species. All the plant specimens were found to be presented in the altitude between 290 m to 1619 m. (Table 1)

It has been observed that the selected study area inside Aizawl District harbours quite diverse and rich bryophytes associated with suitable environmental condition and different physiographic conditions enable and support the natural habitat for rich diversity of bryophytes. This finding will lead to a better knowledge

of Bryophytes and their distribution in Mizoram. And at the same time it will help in encouraging more research work in the field.

Table 1. Lists of plant specimens with family, location and altitude:

Sl.no	Name of Species	Family	Group	Location	Altitude	Habitat
1	*Asterella khasiana* (Griff.)Grolle	Aytoniaceae	Liverworts	TWS, HSF	950 m, 1619 m	Tree bark
2	*Asterella musuriensis*(Kashyap.)	Ayotoniaceae	Liverworts	HSF,TWS,	1400 m,650 m	Tree bark
3	*Bazzania hainanensis L.-P. Zhou et L. Zhang*	Lepidoziaceae	Liverworts	TWS,DFD,HSF	1050 m,774 m, 1000 m	Tree bark
4	*Bazzania pearsonii Steph., Hedwigia*	Lepidoziaceae	Liverworts	AS,TWS,HSF	360 m, 960 m, 1612 m	Tree Bark
5	*Fossombronia cristula* Aust.	Fossombroniaceae	Liverworts	DFD,HSF	1150 m,1619 m	Rock
6	*Dumortiera hirsuta* (Sw.) Nees	Marchantiaceae	Liverworts	HSF,DFD TWS	1400 m,1162 m, 950 m	Soil
7	*Frullania ericoides (*Nees) Mont.	Jubulaceae	Liverworts	HSF,DFD, TWS	1542 m,1000 m, 900 m	Soil
8	*Frullania retusa* Mitt	Jubulaceae	Liverworts	HSF,TWS	1600 m,800 m	Rock
9	*Frullania tamarisci*(L.) Dumort.	Jubulaceae	Liverworts	HSF,TWS,DFD	1670 m, 1200 m, 1074 m	Soil
10	*Frullania wallichiana* Mitt.	Jubulaceae	Liverworts	TWS,HSF,DFD	1700 m, 1200 m, 570 m	Tree bark, Soil
11	*Frullania muscicola* Steph.,	Jubulaceae	Liverworts	DFD,HSF, TWS	1174 m, 1300 m, 1000 m	Soil
12	*Lejunea obfusca* Mitt.	Lejeuneaceae	Liverworts	TWS,HSF	570 m, 1560 m	Rock, Tree bark
13	*Marchantia paleacea* Bertol.	Marchantiaceae	Liverworts	TWS,DFD	989 m,1001 m	Soil
14	*Marchantia polymorpha Subsp.*	Marchantiaceae	Liverworts	TWS,HSF	700 m,1290 m	Soil

15	*Mastigolejeunea humilis*(Gottsche) Schiffn.	Lejeuneaceae	Liverworts	DFD, AS, HSF	1023 m, 350 m, 1560 m	Tree bark
16	*Metzgeria furcata* (L.) Dumort.	Metzgeriaceae	Liverworts	DFD,HSF	1102 m, 990 m	Tree bark
17	*Riccia fruitans* L.	Ricciaceae	Liverworts	DFD,HSF	1014 m, 1200 m	Rock
18	*Riccia glauca* L.	Ricciaceae	Liverworts	TWS,DFD	950 m, 1174 m	Rock
19	*Jungermania comata* Nees,Hepat.	Jungermanniaceae	Liverworts	TWS,DFD	1090 m,1161 m	Tree bark
20	*Trocholejeunea infustaca (Mitt.) Verd.*	Lejeuneaceae	Liverworts	TWS,HSF DFD	1500 m, 1619 m, 1172 m	Tree bark,Rocks
21	*Trocholejunea sandvicensis* Mizut.	Lejeuneaceae	Liverworts	TWS,HSF	1000 m, 1150 m	Tree bark
22	*Atrichum undulatum* (Hedw.) P.Beauv.	Polytrichaceae	Mosses	HSF,DFD	1050 m, 1300m	Soil, Rock
23	*Brachymenium bryoides* Hook.ex Schwagr.	Bryaceae	Mosses	TWS, HSF	980m, 1599 m	Soil
24	*Bryum alpinum* Huds. ex With	Bryaceae	Mosses	HSF,TWS,DFD	1500 m, 870 m, 1200 m	Soil
25	*Bryum auratum* Mitt	Bryaceae	Mosses	DFD,HSF	1280 m,1250 m	Rock,Tree bark
26	*Bryum argen teum* Hewd.	Bryaceae	Mosses	AS,DFD	400 m, 1101 m	Rock, soil
27	*Bryum coronatum* Schwagr.	Bryaceae	Mosses	DFD,HSF	1200 m, 990 m,	Tree bark
28	*Campylopus ericoides (Griff.)A. Jaeger*	Dicranaceae	Mosses	DFD,TWS	1600 m, 700 m	Tree bark
29	*Campylopus pilifer* Brid.	Dicranaceae	Mosses	TWS	970 m	Soil
30	*Dicranum lorifolium*	Ditrichaceae	Mosses	HSF,TWS, DFD	1501 m, 1000 m, 990 m	Soil, Tree bark

31	*Ditrichum heteromallum*	Ditrichaceae	Mosses	HSF,TWS	1501 m, 1000 m	Rock, Tree bark
32	*Funaria hygrometrica* Hedw.	Funariaceae	Mosses	HSF,TWS	1501 m,959 m	Soil, Tree bark
33	*Homaliodendron scapellifolium (Mitt.)M. Fleisch.*	Neckeraceae	Mosses	HSF,TWS	800 m, 2100 m	Soil, Tree bark
34	*Macromitrium nepalense* (Hook. & Grev.)	Orthotrichaceae	Mosses	TWS,HSF	1000 m, 1612 m	Soil
35	*Leucobryum candidium* Brid.ex P.(Beav.) Wilson	Leucobryaceae	Mosses	HSF,TWS	1200 m,1000 m	Soil
36	*Meteoriopsis reclinata (Mull. Hall.)M. Fleisch.*	Meteoriaceae	Mosses	TWS,HSF	229 m, 1700 m	Tree bark
37	*Cryptopapillaria fuscesencs(Hook.) M.*	Meteoriaceae	Mosses	TWS, HSF	1200 m, 1611 m	Tree Bark
38	*Pogonatum aloides* (Hedw.) P. Beauv.	Polytrichaceae	Mosses	DFD,HSF	1174 m, 1619 m	Rocks
39	*Pogonatum neesii* (Mull.Hall) Dozy	Polytrichaceae	Mosses	HSF,AS	1619 m,280 m	Rocks
40	*Philonotis falcata* (Hook.) Mitt	Bartramiaceae	Mosses	AS,TWS,HSF	290 m, 1500 m, 1600 m	Soil

NOTE:
AS=Aizawl to Sairang roadside
DFD=Darlawn Forest Division
HSF=Hmuifang Sub-tropical forest
TWS= Tawi wildlife Sanctuary

Table 2. List of plant specimens in Darlawn forest division:

SI. No.	Name of species	Family	Habitat
1	*Bazzania hainanensis L.-P. Zhou et L. Zhang*	Lepidoziaceae	Tree bark
2	*Fossombronia cristula* Aust.	Fossombroniaceae	Rock
3	*Dumortiera hirsuta* (Sw.) Nees	Marchantiaceae	Soil
4	*Frullania ericoides (*Nees) Mont.	Jubulaceae	Soil
5	*Frullania tamarisci*(L.) Dumort.	Jubulaceae	Soil
6	*Frullania wallichiana* Mitt.	Jubulaceae	Soil, Tree bark
7	*Frullania muscicola* Steph.,	Jubulaceae	Soil
8	*Marchantia paleacea* Bertol.	Marchantiaceae	Soil
9	*Mastigolejeunea humilis*(Gottsche) Schiffn.	Lejeuneaceae	Tree bark
10	*Metzgeria furcata* (L.) Dumort.	Metzgeriaceae	Tree bark
11	*Riccia fruitans* L.	Ricciaceae	Rock
12	*Riccia glauca* L.	Ricciaceae	Rock
13	*Jungermania comata* Nees,Hepat.	Jungermanniaceae	Tree bark
14	*Trocholejeunea infustaca (Mitt.) Verd.*	Lejeuneaceae	Tree bark, Rock
15	*Atrichum undulatum* (Hedw.) P.Beauv.	Polytrichaceae	Soil, Rock
16	*Bryum alpinum* Huds. ex With	Bryaceae	Soil
17	*Bryum auratum* Mitt	Bryaceae	Rock, Tree bark

18	*Bryum argerateum* Hewd.	Bryaceae	Rock, soil
19	*Bryum coronatum* Schwagr.	Bryaceae	Tree bark
20	*Campylopus ericoides (Griff.)A. Jaeger*	Dicranaceae	Tree bark
21	*Dicranum lorifolium*	Ditrichaceae	Soil, Tree bark
22	*Pogonatum aloides* (Hedw.) P. Beauv.	Polytrichaceae	Rocks

Table 3. List of plant specimens in Hmuifang sub-tropical Forest:

Sl. No.	Name of species	Family	Habitat
1	*Asterella khasiana* (Griff.)Grolle	Aytoniaceae	Tree bark
2	*Asterella musuriensis*(Kashyap.)	Ayotoniaceae	Tree bark
3	*Bazzania hainanensis L.-P. Zhou et L. Zhang*	Lepidoziaceae	Tree bark
4	*Bazzania pearsonii Steph., Hedwigia*	Lepidoziaceae	Tree Bark
5	*Fossombronia cristula* Aust.	Fossombroniaceae	Rock
6	*Dumortiera hirsuta* (Sw.) Nees	Marchantiaceae	Soil
7	*Frullania ericoides (*Nees) Mont.	Jubulaceae	Soil
8	*Frullania retusa* Mitt	Jubulaceae	Rock
9	*Frullania tamarisci*(L.) Dumort.	Jubulaceae	Soil
10	*Frullania wallichiana* Mitt.	Jubulaceae	Soil, Tree bark
11	*Frullania muscicola* Steph.,	Jubulaceae	Soil
12	*Lejunea obfusca* Mitt.	Lejeuneaceae	Rock, Tree bark
13	*Marchantia polymorpha Subsp.*	Marchantiaceae	Soil
14	*Mastigolejeunea humilis*(Gottsche)	Lejeuneaceae	Tree bark

	Schiffn.		
15	*Metzgeria furcata* (L.) Dumort.	Metzgeriaceae	Tree bark
16	*Riccia fruitans* L.	Ricciaceae	Rock
17	*Trocholejeunea infustaca (Mitt.) Verd.*	Lejeuneaceae	Tree bark, Rock
18	*Trocholejunea sandvicensis* Mizut.	Lejeuneaceae	Tree bark
19	*Atrichum undulatum* (Hedw.) P.Beauv.	Polytrichaceae	Soil, Rock
20	*Brachymenium bryoides* Hook.ex Schwagr.	Bryaceae	Soil
21	*Bryum alpinum* Huds. ex With	Bryaceae	Soil
22	*Bryum auratum* Mitt	Bryaceae	Rock,Tree bark
23	*Bryum coronatum* Schwagr.	Bryaceae	Tree bark
24	*Dicranum lorifolium*	Ditrichaceae	Soil, Tree bark
25	*Ditrichum heteromallum*	Ditrichaceae	Rock, Tree bark
26	*Funaria hydrometrica* Hedw.	Funariaceae	Soil, Tree bark
27	*Homaliodendron scapellifolium (Mitt.)M. Fleisch.*	Neckeraceae	Soil, Tree bark
28	*Macromitrium nepalense* (Hook. & Grev.)	Orthotrichaceae	Soil

29	*Leucobryum candidium* Brid.ex P.(Beav.) Wilson	Leucobryaceae	Soil
30	*Meteoriopsis relictina (Mull. Hall.)M. Fleisch.*	Meteoriaceae	Tree bark
31	*Cryptopapillaria fuscesencs(Hook.) M.*	Meteoriaceae	Tree Bark
32	*Pogonatum aloides* (Hedw.) P. Beauv.	Polytrichaceae	Rocks
33	*Pogonatum neesii* (Mull.Hall) Dozy	Polytrichaceae	Rocks
34	*Philonotis facata* (Hook.) Mitt	Bartramiaceae	Soil

Table 4. List of plant specimens in Tawi Wildlife Sanctuary:

SI. No.	Name of Species	Family	Habitat
1	*Asterella khasiana* (Griff.)Grolle	Aytoniaceae	Tree bark
2	*Asterella musuriensis*(Kashyap.)	Ayotoniaceae	Tree Bark
3	*Bazzania hainanensis L.-P. Zhou et L. Zhang*	Lepidoziaceae	Tree bark
4	*Bazzania pearsonii Steph., Hedwigia*	Lepidoziaceae	Tree Bark
5	*Dumortiera hirsuta* (Sw.) Nees	Marchantiaceae	Soil
6	*Frullania ericoides (*Nees) Mont.	Jubulaceae	Soil
7	*Frullania retusa* Mitt	Jubulaceae	Rock
8	*Frullania tamarisci*(L.) Dumort.	Jubulaceae	Soil
9	*Frullania wallichiana* Mitt.	Jubulaceae	Soil, Tree bark
10	*Frullania muscicola* Steph.,	Jubulaceae	Soil, Tree bark
11	*Lejunea obfusca* Mitt.	Lejeuneaceae	Rock, Tree bark
12	*Marchantia paleacea* Bertol.	Marchantiaceae	Soil
13	*Marchantia polymorpha Subsp.*	Marchantiaceae	Soil
14	*Riccia glauca* L.	Ricciaceae	Rock
15	*Jungermania comata* Nees,Hepat.	Jungermanniaceae	Tree bark
16	*Trocholejeunea infustaca (Mitt.) Verd.*	Lejeuneaceae	Tree bark, Tree bark

17	*Trocholejunea sandvicensis* Mizut.	Lejeuneaceae	Tree bark
18	*Brachymenium bryoides* Hook.ex Schwagr.	Bryaceae	Soil
19	*Bryum alpinum* Huds. ex With	Bryaceae	Soil
20	*Campylopus ericoides (Griff.)A. Jaeger*	Dicranaceae	Tree bark
21	*Campylopus pilifer* Brid.	Dicranaceae	Soil
22	*Dicranum lorifolium*	Ditrichaceae	Soil, Tree bark
23	*Ditrichum heteromallum*	Ditrichaceae	Rock, Tree bark
24	*Funaria hydrometrica* Hedw.	Funariaceae	Soil, Tree bark
25	*Homaliodendron scapellifolium (Mitt.)M. Fleisch.*	Neckeraceae	Soil, Tree bark
26	*Macromitrium nepalense* (Hook. & Grev.)	Orthotrichaceae	Soil
27	*Leucobryum candidium* Brid.ex P.(Beav.) Wilson	Leucobryaceae	Bark
28	*Meteoriopsis relictina (Mull. Hall.)M. Fleisch.*	Meteoriaceae	Tree bark
29	*Philonotis facata* (Hook.) Mitt	Bartramiaceae	Soil

Table 5. List of plant specimens in Aizawl to Sairang roadside:

SI.No.	Name of species	Family	Habitat
1	*Bazzania pearsonii Steph., Hedwigia*	Lepidoziaceae	Tree Bark
2	*Mastigolejeunea humilis*(Gottsche) Schiffn.	Lejeuneaceae	Tree Bark
3	*Bryum argerateum* Hewd.	Bryaceae	Rocks
4	*Pogonatum neesii* (Mull.Hall) Dozy	Polytrichaceae	Rocks
5	*Philonotis facata* (Hook.) Mitt	Bartramiaceae	Soil

CHAPTER – 6

CONCLUSIONS

During the study period it has been observed that a large number of bryophytes are exposed to an ever increasing encroachment on the natural vegetation. Vast areas are being denuded yearly due to increase in urbanization and pressure imposed by population growth, anthropogenic activities, land use and different kinds of developmental activities. Bryophytes especially mosses have high water retention capacity, which provide microhabitat for other plants and organisms, their role in the ecosystem is reasonably important. Deforestation has an impact on achieving healthy environment and resulting climate change associated with destruction of vegetation and loss of precious bryophytic flora. It consequently, appears that a wide-ranging decline has occurred, the main cause of which definitely is the growing level of deforestation all over the State. So, there is an imperative need to carry out an efficient floristic study on the bryophytes of Mizoram.

Hmuifang Reserved forests where some part of the area are still covered with virgin forest and received adequate amount of rainfall with the highest diversity of the plant species. The temperature ranges between 20°C - 29°C during summer and winter temperature ranges from 7°C - 21°C and having the highest altitude (1619 m) among selected study sites, followed by Tawi Wildlife Sanctuary which is located in the South eastern part of Aizawl, Mizoram with an altitudinal range between 500m – 1178 m. Aizawl to Sairang roadside recorded the least number of species, where temperature ranges from 11°C- 32°C with an altitude of 200 – 600 m, and the soil frequently shows high degree of pollution attributed to road traffic movement,

unscientific dumping of garbage, road construction and other developmental activities which do not support luxuriant growth of the plant species. All the plant specimens were found to be present in the altitude between 290 m to 1619 m. The result shows that the distributions of the plant species are more abundant in the higher altitude within the study areas.

Common bryophytes species used by the local people include *Bryum, Mnium, Philonotis spp., Poltrichum spp.,* for healing burns, bruises and wounds. *Marchantia polymorpha* are used to cure fresh wounds and cuts, poisonous snake bite and insects bites. The species *Frullania tamarici* are used for antiseptic activity, *Frullania ericoides* are used for nourishment of hair, and some dried mosses are also used as a fire starter.

Bryophytes are used in medicines, decoration, horticulture, agriculture, fuel in industries and as ecological indicators. Although bryophytes are the oldest among land plants, their values are quite unknown to people due to lack of study and lack of information, they are widely used as bioindicators of environment for their unique capacity to absorb the pollutants and very definite responses as some species are particularly sensitive to pollutants and exhibit visible injury symptoms even in the presence of very minute quantities of pollutants. Bryophytes are predominantly accepted as soil additives because of their remarkably high water holding capacity and high water retention capacity they are widely used by home gardeners for moisture retention in their garden. They are also used as a green house plants, potted ornamental plants and seedlings, and also in the garden for soil moisture retention.

It has been observed that, the information collected on the economic importance of bryophytes from the primary sources are minimal due to negligence of the study on this group of plants. The reason for lack of study and negligence in the field of bryophytes research in Mizoram is due to lack of expert in the field, inadequate number of educational and research Institutions with good laboratory facilities and lack of awareness towards this group of plants, which resulted in less interest on the research for this group of plants. The present study is the first attempt to investigate the economic uses of bryophytes in Mizoram. The plant specimens were collected from the study area during the month of July to September of the study period where rainfall is highest during these months and at the same time the best collecting season of the year. During the post rainy season most of the plant species were dried up. Rainy season and post – rainy season have the highest and abundant distribution of bryophytes.

Bryophytes play an important role in nutrient cycling, soil formation; provide microhabitat for other plants and animals. In other countries they are broadly used for different purposes like pollution monitoring, the moss Sphagnum due to its high level of water holding capacity is a good material for delivery of plants, fresh vegetables and flowers, and widely used by home gardener. In France the industry of moss have manufacture moss carpets in different sizes. Developed countries like Finland, Sweden, Ireland, Germany, Poland and Russia in which liverworts and mosses have been extensively tried and used as a fuel.

In Mizoram, only little information on their economic importance is known and their value is still unknown due to lack of information and knowledge on the

plants. The protection of bryophytes is essential in view of their critical role in ecosystem. So the present study is expected to have an outcome on the distribution, and status of Bryophytes flora of Mizoram. These will ensure the protection and conservation of rare and potentially economic important Bryophytes.

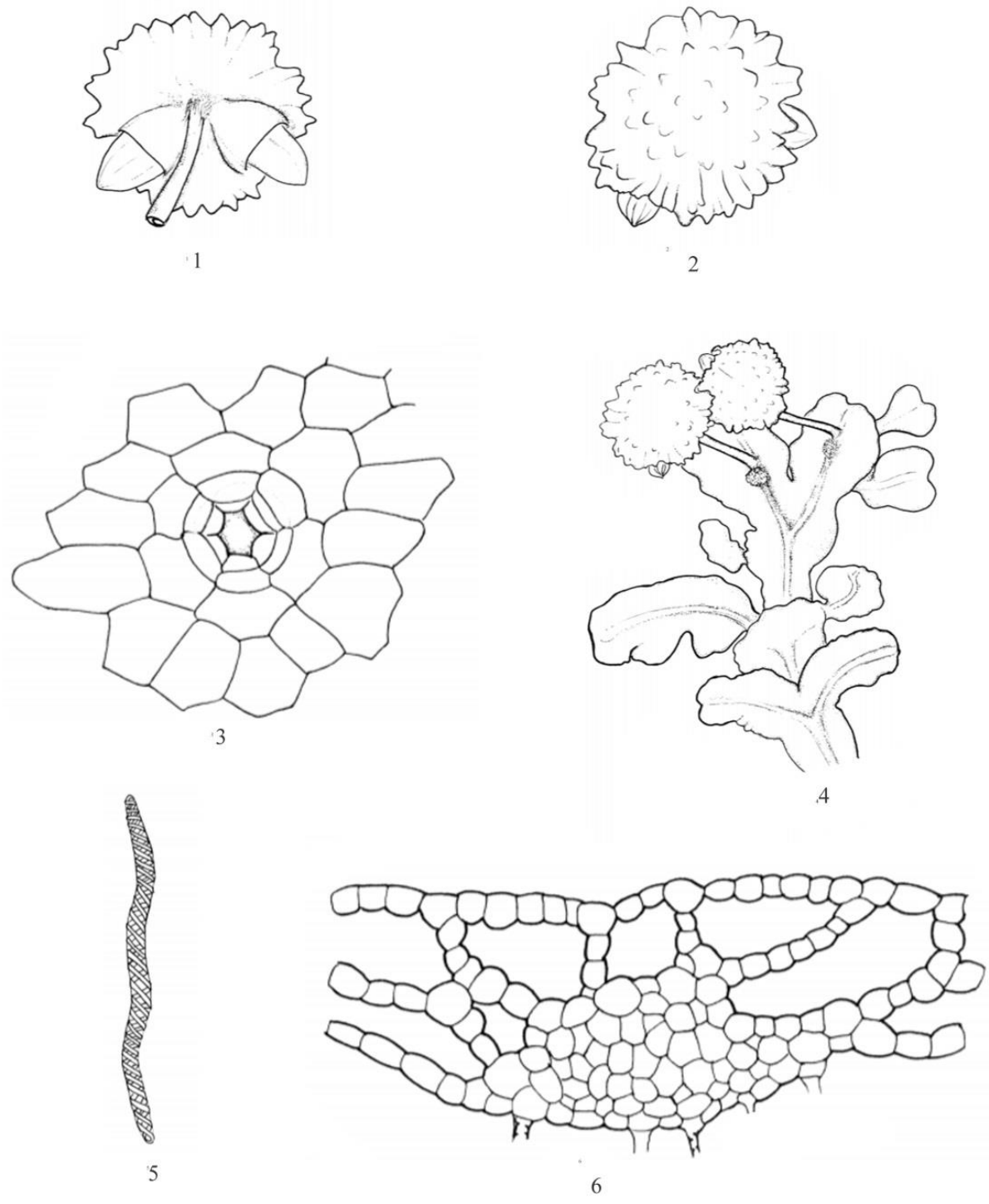

Fig 6. *Astrella khasyana* (Griff.) Pande, K.P. Srivast and Sultan Khan. 1 = ventral view of carpocephalum; 2 = dorsal view of carpocephalum; 3 = air pore from dorsal epidermis of thallus; 4 = a fertile thallus showing androecium and archegoniophore; 5 = elater; 6 = transverse section of thallus

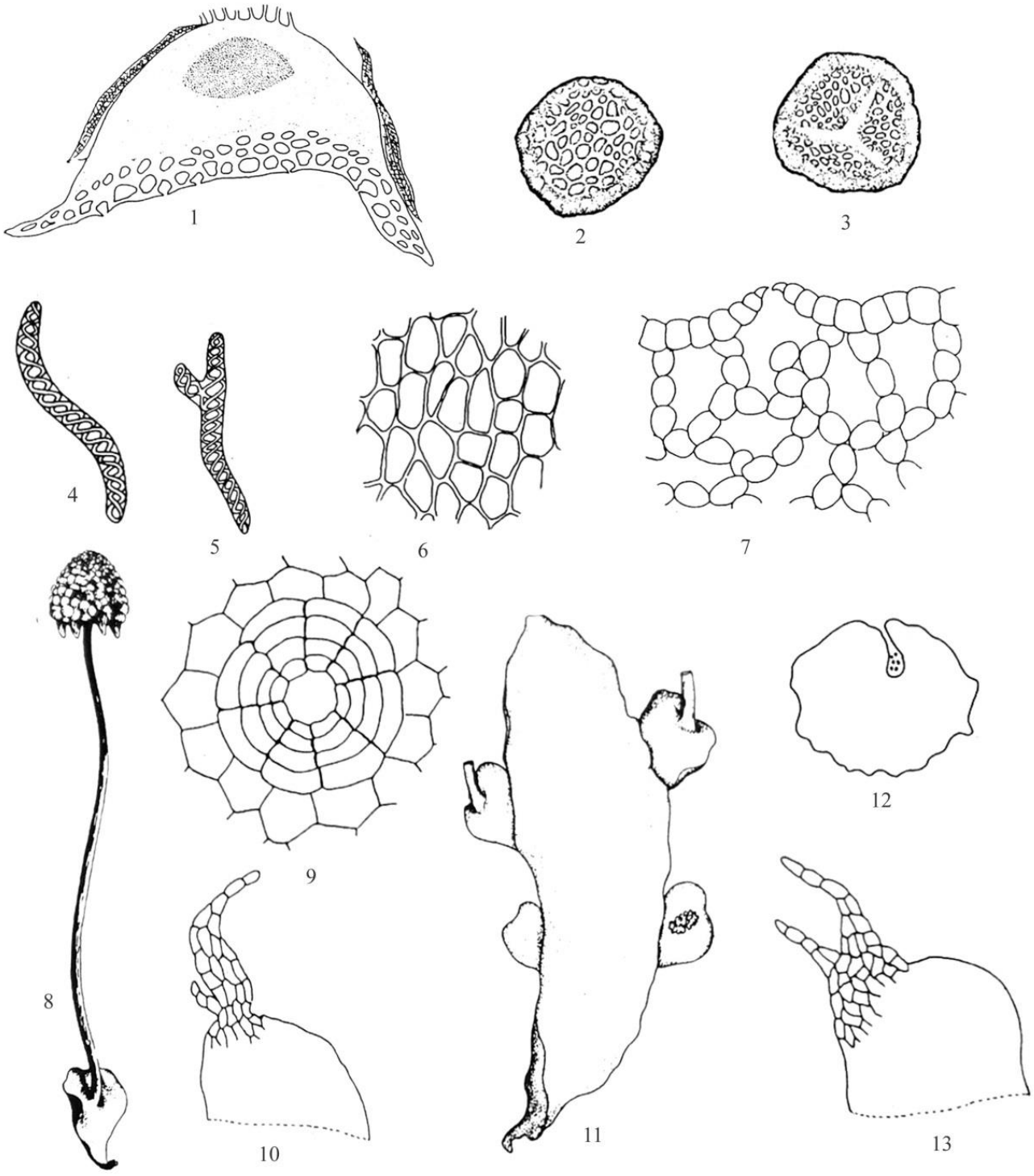

Fig 7. Asterella mussuriensis subsp. mussuriensis, 1= A portion of T.S thallus; 2 = spore in distal view; 3 = spore in proximal view; 4, 5 = elaters; 6 = capsule wall in surface view; 7 = a portion of T.S thallus enlarged; 8 = a lateroventral shoot with sporophytes; 9 = epidermal pore; 10, 13 = ventral scales; 11 = a monoecious thallus;12 = T.S stalk of archegoniophore.

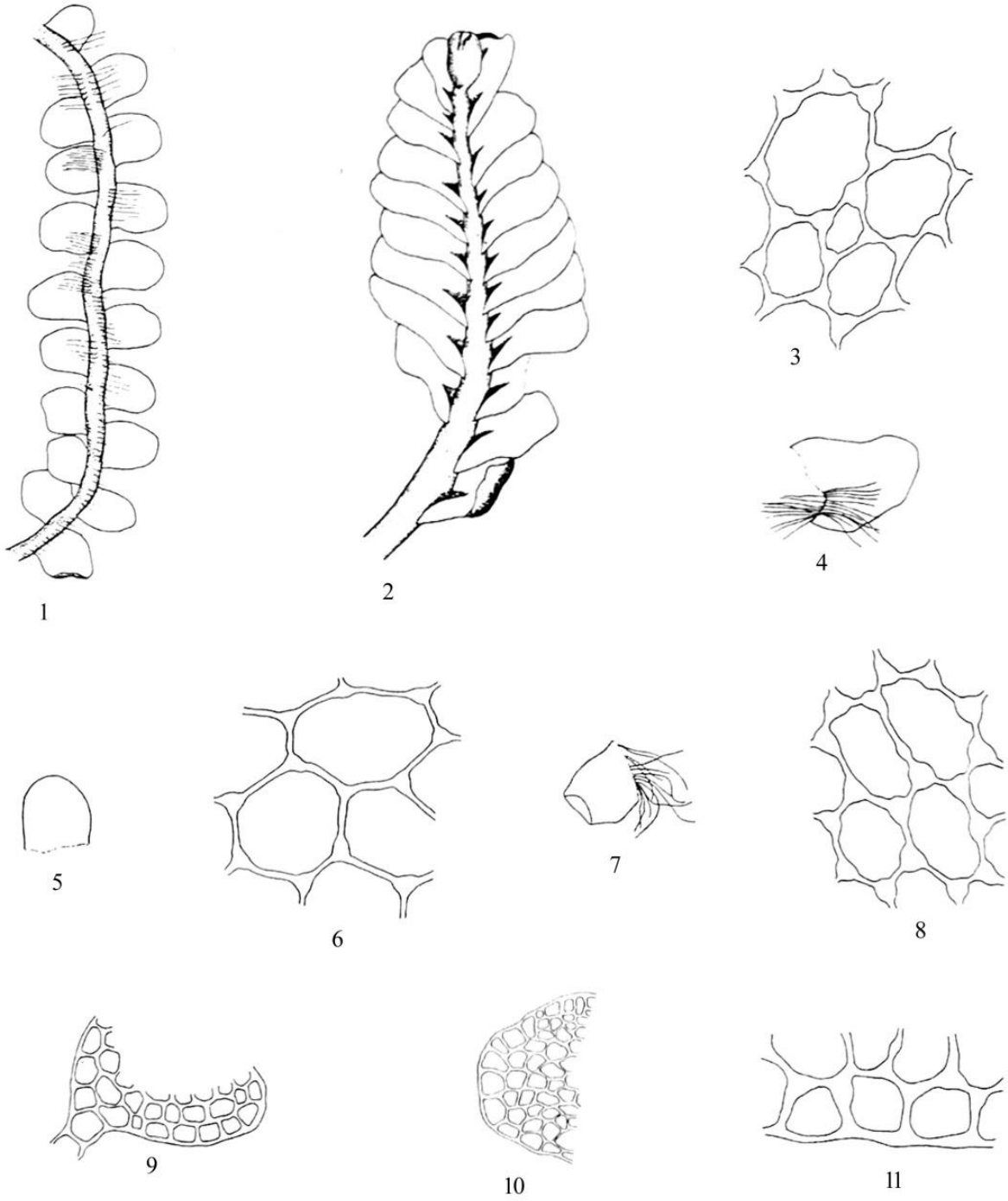

Fig 8. *Jungermannia comata.* 1 = Plant ventral view; 2 = plant dorsal view; 3 = leaf basal cells; 4-5 = leaves; 6 = leaf basal cells; 7 = leaf; 8 = leaf median cells; 9-10 = cross section of stem; 11 = leaf marginal cells.

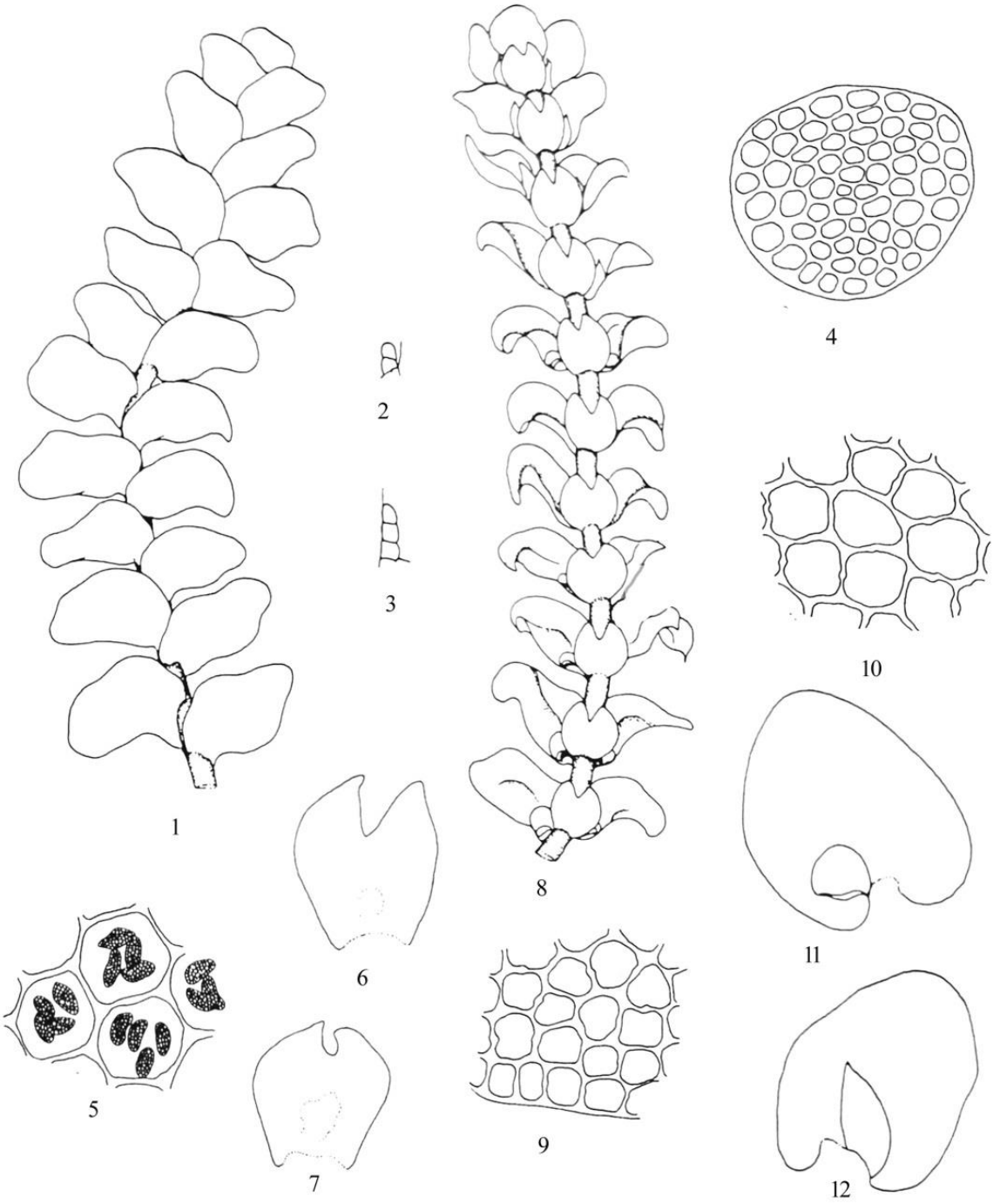

Fig 9. *Frullania ericoides*. 1 = a portion of plant in dorsal view; 2-3 = styli; 4 = T.S stem; 5 = oil bodies in median cells of leaf lobe; 6-7 = underleaves; 8 = a portion of plant in ventral view; 9 = marginal leaf lobe cells towards apex; 10 = median leaf lobe cells; 11-12 = leaves with lobe and lobule

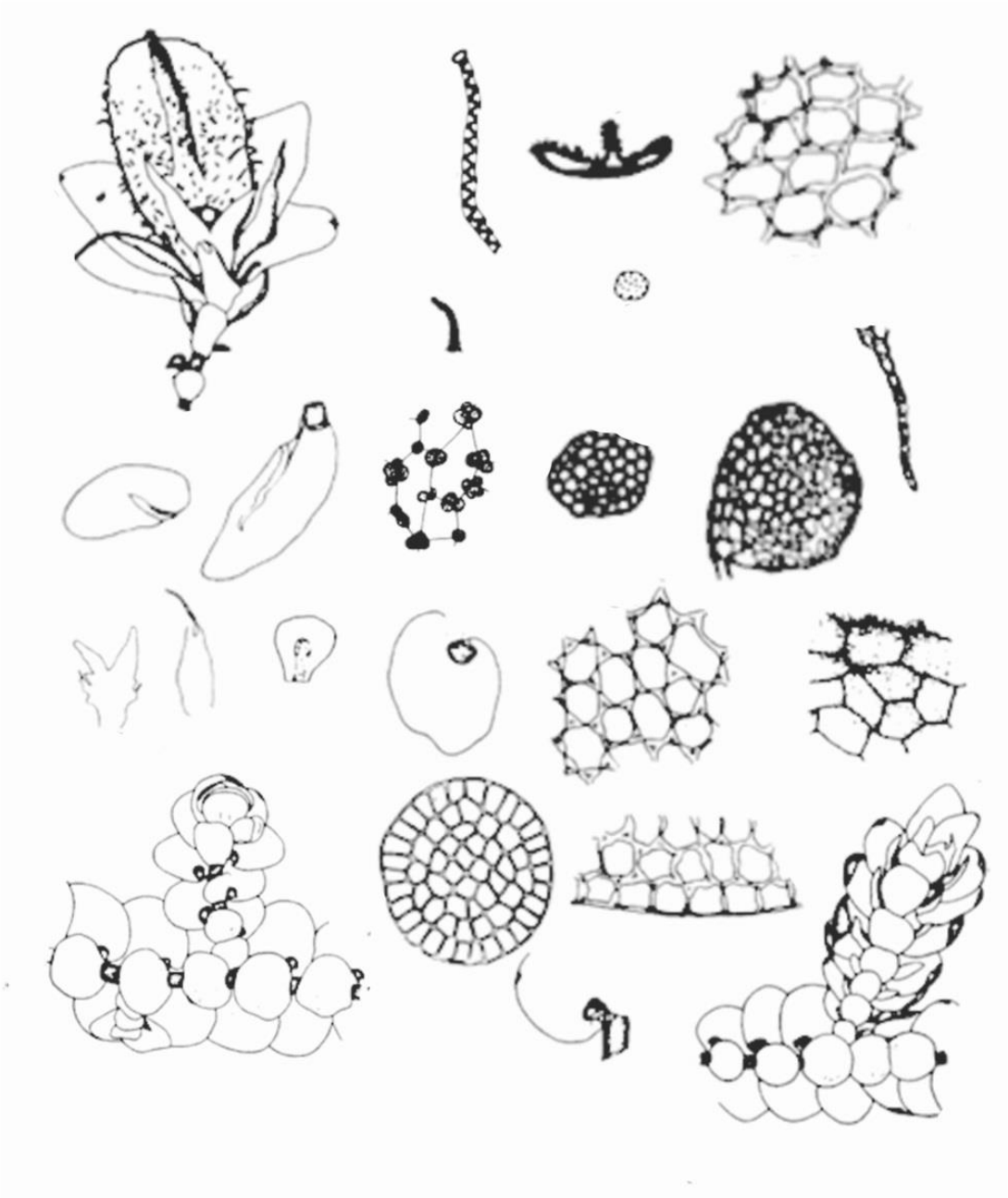

Fig 10. Frullania retusa Mitt. 1 = a portion of female plant; 2 = elater; 3 = crossection of the perianth; 4 = median cells of the leaf; 5 = spore; 6 = spinous outgrowth; 7-8 = female bracts; 9 = outer layer of capsule wall; 10 = cross section of the branch; 11 = cross section of the stem; 12 = stylus; 13-14 = female bracteoles; 15 = amphigastria; 16 = leaf; 17 = basal cells of the leaf; 18 = inner layer of the capsule wall; 19 = a portion of vegetative plant; 20 = cross section of the seta; 21 = a part of the plant showing attatchment of lobule with stem; 22 = marginal cells of the leaf; 23 = a portion of the branch

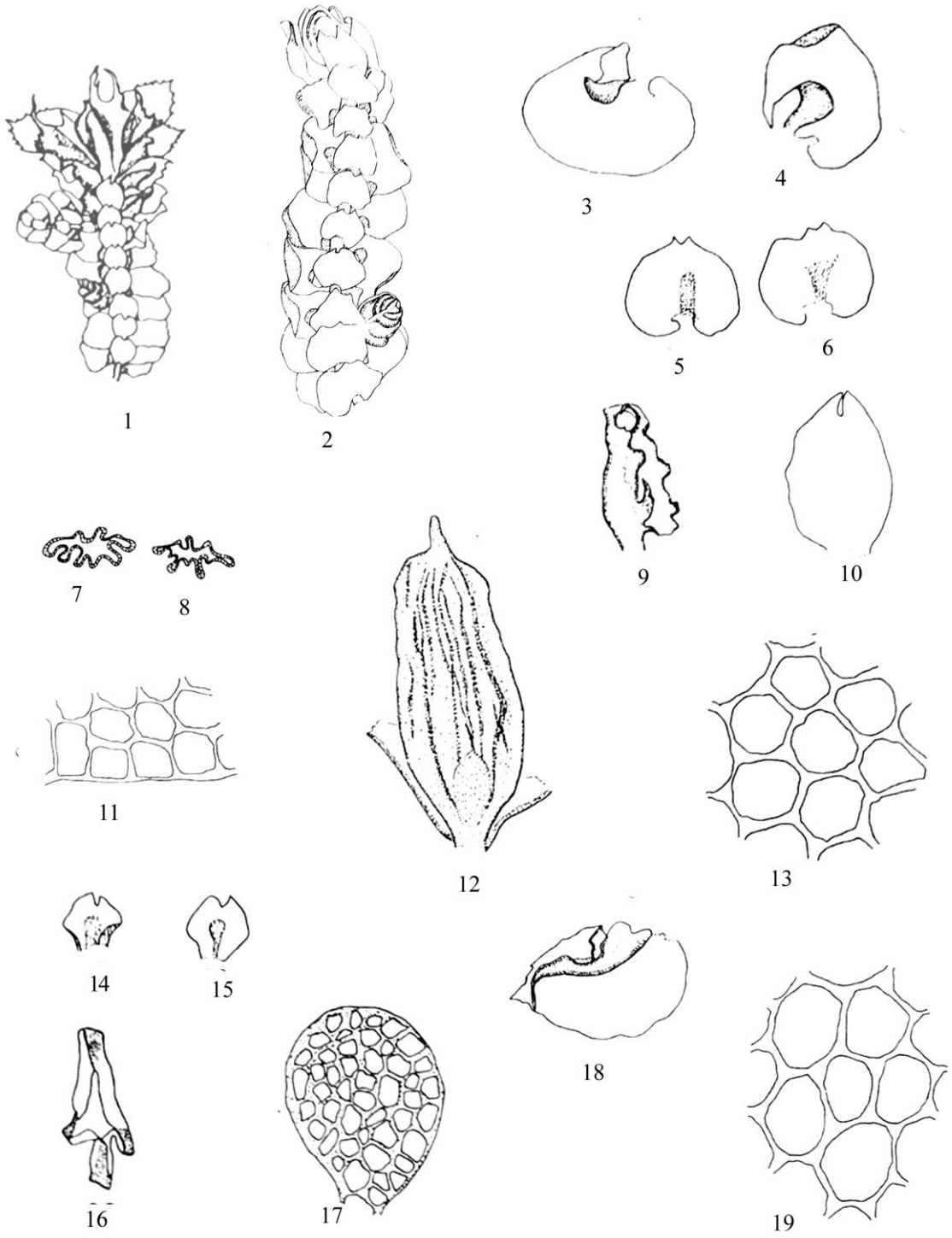

Fig 11. *Frullania wallichiana.* 1 = Fertile plant; 2 = plant ventral view; 3-4 = leaves; 5-6 = underleaves; 7-8 = cross section of perianth; 9-10 female bractioles; 11 = leaf marginal cells; 12 = perianth; 13 = leaf median cells; 14-15 = underleaves; 16 = cross section of perianth; 17 = cross section of stem; 18 = female bract; 19 = leaf basal cells.

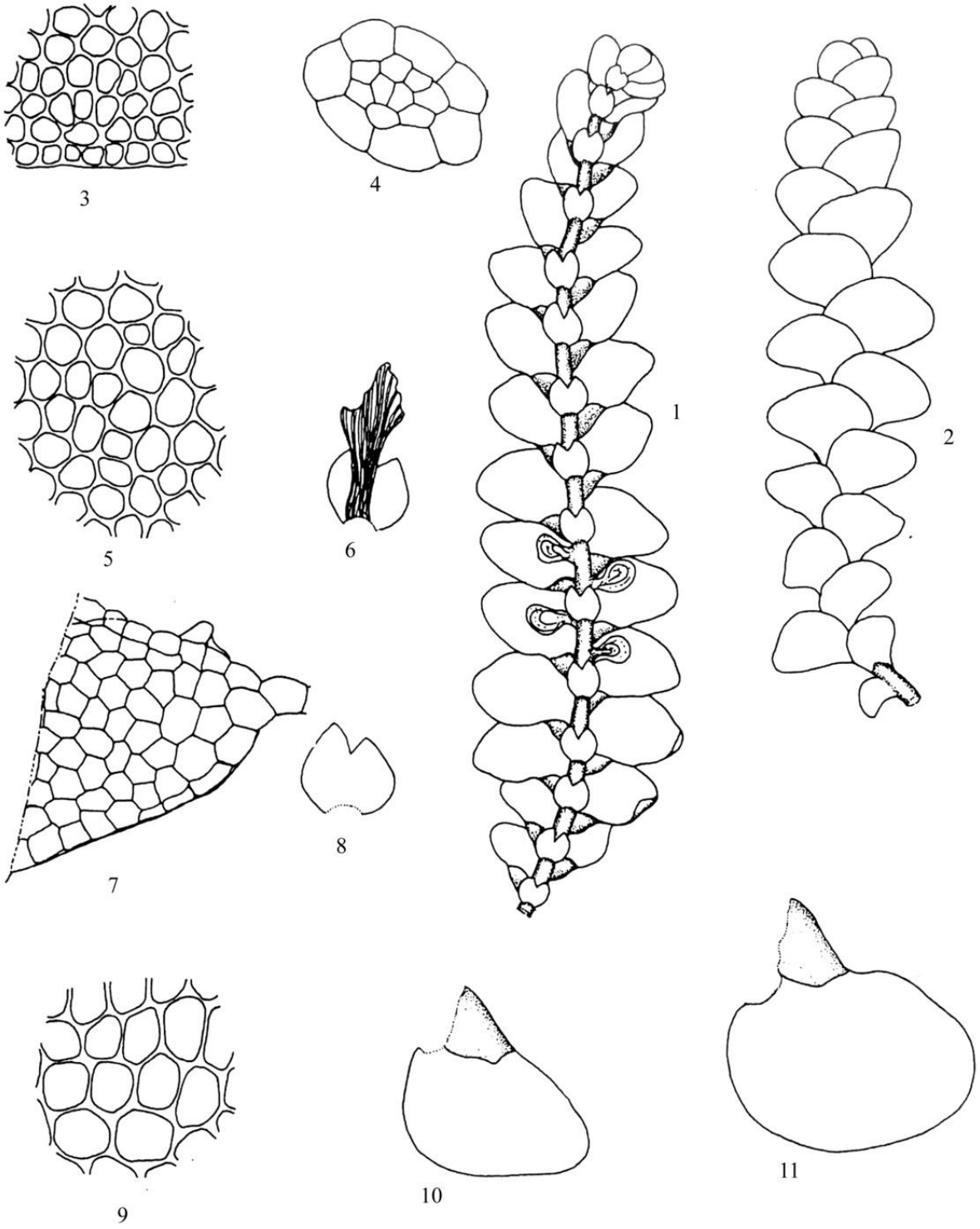

Fig 12. *Lejeunea obfusca.* 1 = a portion of plant in dorsal view; 2 = a portion of plant in ventral view; 3 = marginal leaf lobe cells; 4 = T.S stems; 5 = median leaf lobe cells; 6,8 = underleaves; 7 = leaf lobule; 9 = basal leaf lobe cells; 10-11 = leaves with lobe and lobule.

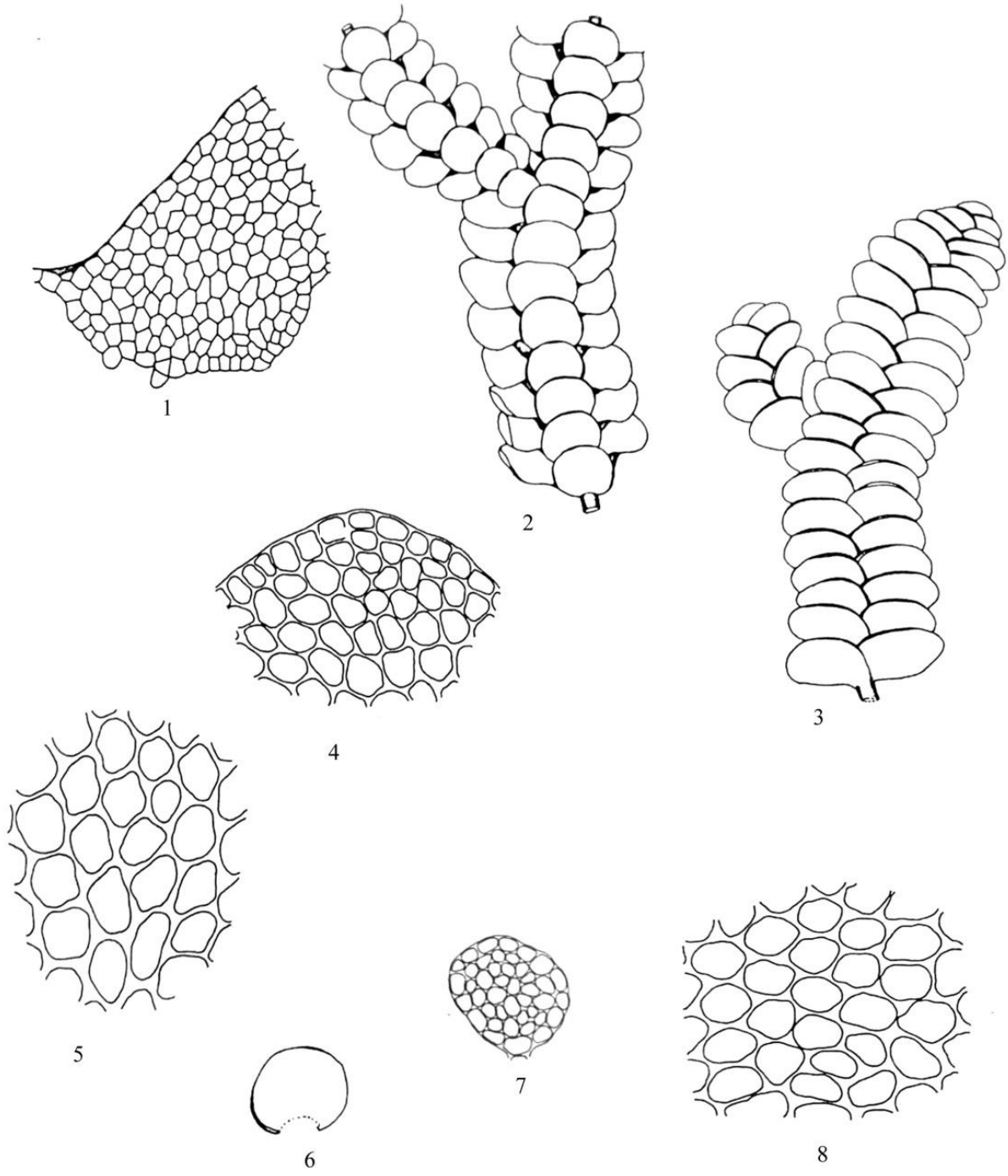

Fig 13. *Trocholejeunea infuscata.* 1 = leaf lobule; 2 = a portion of plant in ventral view; 3 = a portion of the plant in dorsal view; 4 = marginal leaf-lobe cells towards apex; 5 = basal leaf lobe cells; 6 = underleaf; 7 = T.S of stem; 8 = median leaf lobe cells.

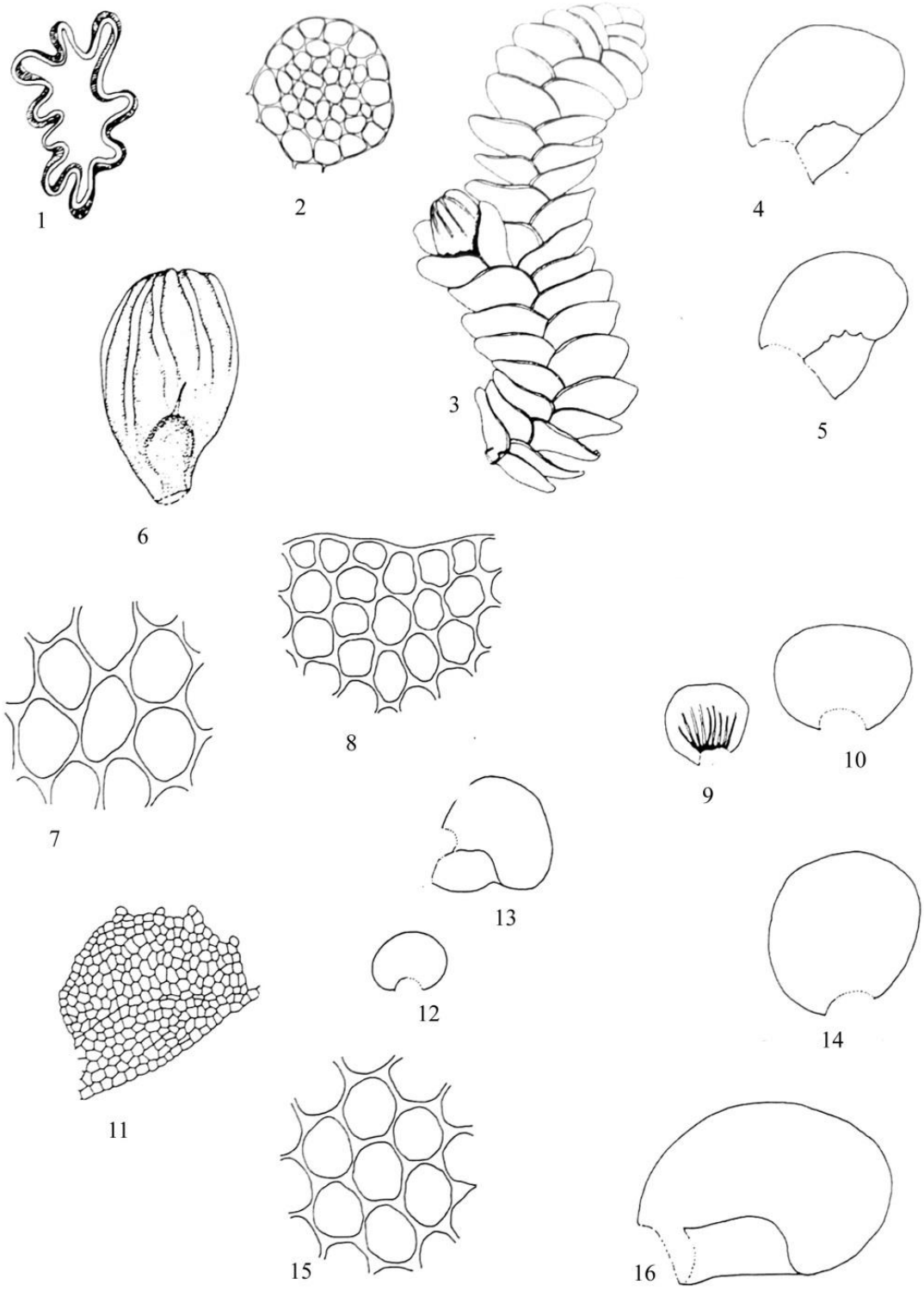

Fig 14. Trocholejeunea sandvicensis. 1 = T.S perianth; 2 = T.S stems; 3 = a portion of plant in dorsal view; 4 -5 = leaves with lobe and lobule; 6 = a perianth; 7 = basal leaf-lobe cells; 8 = marginal leaf-lobe cells towards apex; 9-10 = underleaves; 11 = leaf lobules; 12-13 = male bracteoles; 14 = female bracteoles; 15 = median leaf-lobe cells; 16 = female bracts

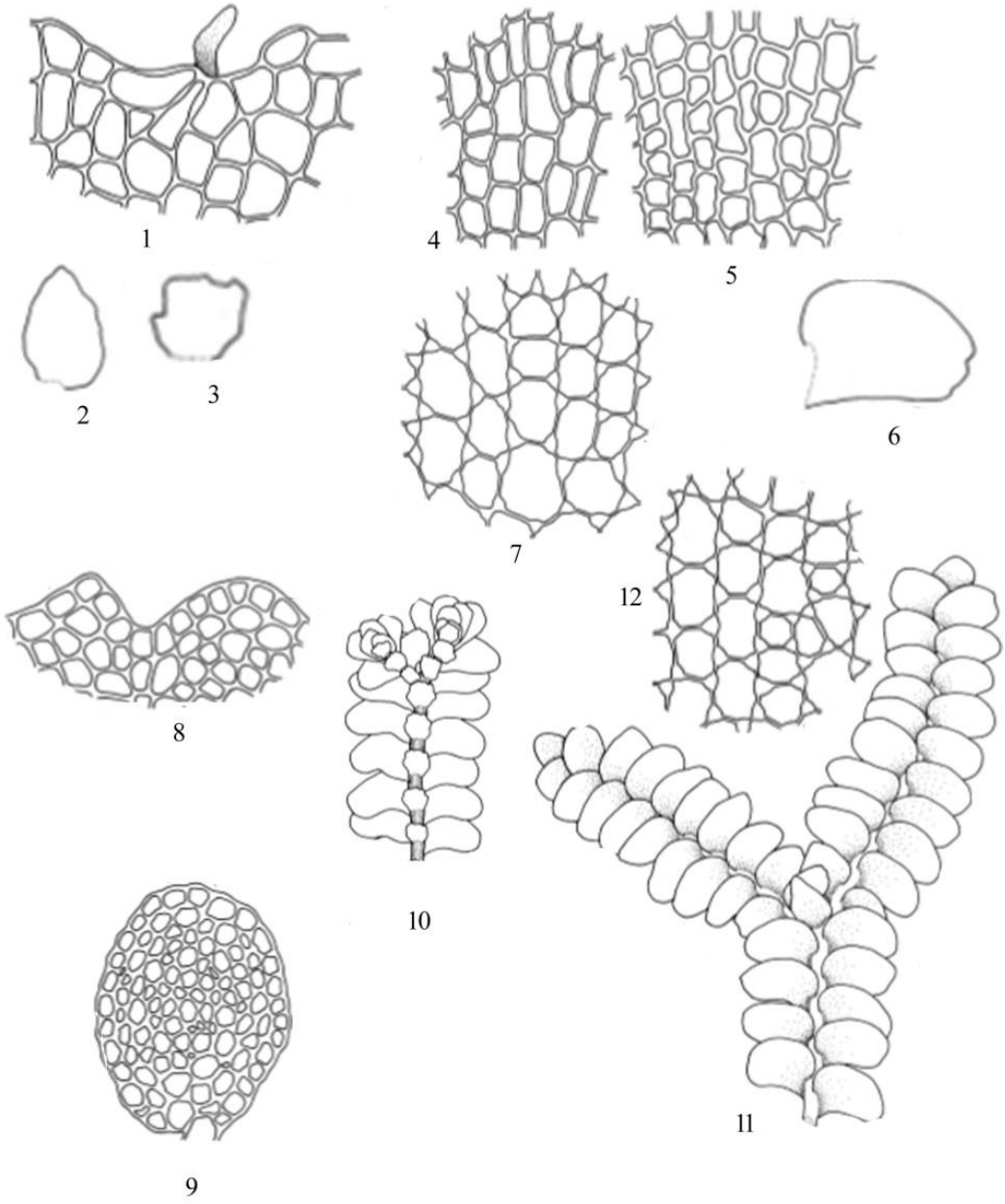

Fig.15 *Bazzania hainanensis* L.-P. Zhou et Zhang. 1 = apical cells of underleaf showing papillae; 2 = leaf near branch emergence; 3 = underleaves; 4 = median cells of underleaf; 5 = basal cells of underleaf; 6 = leaf; 7 = leaf basal cells; 8 = leaf apical cells; 9 = cross section of stem; 10 = plant in ventral view; 11 = plant in dorsal view; 12 = median cells of leaf

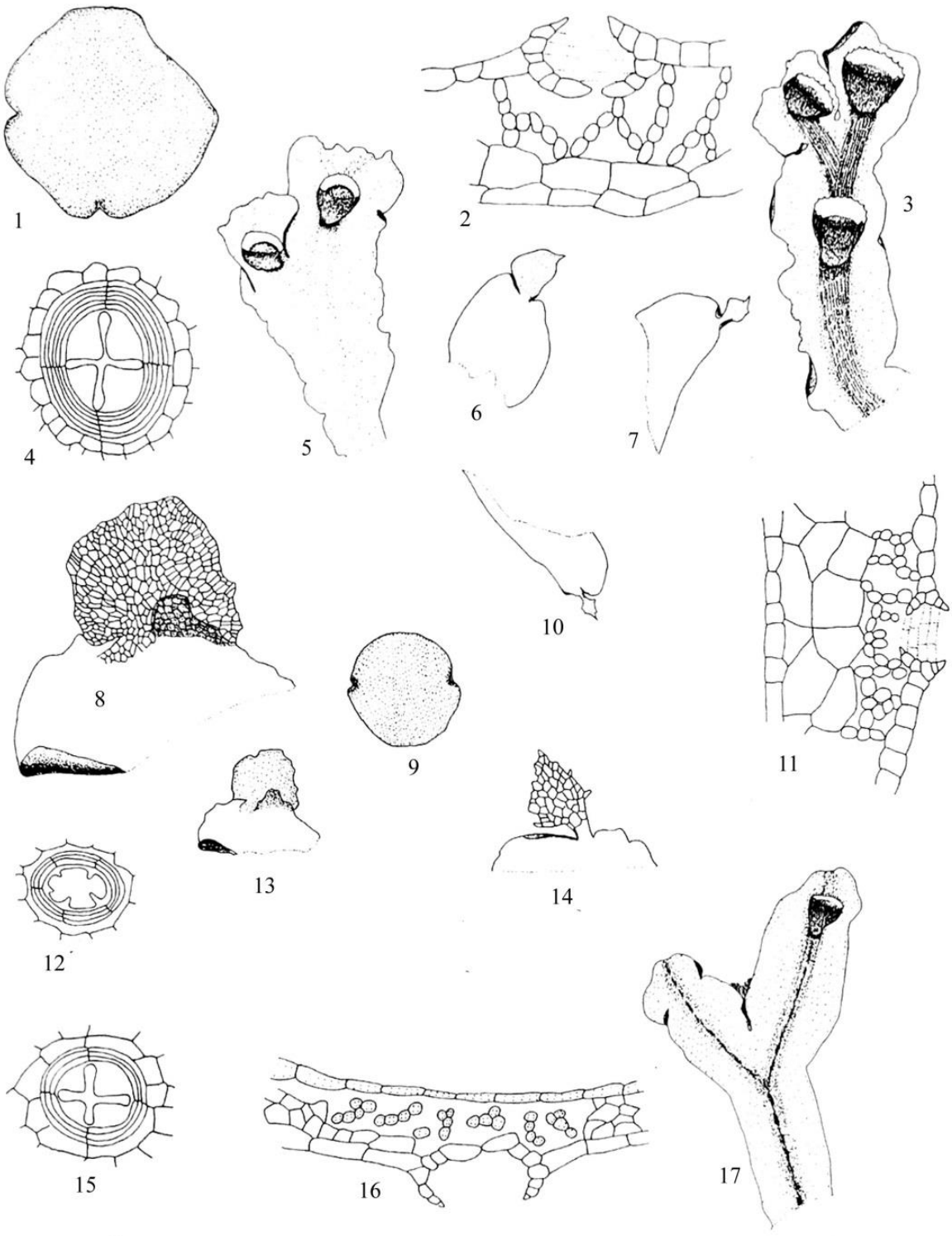

Fig 16. *Marchantia polymorpha.* 1 = Gemmae *M paleaceae* Bertol; 2 = cross section of thallus; 3 = thallus dorsal view; 4 = dorsal air pore; 5 = thallus dorsal view; 6-7 = ventral scales; 8 = ventral scale magnified view; 9 = Gemmae *M gemminata* Nees; 10 = ventral scales; 11 = cross section of thallus; 12 = dorsal air pore; 13 = ventral scale; 14 = ventral scale magnified view; 15 = dorsal airpore; 16 = cross section of thallus; 17 = thallus dorsal view.

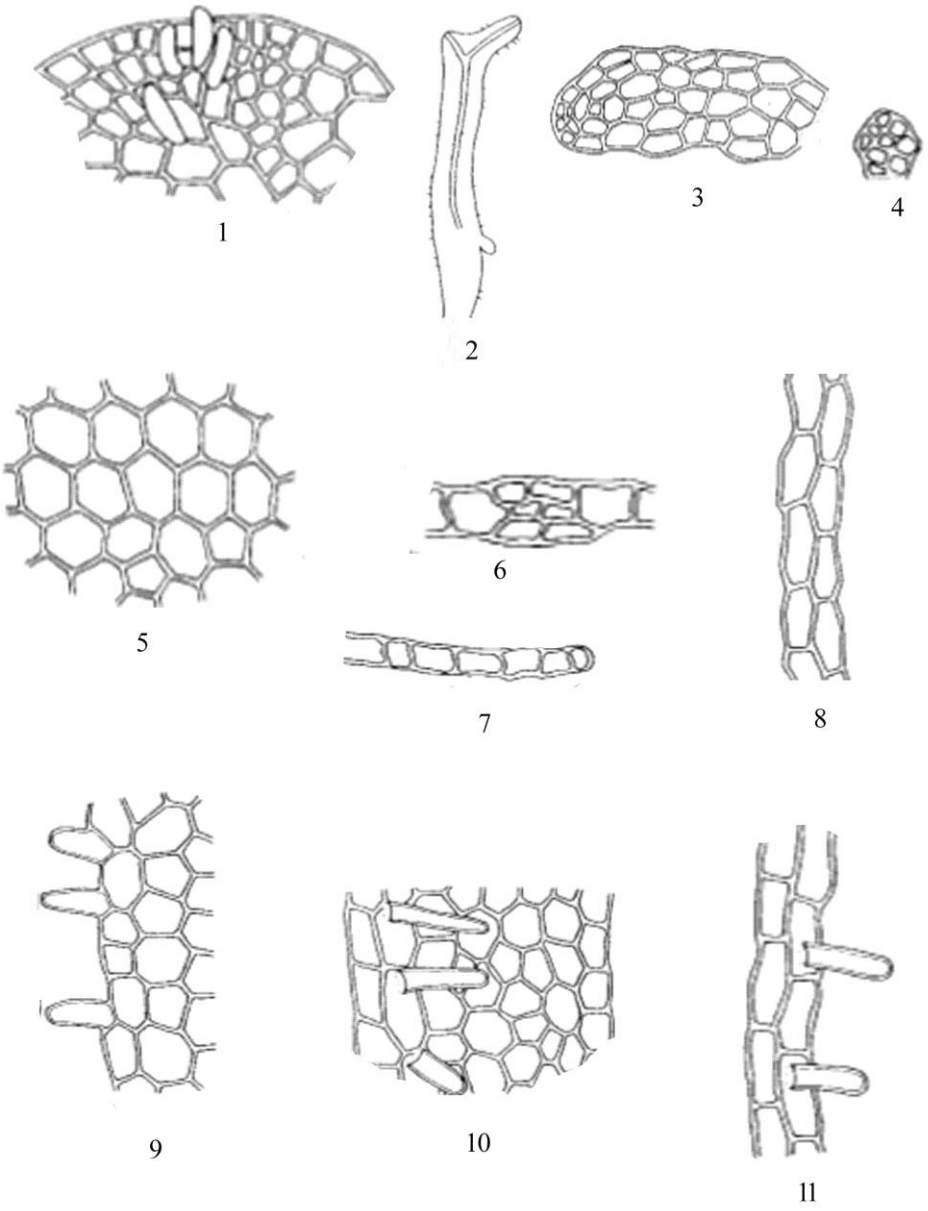

Fig 17. *Metzgeria furcata* (L.) Dumort. var. uvula Nees. 1 = thallus showing mucilage papillae (ventral view); 2 = thallus; 3-4 = gemmae; 5 = median cells of wing; 6-7 = T.S. of thallus; 8 = dorsal epidermal cells of midrib; 9 = marginal cells of the wing; 10 = cells between midrib and margin of the wing; 11 = ventral epidermal cells of midrib

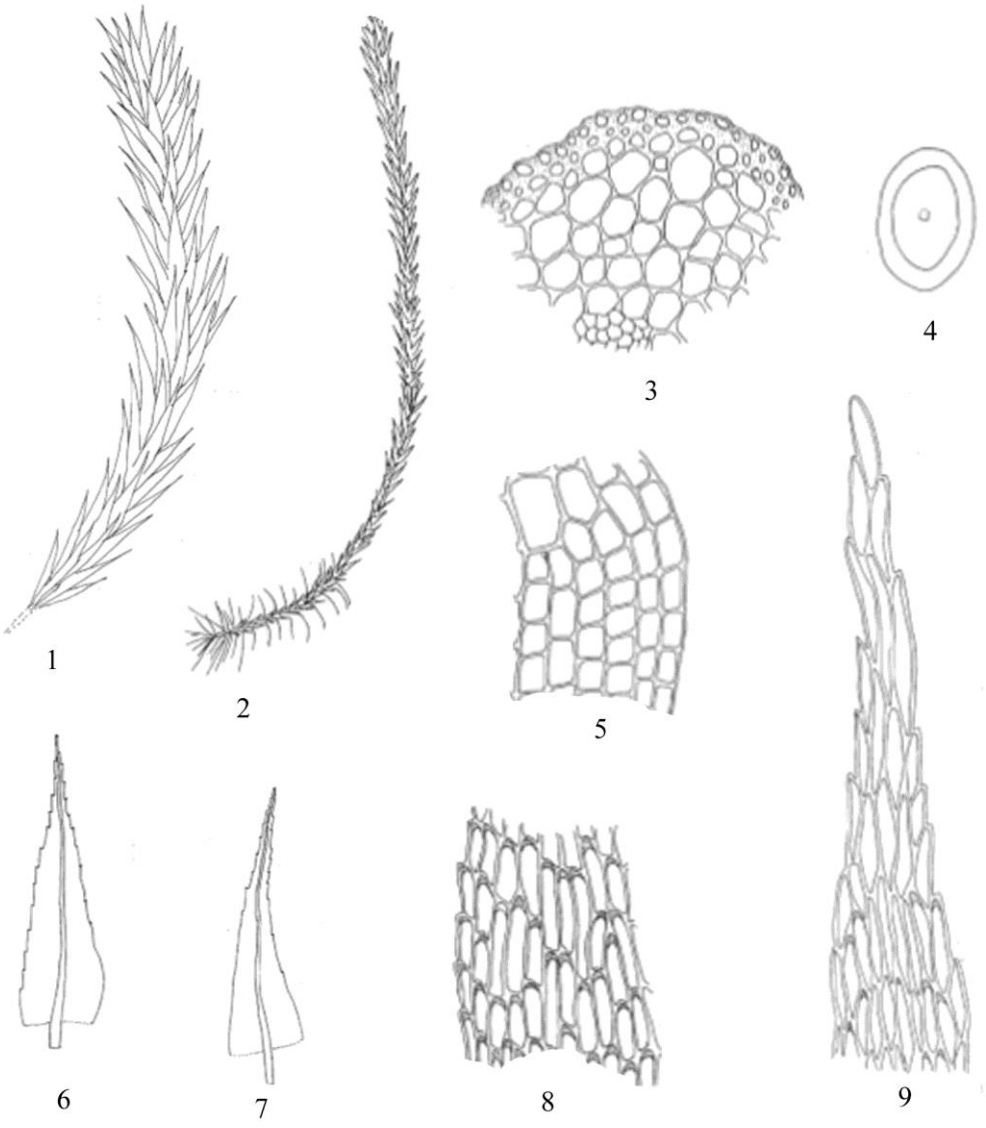

Fig 18. *Philonotis falcata* (Hook.) Mitt. 1-2 = habit of plants; 3-4 = cross section of stem; 5 = basal leaf cells; m6-7 = leaves; 8 = meadian leaf cells; 9 = apical leaf cells.

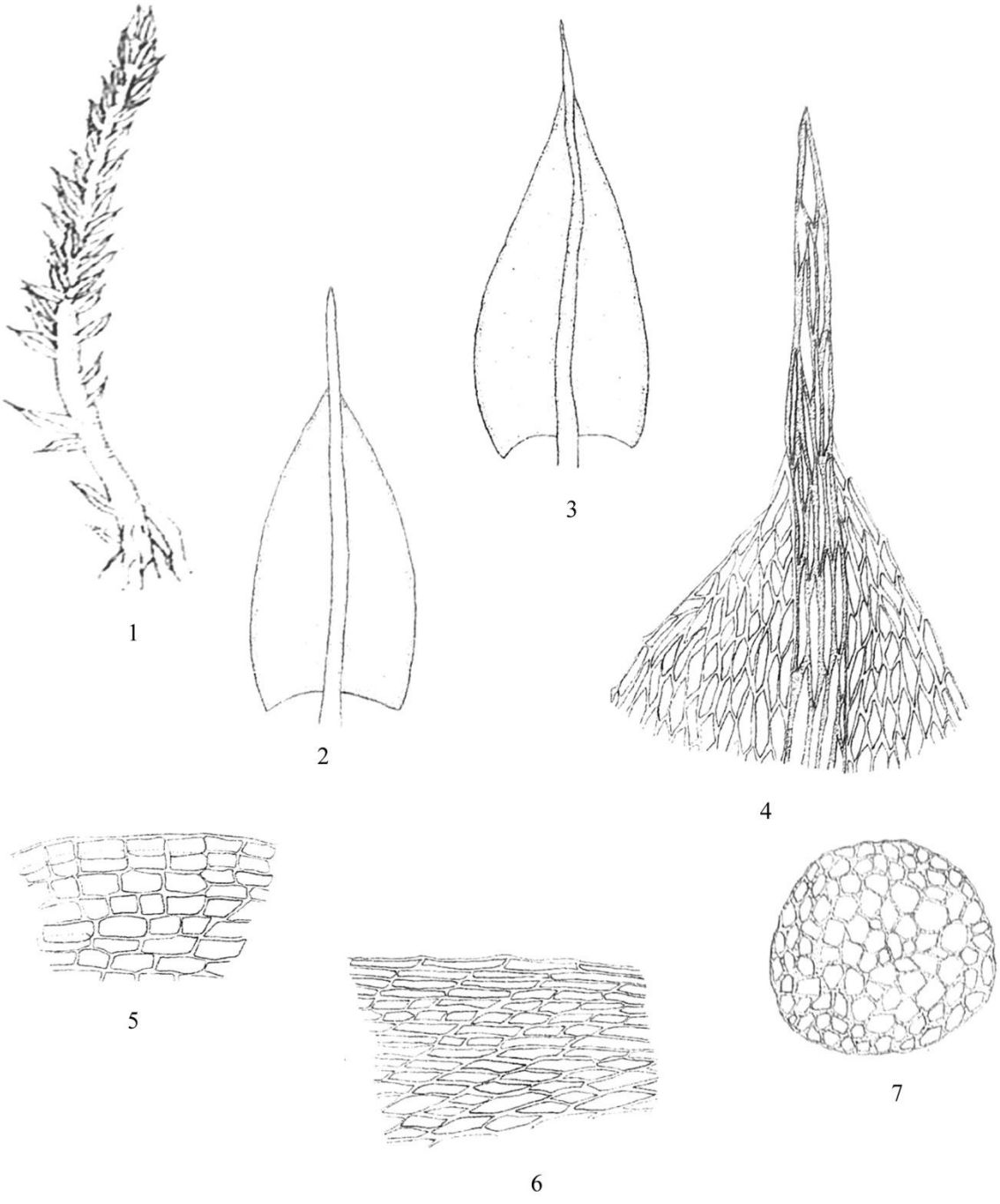

Fig 19. *Brachymenium bryoides* Hook. ex Schwaegr. 1 = Plant habit; 2-3 = leaves; 4 = apical laminal cells; 5 = basal laminal cells; 6 = middle laminal cells; 7 = cross section of stem.

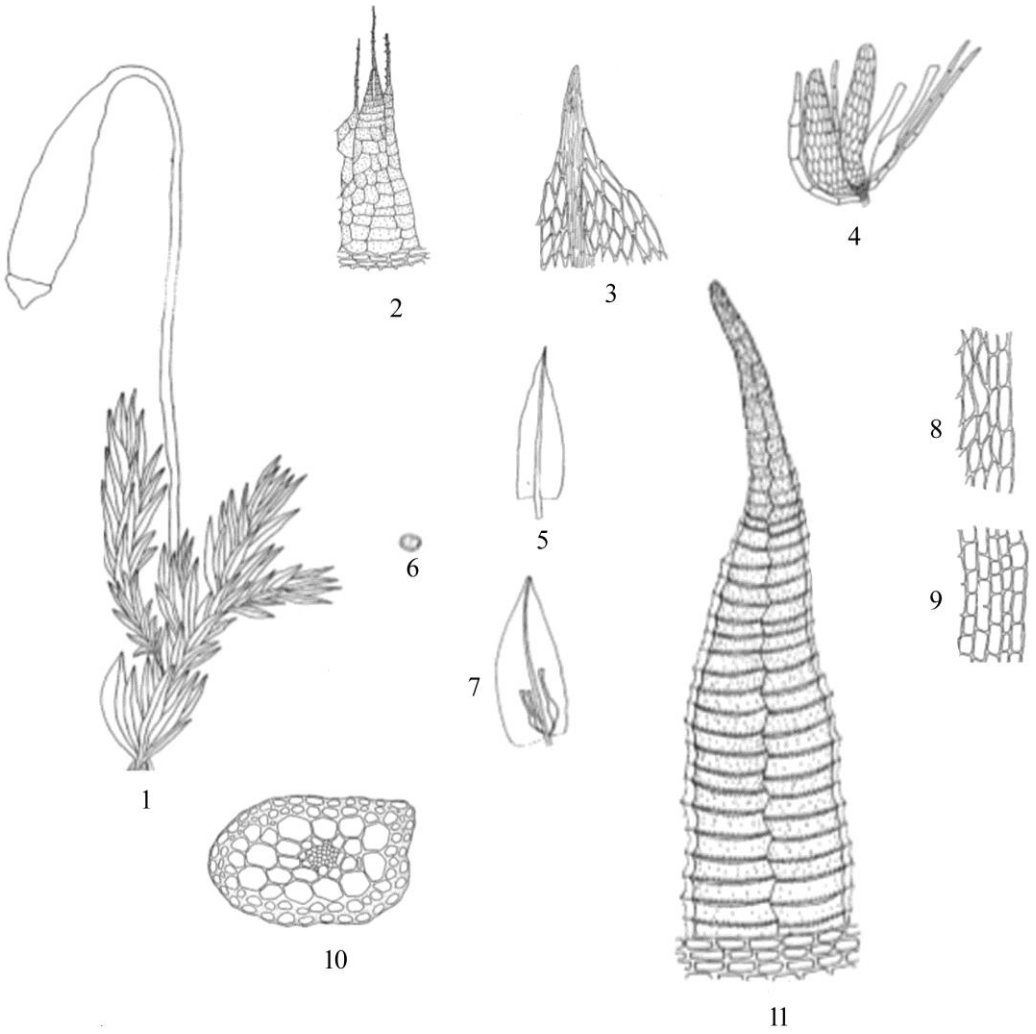

Fig 20. *Bryum alpinum* Huds.ex With. 1 = habitat of plant; 2 = endostome; 3 = apical leaf cells; 4 = reproductive organ; 5 = leaf; 6 = spore; 7 = pericheatial leaf; 8 = median leaf cells; 9 = basal leaf cells; 10 = cross section of stem; 11 = exostome

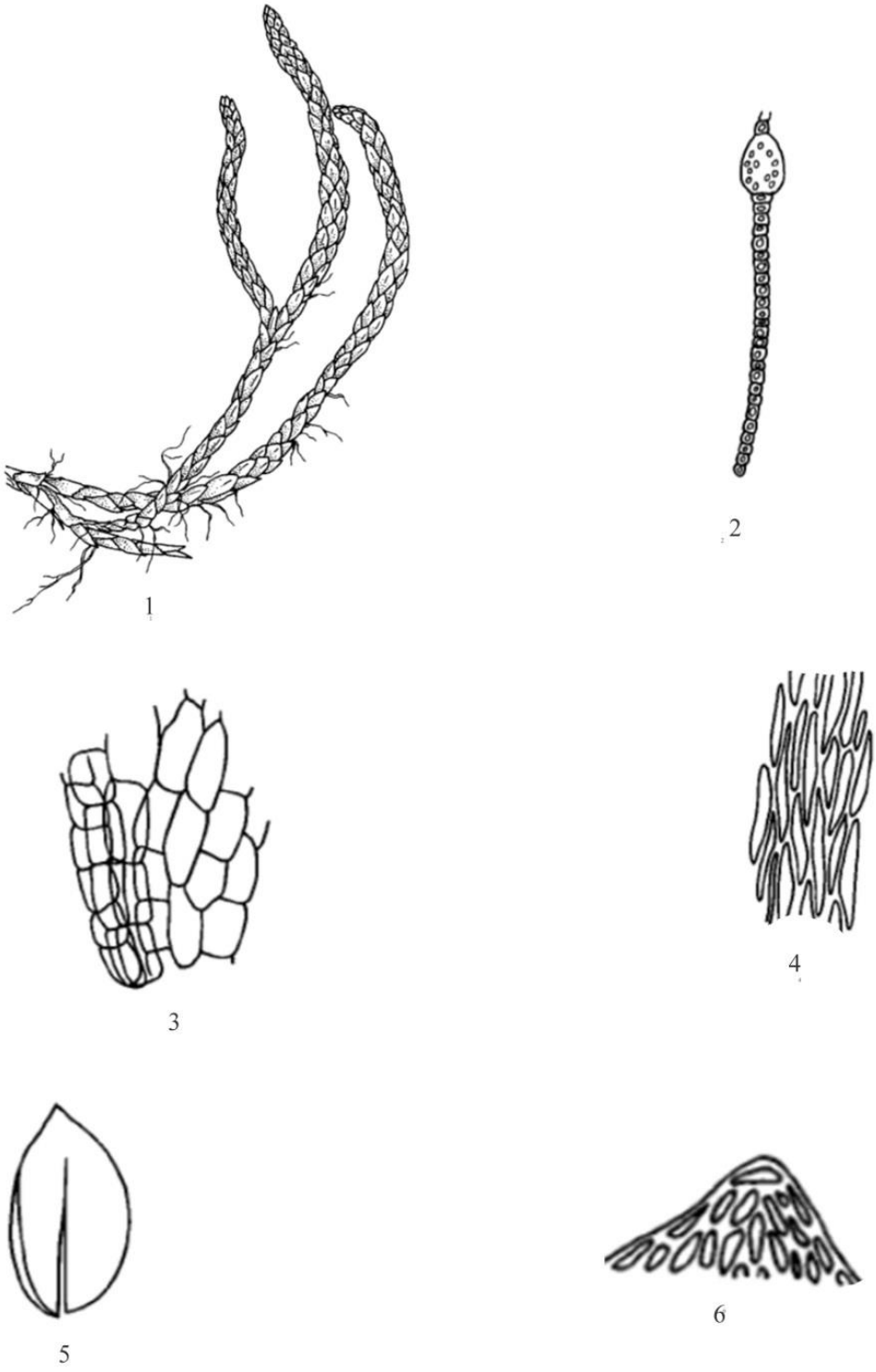

Fig 21. *Bryum auratum* Mitt. 1 = habit of plant; 2 = T.S of leaf; 3 = basal leaf cells; 4 = mid laminal cells; 5 = leaf; 6 = leaf apical cells.

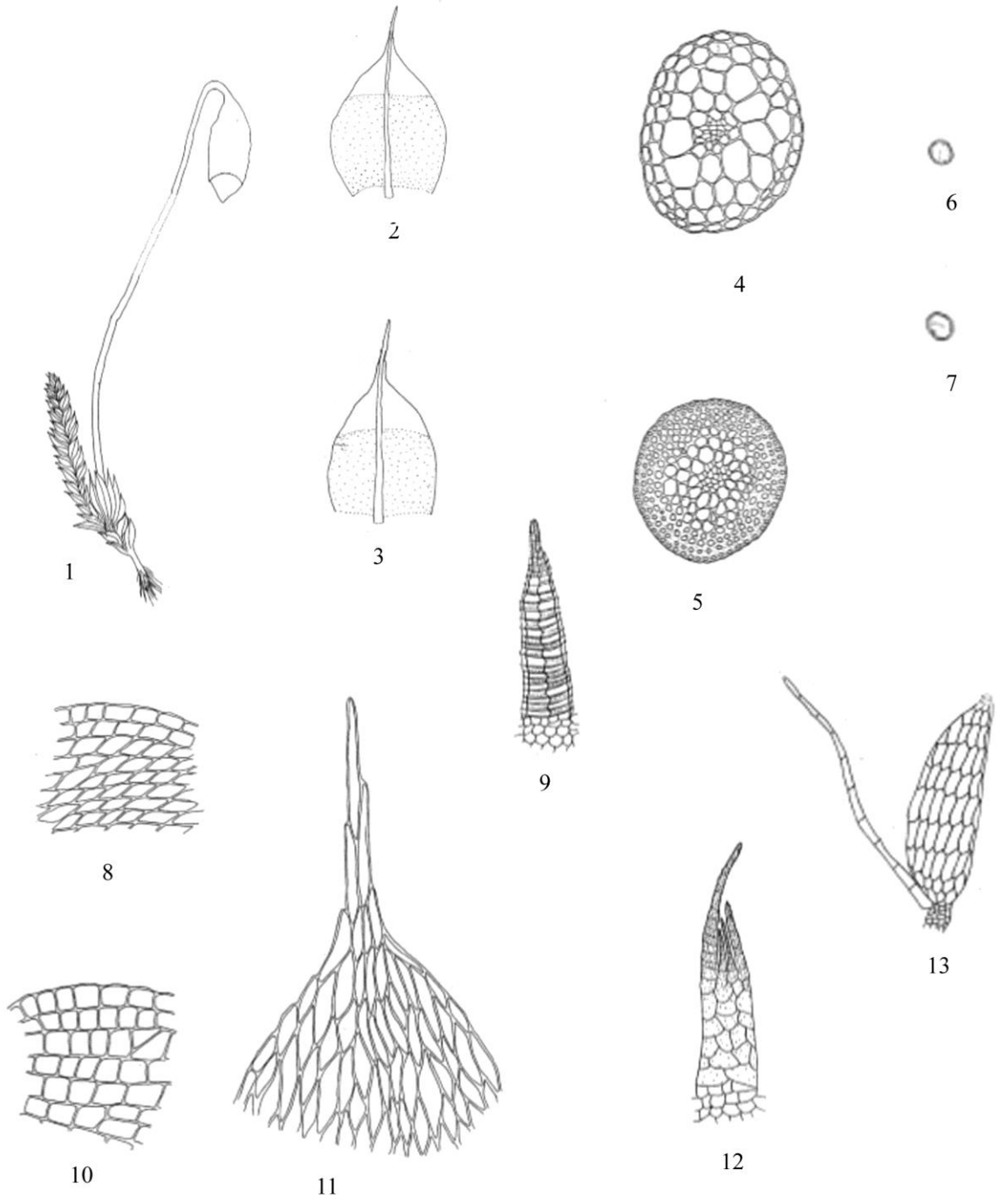

Fig 22. *Bryum argenteum* Hedw. 1 = habit of plant; 2-3 = leaves; 4 = cross section of stem; 5 = cross section of seta; 6-7 = spores; 8 = median leaf cells; 9 = exostome; 10 = basal leaf cells; 11 = apical leaf cells; 12 = endostome; 13 = antheridium

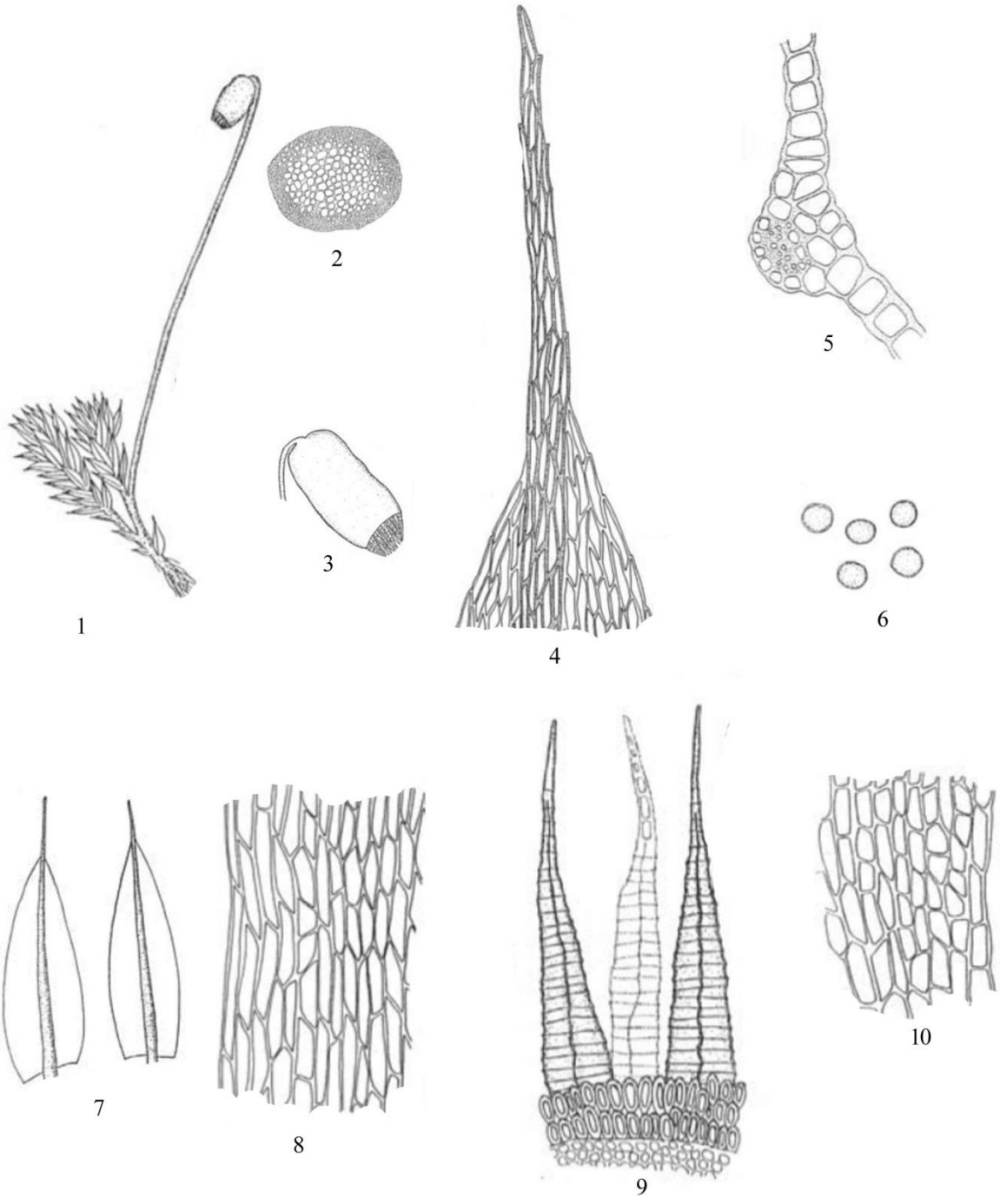

Fig 23. *Bryum coronatum* Schwaegr. 1 = habitat of plant; 2 = cross section of seta; 3 = view of capsule; 4 = apical laminal cells; 5 = cross section of leaf; 6 = spores; 7 = leaves; 8 = middle laminal cells 9 = peristome teeth; 10 = basal laminal cells

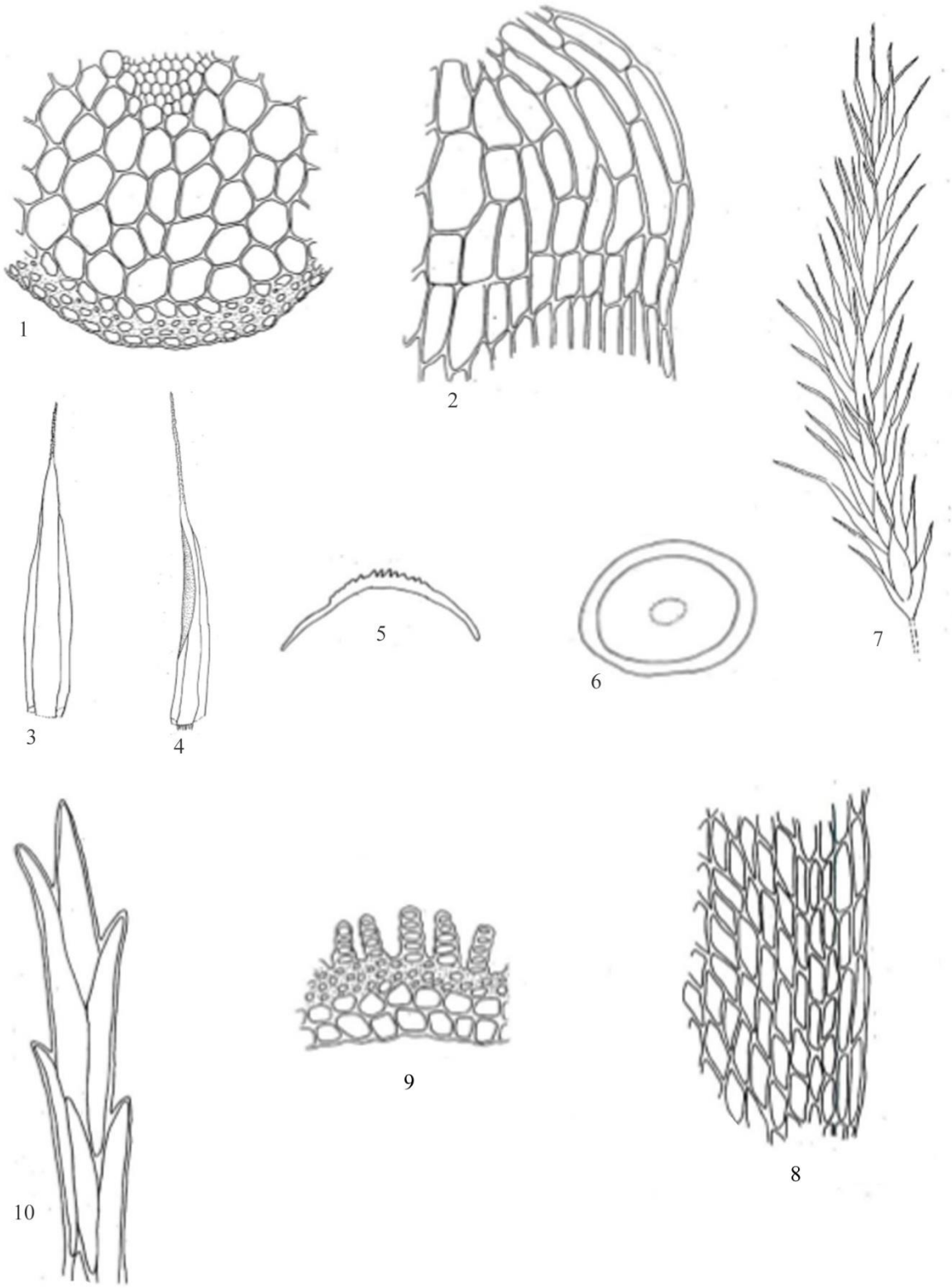

Fig 24. *Campylopus pilifer* Brid. 1,6 = cross section of stem; 2 = basal leaf cells; 3,4 = leaves; 5,9 = cross section of leaf; 7 = habit of plants; 8 = median leaf cells; 10 = apical leaf cells

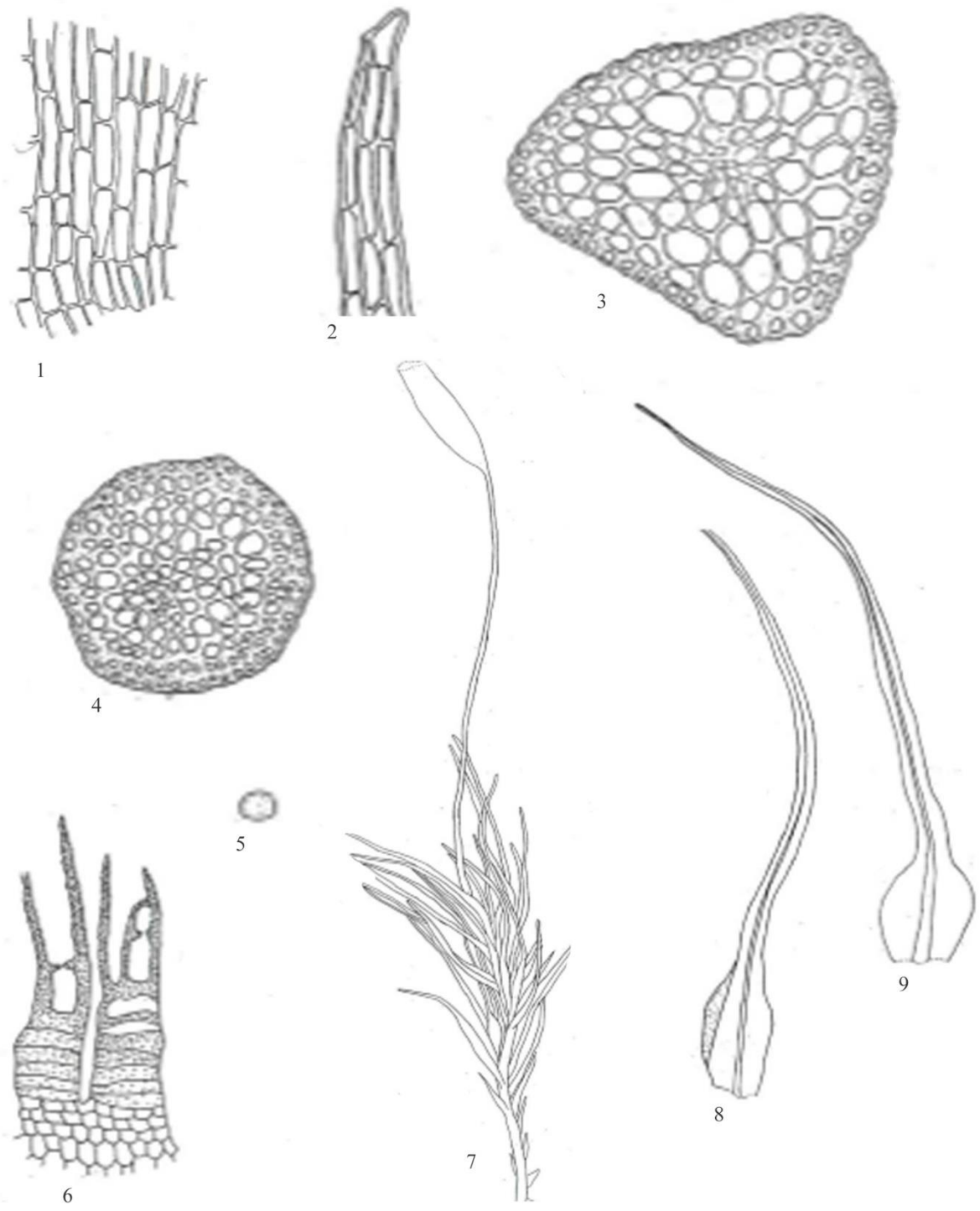

Fig 25. *Ditrichum heteromalum* var. *emodi* Gangulee. 1 = basal leaf cells; 2 = apical leaf cells; 3 = cross section of stem; 4 = cross section of seta; 5 = spore; 6 = peristome teeth; 7 = habit of plants ; 8 = leaves; 9 = pericheatial leaf

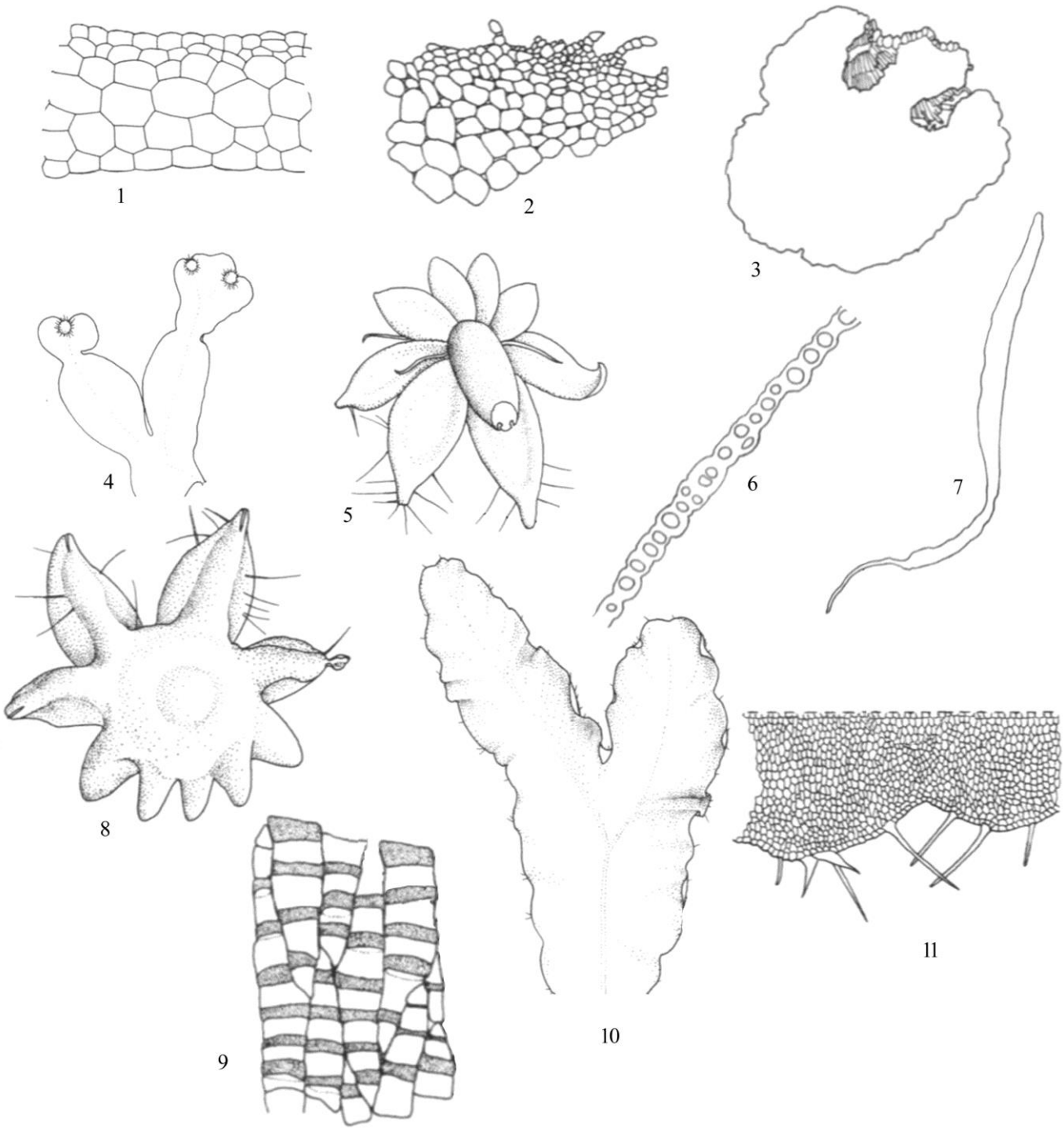

Fig 26. *Dumortiera hirsuta.* 1 = Transverse section of thallus; 2 = lower cells of costa and vestigial scales in transverse section; 3 = transverse section of stalk; 4 = male plant with recepticles at apex; 5 = female recepticle; 6,9 = transverse section of capsule wall; 7 = filiform scale; 8 = female recepticle seen from above; 10 = dorsal view of thallus; 11 = margin of thallus with hairs.

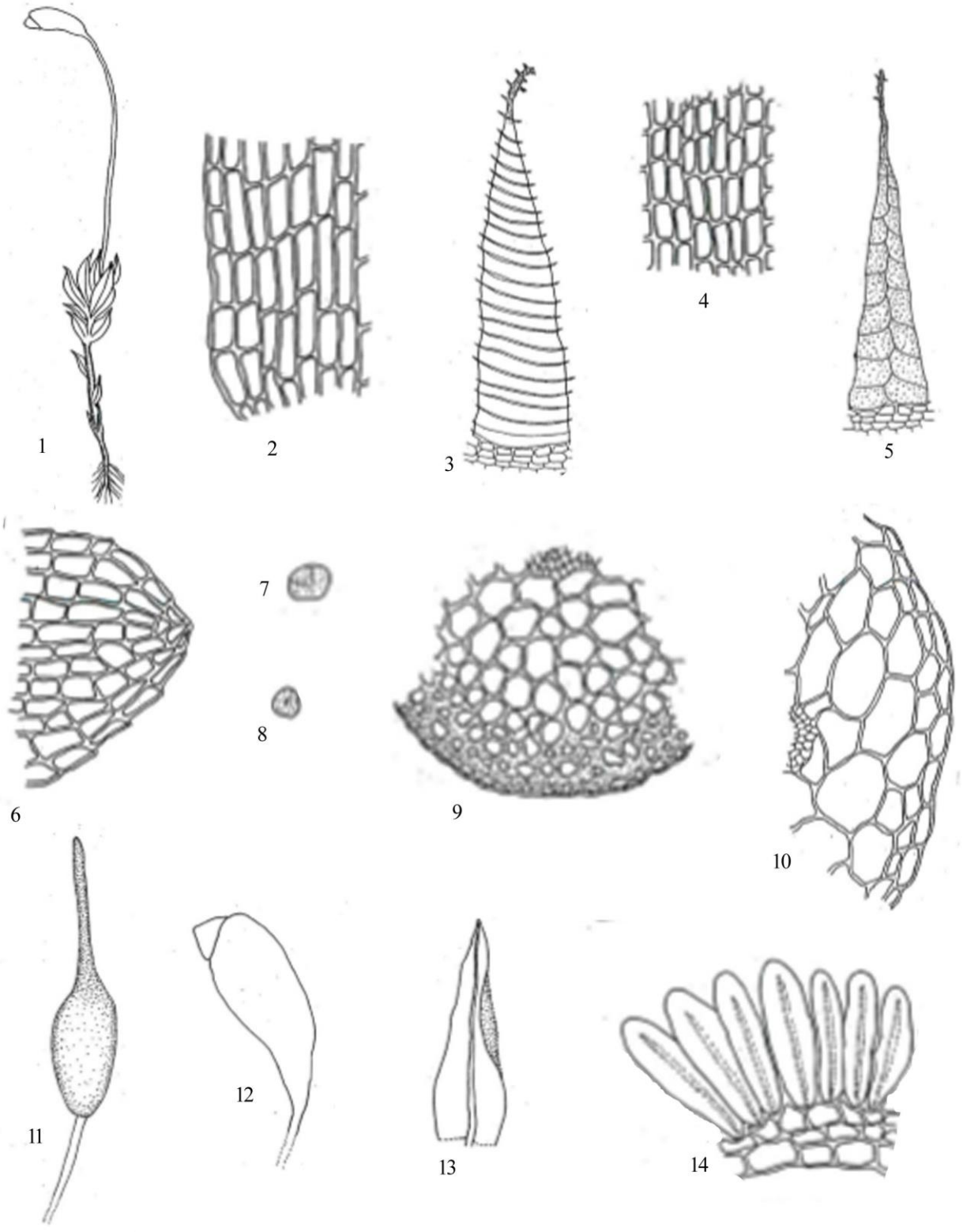

Fig 27: *Funaria hygrometrica* var. calvescens (Schwagr.) Mont. 1 = habit of plant;
2 = basal leaf cells; 3 = exostome; 4 = median leaf cells; 5 = endostome; 6 = apical leaf cells;
7-8 = spores;9 = cross section of seta; 10 = cross section of stem; 11 = calyptra; 12 = capsule;
13 = leaf; 14 = portion of annulus

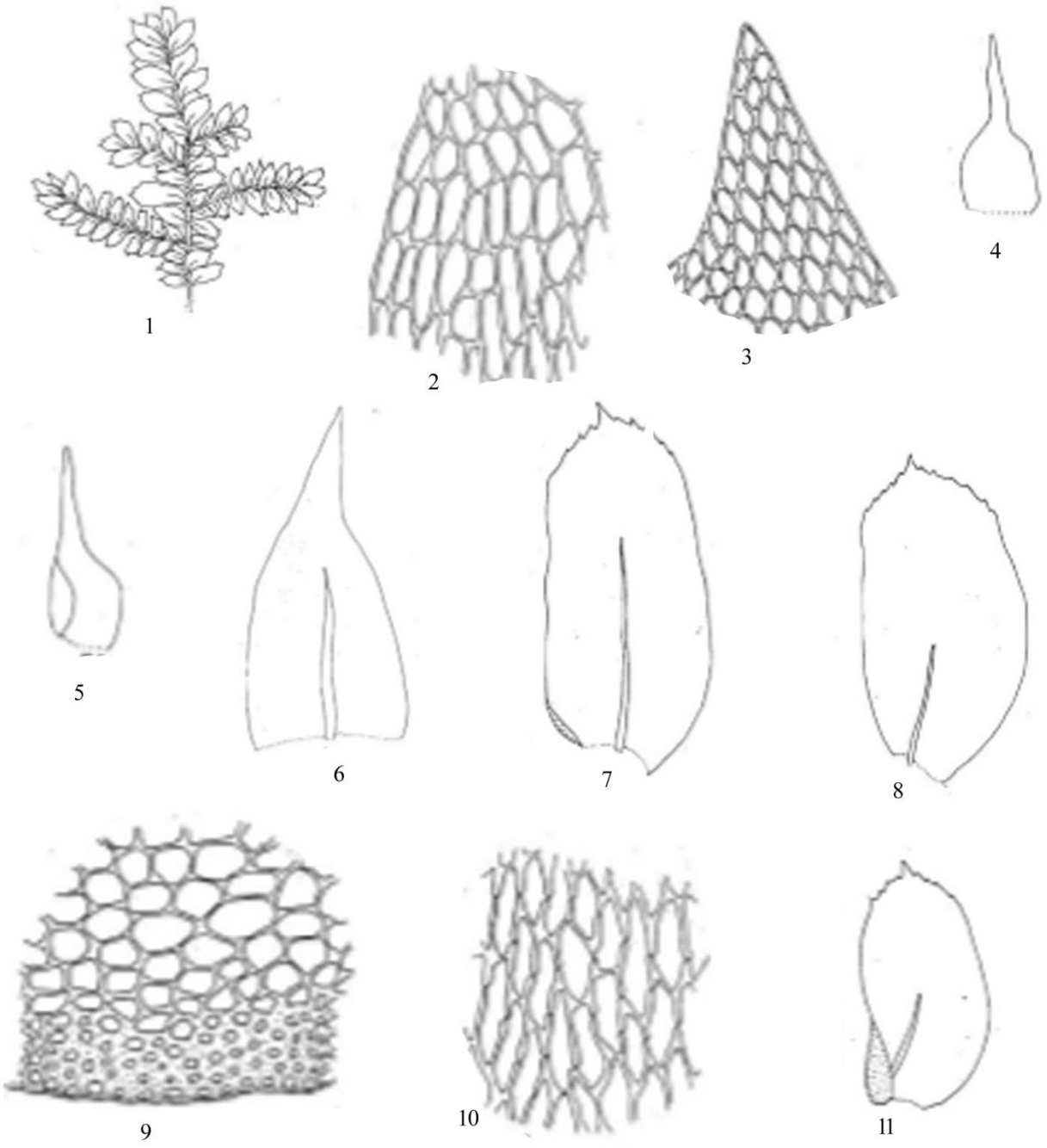

Fig 28. *Homaliodendron scalpellifolium* (Mitt.) M.Fleisch. 1 = habit of plant; 2 = basal leaf cells; 3 = apical leaf cells; 4-5 = pericheatial leaves; 6 = stype leaf; 7-8 = stem leaves; 9 = cross section of stem; 10 = median leaf cells; 11 = branch leaf

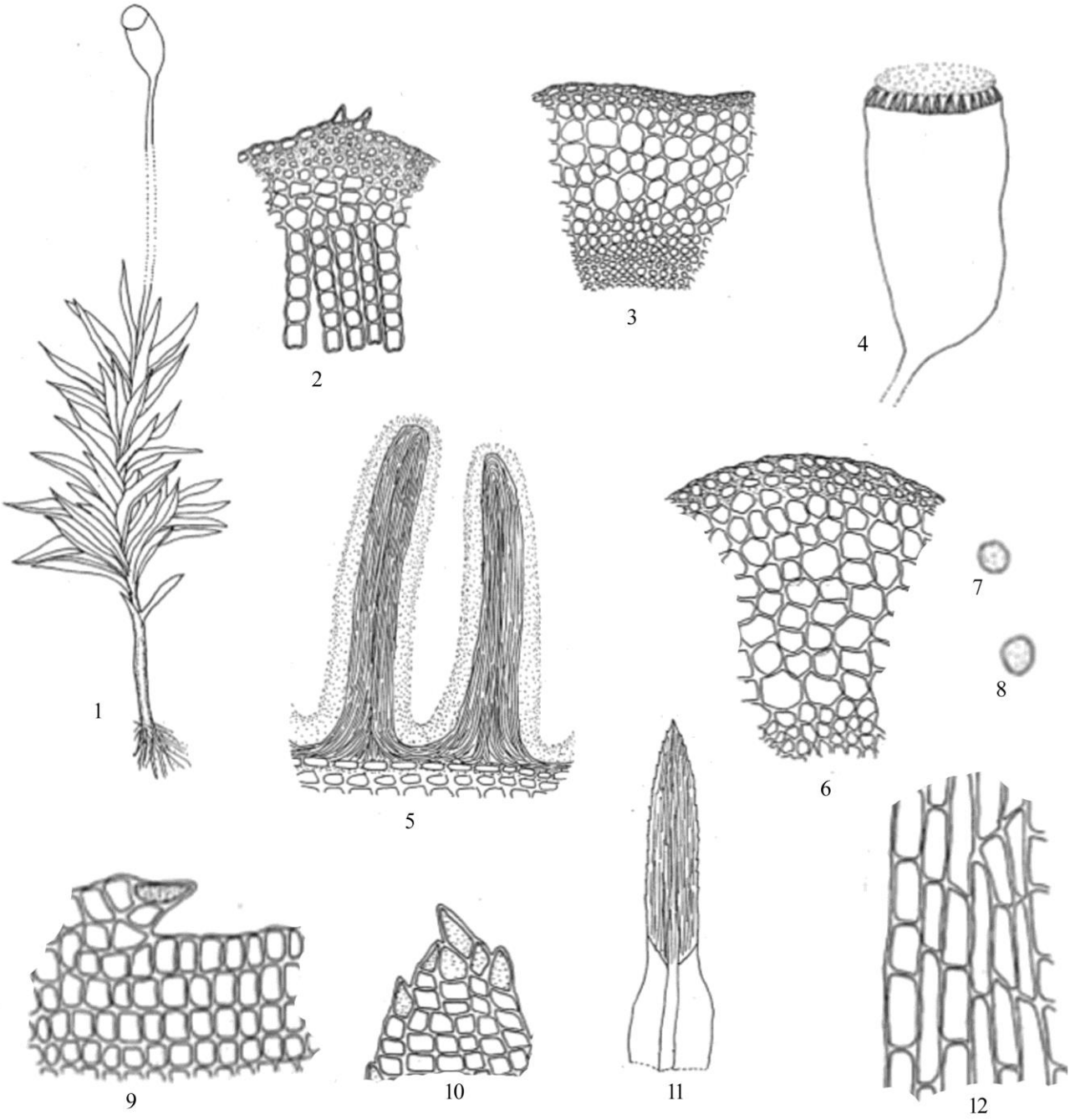

Fig 29. *Pogonatum neesii* (Mull. Hal.) Dozy. 1 = habit of plant; 2 = cross section of leaf; 3 = cross section of stem; 4 = capsule; 5 = peristome teeth; 6 = cross section of seta; 7-8 = spores; 9 = median leaf cells; 10 = apical leaf cells; 11 = leaf; 12 = basal leaf cells.

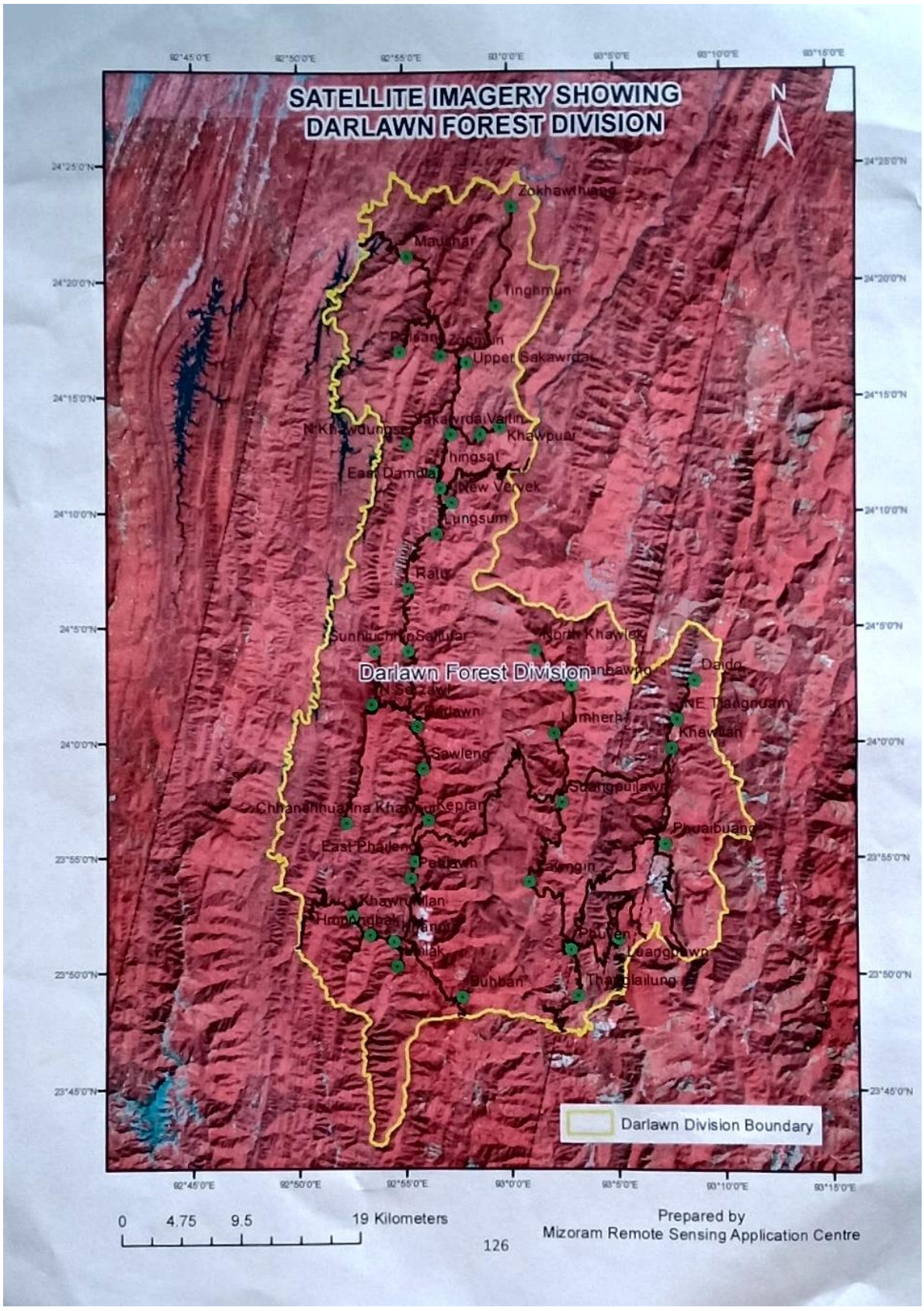

Fig 2: Satellite imagery showing Darlawn Forest Division

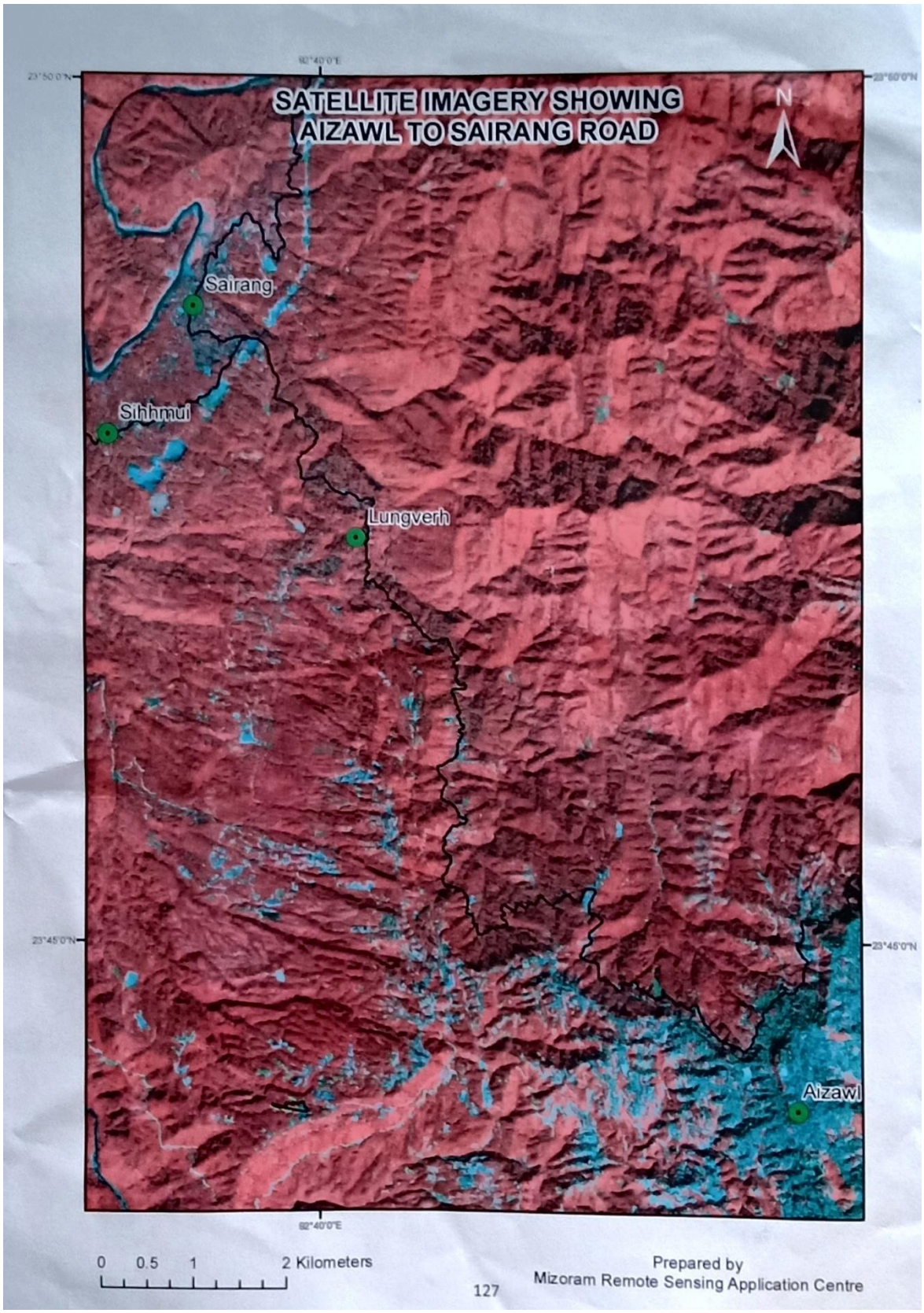

Fig 3: Satellite imagery showing Aizawl to Sairang Roadside

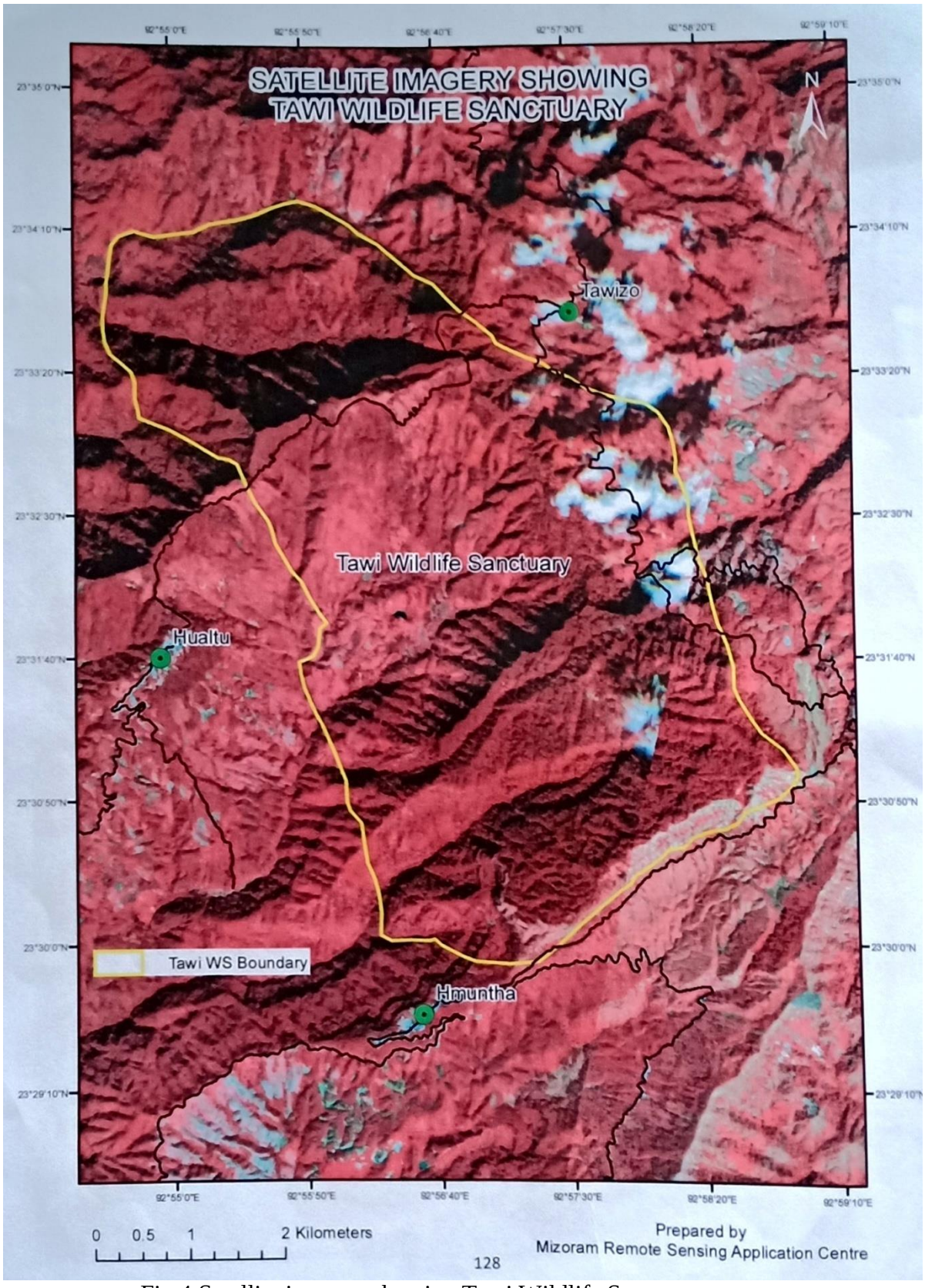

Fig 4:Satellite imagery showing Tawi Wildlife Sanctuary

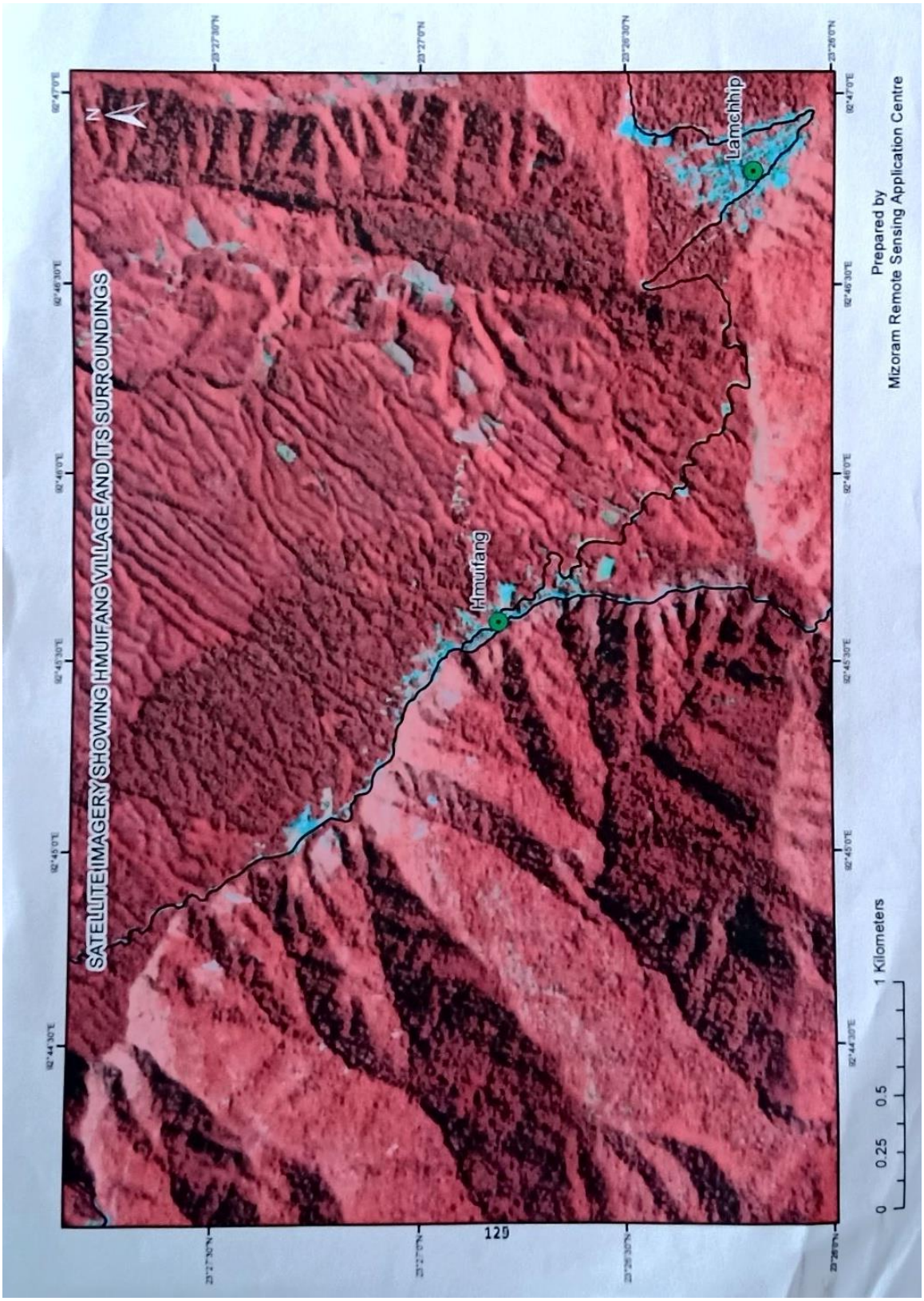

Fig 5: Satellite imagery showing Hmuifang

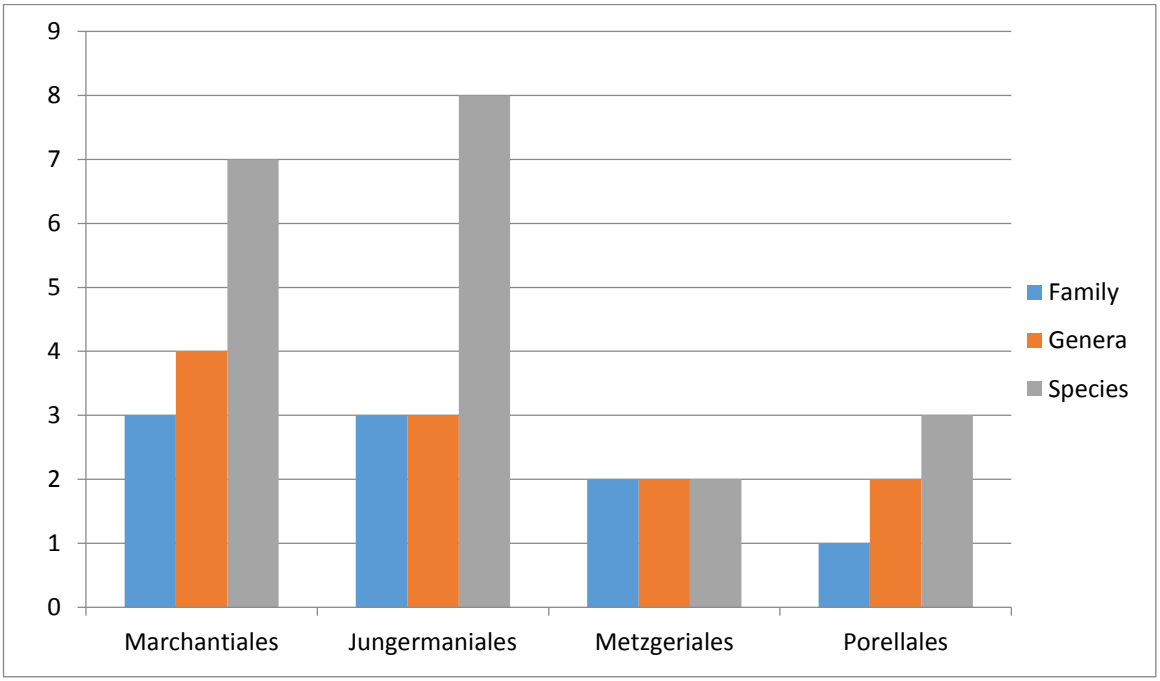

Fig. 30: Order-wise distribution of family, genera and species of Liverworts

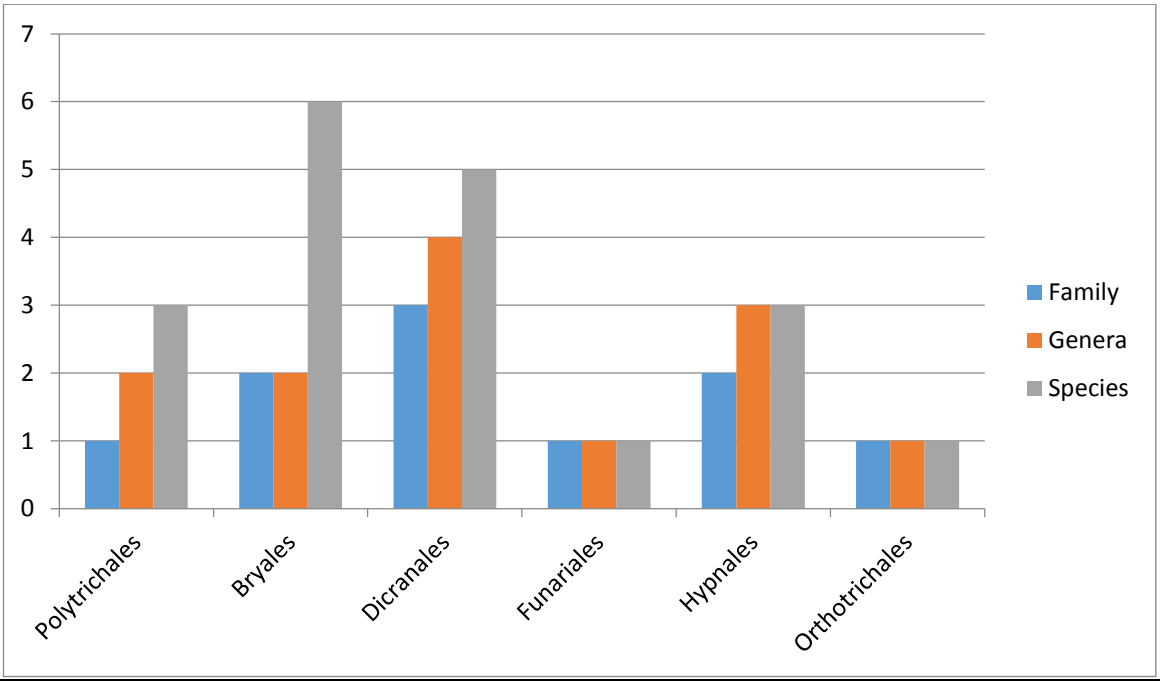

Fig.31: Order-wise distribution of family, genera and species of mosses

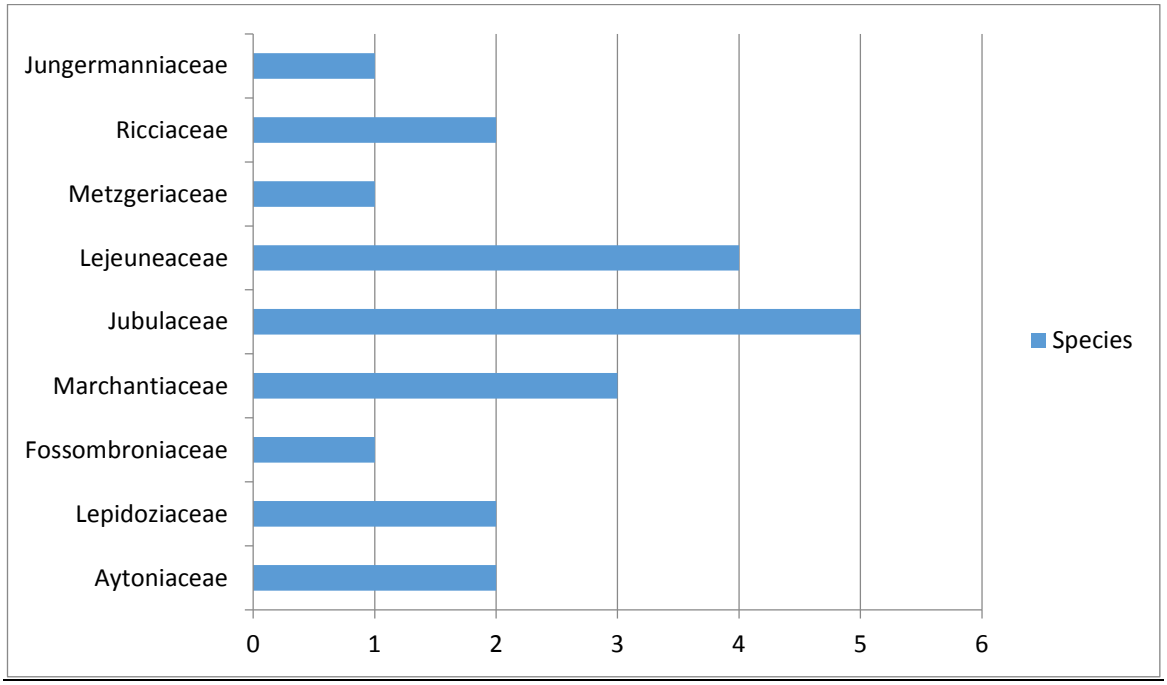

Fig.32: Distribution of plant species in different families of liverworts

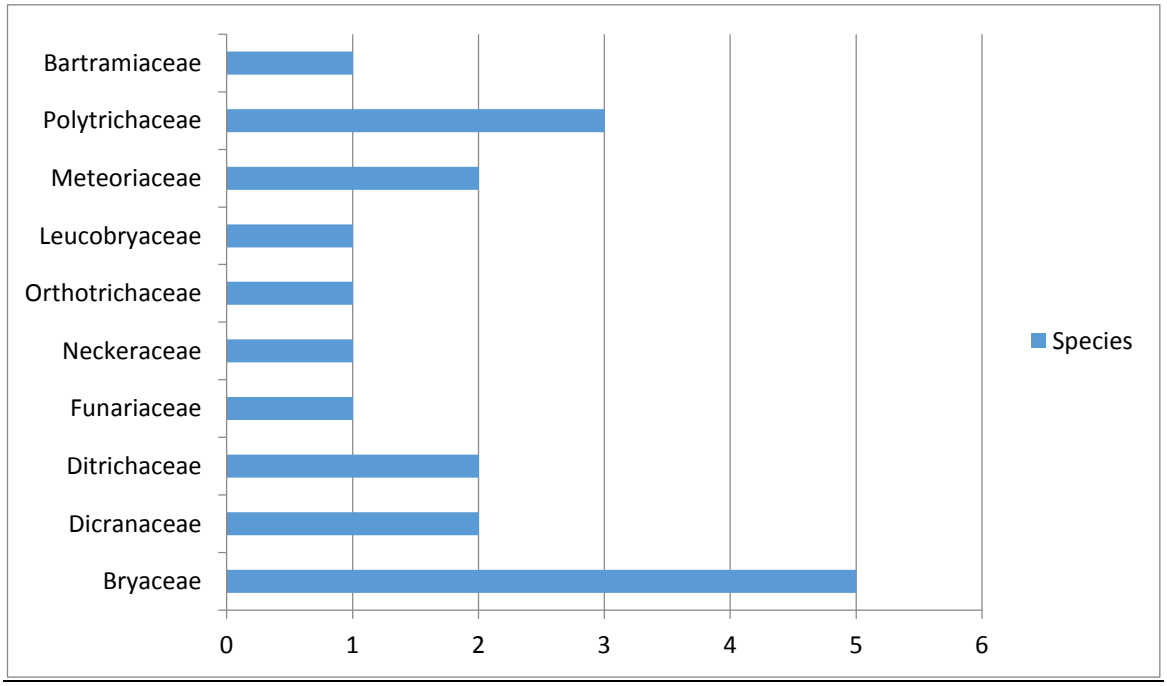

Fig.33: Distribution of plant species in different families of Mosses

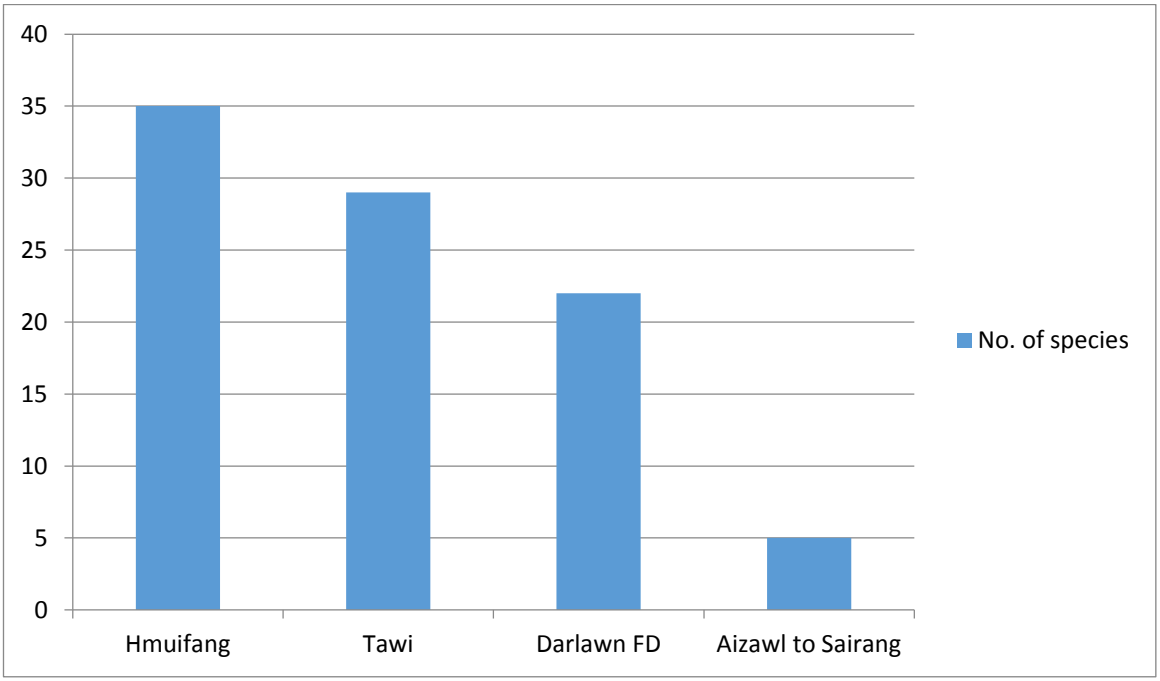

Fig.34: Distribution of plant species at different study sites

Plate 1: Marchantia polymorpha

Plate 2: Bryum argenteum

Plate 3: Campilopus pillifer

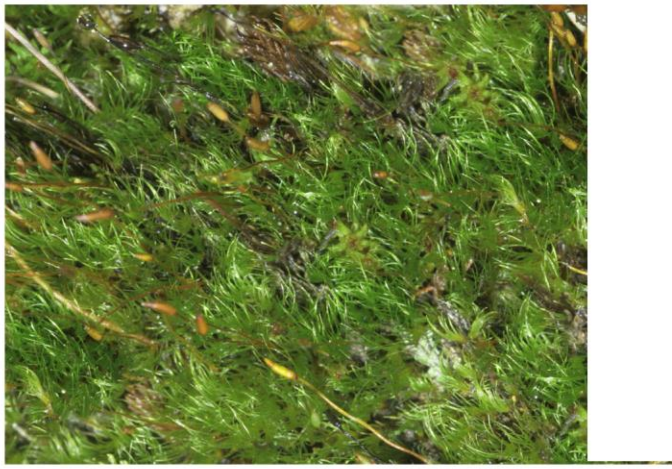

Plate 4: Ditrichum heteromallum

Plate 5:Dicranum lorifolium

Plate 6: Dumortiera hirsuta

Plate 7: Frullania ericoides

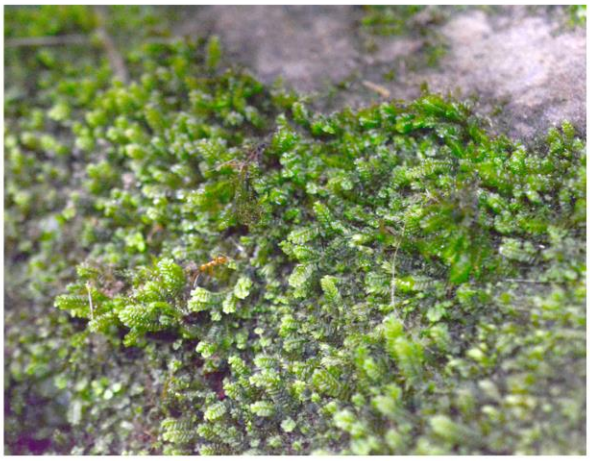

Plate 8: Frullania muscicola

Plate 9: Funaria hygrometrica

Plate 10: Jungermannia comata

Plate 11: Leucobryum candidum

Plate 12: Marchantia paleacea

Plate 13: Metzgeria furcata

Plate 14: Riccia glauca

Plate 15: Trocholejeunea infuscata

Plate 16: Trocholejeunea sandvicensis

Plate 17: Artrichum undulatum

Plate 18: Bryum auratum

Plate 19: Marchantia palacea

Plate 20: Marchantia polymorpha

Plate 21: Phillonotis falcata

Plate 22: Pogonatum aloides

Plate 23: Bazzania hainanensis

Plate 24: Bryum coronatum

Adamek, W. (1976). Introductory report on oncostatic and therapeutic nature of the peat preparation in human neoplastic disease. Pp. 417 – 433 In: *Proc. 5th Intern.Peat Congress, Poznan, Poland*. September 21 – 25, 1976. Vol.1. *Peat and Peatlands in the Natural Environment Protection*. Wydawnictwa Czasopism Technicznych Not. Warsaw, Poland.

Ah-Peng, C., Chualh-Petiot, M., Descamps-Julien, B., Bardat, J., Stamenoff, P. And Strasberg, D. (2007). Bryophyte diversity and distribution along an altitudinal gradient on a lava flow in La reunion. *Diversity and Distributions*. 13: 652 - 664.

Alam, A. (2013). Moss flora of Western Himalayas, India - An updated Checklist. *Archive for Bryology*, 168: 1 - 28.

Ando, H. (1983). Use of bryophytes in China. *Proceedings of the Bryological Society of Japan.Tokyo* 3: 104 – 105.

Asakawa, Y. (2001). Recent advances in phytochemistry of Bryophytes from selected liverworts. *Phytochemistry*, 56: 297 - 312.

Asakawa, Y. (2007). Biologically active compounds from Bryophytes. *Pure and Applied Chemistry*. 79: 557 - 580.

Asakawa, Y., Ludwiczuk, A. and Nagashima, F. (2013). Chemical constituents of bryophytes: bio and chemical diversity, biological activity, and chemosystematics (Progress in the chemistry of organic natural products). *Springer, Vien*, 796 pp.

Asthana, A. K. and Sahu, V. (2013). Bryophyte Diversity in Mukteshwar (Uttarakhand):

An overview. *Archive for Bryology*, 112: 1 - 11.

Asthana, A.K. and Srivastava, S.C. (1991). Indian Hornworts (A taxonomicstudy). *Bryophyt. Biblioth*. 42: 1 – 158.

Asthana, G., Srivastava , S.C. and Asthana, A.K. (1995). The genus Cheilolejeunea in India. *Lindbergia* 20: 125 – 143.

Bahuguna, Y. M., Gairola S., Semwal, D.P., Uniyal P.L., Bhatt, A.B. (2013). Bryophytes and Ecosystem. *Biodiversity of Lower Plants* : pp. 279 - 282.

Banerjee, R.D. (1974). Studies on antibiotic activity of bryophytes and pteridophytes.*Ph.D. Thesis*. University of Kalyani. India.

Bansal, P. and Nath,V.(2013). Current Status of Genus Bryum Hedw. in Eastern Himalaya,India. *Taiwania*, 58 (3): 205 - 212.

Barukial, 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.

Bastos, C.J.P. and Valente, E.B. (2008). Hepáticas (Marchantiophyta) da Reserva Ecológica da Michelin, Igrapiúna, Bahia, Brasil. *Sitientibus Série Ciências Biológicas*, 8 : 280 - 293.

Bastos, C.J.P. and Vilas Bôas-Bastos, S.B. (2008). Musgos acrocárpicos ecladocárpicos (Bryophyta) da Reserva Ecológica da Michelin, Igrapiúna, Bahia, Brasil. Sitientibus - *Série Ciências Biológicas*, 8: 275 - 279.

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.

Beike, A.K., Decker, E.L., Frank, W., Lang, D., Vervleit–Scheebaum, M., Zimmer, A.D. and Reski, R. (2010), Applied Bryology- Bryotechnology. *Tropical Bryology* 31, 22 – 32.

Bisang, I. and Urmi, E. (Eds) (1995). Conservation of Bryophytes in Europe. *Cryptogamica Helvetica.* 18: 193.

Bland J.M. (1971). Forests of Lilliput: the realm of mosses and lichens prentice-hall, Inc., Englewood cliffs. 210

Brown, D. H. (1982). Mineral nutrition. In: A.J.E. Smith (ed.), *Bryophytes ecology*: 383 – 445. Chapman and Hall, London and New York. Cambridge University Press.

Carol D.M. (2003). Bryophytes indicator of water level and salinity change along the Northeast cape fear River. *Ph.D thesis* submitted to the university of California. Pp. 1 – 3

Chaturvedi, S.K, Eshuo, K, Sale, V. (2011a). Fossombronia wondraczekii (Corda) Dum. (Fossombroniaceae): New to Eastern Himalayas. *Phytomorphology* 61 (3 & 4), 107 – 110

Chaturvedi, S.K., Eshuo, K., Sale V. (2011b). Morpho – taxonomic study on some corticolous Mosses of Longkhum Reserve forest, Mongkokchung District, Nagaland. *Bionature* 31 (1), 1 – 12

Chaturvedi, S.K and Chaturvedi S. (2008). Diversity of Thalloid Liverworts in Mongkokchung District, Nagaland. *Bryology in the new millennium.* 83 – 91 pp.

Chaturvedi, S.K and Eshuo, K. (2012). Abnormal Asexual reproduction in *Asterella khasyana* (Griff.) Pande, K.P. Srivast. and Sultan Khan (Marchantiophyta: hepacea) from Nagaland. *The International Journal of plant reproductive biology* 4 (2) pp. 89 – 92.

Chaudhary, BL., Kumar P. (2011). Antibacterial activity and preliminary phytochemical screening of epiphytic moss Stereophyllum ligulatum Jaeg. *International Journal of Pharma and Bio Sciences*, 2 (4), 674 - 681.

Cheng, X., Xiao, Y., Wang, X., Wang, P., Li, H., Yan, H. and Liu Q. (2012). Anti-tumor and proapoptic activity of ethanolic extract and its various fractions from Polytrichum commune L. Ex Hedw in L1210 cells. *Journal of Ethnopharmacology* 143, 49 – 56.

Chobot V., Kubicova L., Nabbout S., Jahodar L., Vytlacilova J. (2006). Antioxidant and free radical scavenging activities of five moss species. *Fitoterapia*, 77, 598 - 600.

Chopra, R. S. and Kumar, S. S. (1981). Mosses of Western Himalayas and adjacent plains. *The Chronica Botanica Co.* New Delhi.

Chopra, R. S. (1975). Taxonomy of Indian Mosses. New Delhi, CSIR. India, pp. 1 - 631.

Chopra, R.S.(1943). A census of Indian Hepatics. J. Indian Bot. Soc. 22: 237 – 260.

Chopra, R.S. (1975). *Taxonomy of Indian mosses*. New Delhi.

Choyal, R. and Sharma, S. K. (2011). Study of Moss Flora and Growth Forms of Moss in Varied Habitats in Dharmshala of Kangra District (H.P), India. *Indian Journal of Fundamental and Applied Life Sciences* Vol. 1 (3): 271 - 273.

Cremer, K. W. and Mount, A. B. (1965). Early stages of plant succession following the complete felling and burning of Eucalyptus regnans forest in the Florentine Valley, Tasmania. *Australian Journal of Botany* 13: 303 - 322.

Crosby, M. R., (1980). The diversity and relationships of mosses, pp: 29-115. In R.J. Taylor and A.E. Leviton (ed.), The Mosses of North America, San Francisco , CA: *Pacific Division, AAAS.*

Dandotiya, D., Gobindpyari, H., Suman. S. and Uniyal, P. L. (2011). Checklist of the Bryophytes of India. *Archive for Bryology*, 88: 1-126.

Daniel, A. E. D and Daniel, P. (2013). The Bryoflora of the Southernmost Western Ghats, India. Bishen Singh and Mahendra Pal Singh, Dehra Dun, pp. 25 – 50

Daniels, A. E. D. and Daniel, P. (2007). The Mosses of South Western Ghats. In: V. Nath and A. K. Asthana, eds. *Current trends in Bryology*. Bishen Singh Mahendra Pal Singh, Dehra Dun, pp, 227 - 243.

Daniels, A.E.D. and P. Daniel. (2002). Two new species of Riccia L.(Hepaticae: Marchantiales) from the Western Ghats of Tamil Nadu. *Bull. Bot. Surv. India*. Vol. 44 (1 - 4): 135 - 140.

Daniels, A.E.D. and P. Daniel. (2003a). An Addition to the bryoflora of India. *Bull. Bot. Surv. India.* Vol. 45 (1 - 4): 225 – 226.

Daniels, A.E.D. and P. Daniel. (2003b). Additions to the bryoflora of Peninsular India. *Indian J. Forestry* 26: 389 - 396.

Daniels, A.E.D. and P. Daniel. (2004). Leptolejeunea balansae (Hepaticae: Jungermanniales) – a new record of Bryoflora from the Indian mainland. *J. Bombay Nat. Hist. Soc*. 101: 333.

Daniels, A.E.D. (2010). Checklist of the bryophytes of Tamil Nadu, India. *Archive for bryology*, 9 - 65pp.

Daniels, A.E.D. (2004). Bryophytes. In: Annamalai, R. (ed.), Tamil Nadu Biodiversity Strategy and Action plant. *Wild Plant Diversity*: 49 – 70pp.

Daniels, AE.D. and P. Daniel. (2003). Fissidens griffithii Gangulee (Musci: Fissidentales) – An addition to the bryoflora of India. *Indian J. Forestry* 26: 193 - 194.

Dash, P.K., Sahu, D.K. and Saxena, D.K. (2009). Bryoflora of Baphlamali Hill in Eastern Ghatts of Orissa, India. *Newsletter*, 15(1): 3 - 8.

Dässler, H.G. and Ranft, H. (1969). Das Verhalten von Flechten und Moosen unter Einfluss einer Schwefeldioxid-begasung. *Flora*, Abt. B, 1958. Pp. 454 – 461.

Delucia, E.H., Turnbull, M.H., Walcroft, A.S., Griffen, K.L., Tissue, D.T., Glenny, D., McSeventy, T. M. & Whitehead, D.(2003). The contribution of bryophytes to the carbon exchange for a temperate rainforest, *In Global Change Biology*, 9 (8): 1158 - 1170.

Ding, H. (1982). Medicinal spore-bearing plants of China. *Shanghai Scientific Publisher, Shanghai*.

Dulger B., Yayintas OT., Gonuz A. (2005). Antimicrobial activity of some mosses from Turkey. *Fitoterapia*, 76, 730 - 732.

Dymytrova L. (2009). Epiphytic lichens and bryophytes as indicators of air pollution in Kyiv city (Ukraine). Folia Cryptog. *Estonica*, Fasc. 46: 33 – 44.

Easa, P.S. (2003). Biodiversity documentation for Kerala. Part 4: Bryophytes. *KFRI Handbook* 17: 1 – 47. KFRI, Peechi, Kerala.

Edwards, D. (2000). The role of mid-paleozoic mesofossils in the detection of early bryophytes. *Philosophical Transaction of the royal Society of London*, 355B: 733 - 55.

Elibol, B., Ezer, T., Kara, R., Çelik, G. Y. and Çolak, E. (2011). Antifungal and antibacterial effects of some acrocarpic mosses. *African Journal of Biotechnology*. 10 (6): 986 - 989

Eshuo K. and Chaturvedi S.K. (2011). Ditributional range of genus Saccogynidium. Grolle (Hepaticea: Geocalycaceae) in the North East India. *Bionature*, 31 (2), 85 – 89.

Flowers, S. (1957). Ethnobryology of the Gosuite Indians of Utah. *Bryologists* 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: 223 – 226.

Forman, R.T.T. (1968). Caloric values of bryophytes. *Bryologist*, 71, 344 – 347.

Forrest L.L., Davis EC., Long D.G., Crandall-Stotler B.J., Clark A, Hollingsworth ML. (2006). Unraveling the evolutionary history of the liverworts (Marchantiophyta): multiple taxa, genomes, analyses. *Bryologist*, 109, 303 - 334.

Frahm, J. P. (1990). Bryophyte phytomass in tropical ecosystems. *Botanical Journal of the Linnean Society* 104: 23 - 33.

Frahm, J. P. (2013). Mosses and Liverworts of the Western Ghats, India- a picture book. *Archive for Bryology Special Volume* 14: 1 - 62.

Frahm, J. P. and Gradstein, S.R. (1991). An altitudinal zonation of tropical rain forests using bryophytes. *Journal of Biogeography*. 18: 669 - 678.

Frego, K.A. (2007). Bryophytes as potential indicators of forest integrity. *Forest Ecology and Management*, 242: 65 – 75.

Fu, P., Lin, S., Shan, L., Lu, M., Shen, Y.H., Tang, J., Liu, R.H., Zhang, X., Zhu, R.L. & Zhang, W.D. (2012). Constituents of the moss *Polytrichum commune*. *Journal of Natural Products* 72, 1335 – 1337.

Funch, L.S. (2008). Florestas do Parque Nacional da Chapada Diamantina e seu entorno. pp:63-77. In: Funch, L.S., Funch, R.R. and Queiroz, L.P. (Orgs.) Serra do Sincorá: *Parque Nacional da Chapada Diamantina.*

Gangulee, H. C. (1969 – 72). Mosses of Eastern India and adjacent regions. Calcutta, India: *Sri Saraswati Press, Fasc*. 1 – 3: 1 - 830.

Gangulee, H. C. (1978 – 80). Mosses of Eastern India and adjacent regions. Calcutta, India: *Sri Saraswati Press, Fasc*. 7 – 8: 1547 - 2145.

Geissler, P. and Greene, S.W. (1982). Bryophyte taxonomy methods, practices and floristic exploration. Proceedings of the International Association of Bryology Taxonomy Workshop Meeting, Genève 27 Aug – 2 Sept 1979. *J. Cramer, Vaduz.*

Glime, J.M. (1984) Physio-ecological factors relating to reproduction and phenology in Fontinalis dalecarlica. *The Bryologist*, 87(1), 17 - 23.

Glime, J.M. (2007). Bryophyte Ecology. Physiological Ecology. E-book. Michigan Technological University, *International Association of Bryologists*. Vol.1.

Glime, J.M. and Saxena, D. (991). *Uses of bryophytes*. Today and Tomorrow's Printers and Publishers, New Delhi.

Govindapyari, H., Leleeka, M., Nivedita, M., and Uniyal, P. L. (2010). Bryophytes: indicators and Gradstein, S.R., Churchill, S.P., and Salazar - Allen, N. (2001). *Guide to the Bryophytes of Tropical America*. New York: The New York Botanical Garden Press.

Greven, H.C. (1992). *Changes in the Dutch bryophyte flora and air pollution*. Diss. Bot. J. Cramer, Berlin, Germany.

Gulabani, A. (1974). Bryophytes as economic plants. *Botanica* 14: 71 – 75

Haines, W.P. and Renwick, J.A.A. (2009). Bryophytes as food: comparative consumption and utilization of mosses by a generalist insect herbivore. *Entomologia experimentalis et apllicata*, 133, 296–306.

Hallingbäck, T. (1995). The practice of bryophyte conservation. *Cryptogamica Helvetica. Geneva,Teufen* 18: 119–130.

Hallingbȁck , T and Hodgetts, N. (2000).Compilation on *Status and Conservation Action Plan for Bryophytes*. Published by IUCN, Gland, Switzerland and Cambridge, UK in collaboration with the Swedish. 106 – 235pp

Heckman, D. S. and Geiser, D. M. (2001). Molecular evidence for the early colonization of land, fungi and plants. *Science*, 293: 1129 - 33.

India State of Forest Report (2017). Forest cover in the North – Eastern States..

Isomura, K., Higuchi, M., Shibata, H., Tsukada, H., Iwashima K. and Sugiyama, H. (1993). Distribution of radioactive caesiums in mosses and application of mosses for monitoring of radioactive caesiums. *Radioisotopes* 42: 157–163.

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 N.V. Biradar. (1984). Studies on the liverwort flora of Western Ghats with special reference to Maharashtra, India. *J. Hattori Bot. Lab*. 56: 45 – 52.

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.

Kenrick, P. and Crane, P.R. (1997). *The origin and Early Diversification of land plants*. Washington, D. C., Smithsonian Institution Press.

Kessler, M. (2000). Altitudinal zonation of Andean cryptogam communities. *Journal of Biogeography*, 27 : 275 - 282.

Koponen, T. (1992). Endangered bryophytes on a global scale. *Biological Conservation* 59: 255 – 258.

Krishnan R., Manoj G.S., Murugan K. (2012): In vitro microbicidal potentiality of Targionia hypophylla L. and Bryum species- Bryophytes. *International Journal of Pharmacy and Pharmaceutical Sciences* Vol 4, Issue 2, 2012. ISSN; 0975 - 1491.

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

Kumar, G. V. and Krishnamurthy, K. V. (2007). Moss Flora of Shervaroy Hills of Eastern Ghats (South India). In: V. Nath and A. K. Asthana, eds. *Current trends in Bryology*, Bishen Singh Mahendra Pal Singh, Dehra Dun pp. 37 - 45.

Kumar, S.S. and P. Maniselvan. (1994). A report on the moss flora of Udhagamandalam in south India – I. *Res. Bull. Panjab Univ*. 44: 99 – 103.

Lalhriatpuia and Laha (2015a). Bryophytes Diversity in Mamit District Mizoram; North East *India International Journal of pharma and Bio Sciences* 6(4): B 1204 – B1209.

Lalhriatpuia and Laha (2015b). Diversity of Bryophytes in Aizawl District Mizoram: *Internatinal Journal of science and research* ISSN: 2319-7064.

Lal, J. (2005). *A checklist of Indian Mosses*, India: Bishen Singh Mahendra Pal Singh, Dehra Dun. pp. 1 - 164.

Longton, R.E., (1988). *The Biology of Polar Bryophytes and Lichens*. Cambridge University Press, Cambridge.

Madhusoodan, P. V., Nair, M. C. and Easa, P. S. (2007). *Diversity of Bryophytes in Eraviculam National Park, Kerala (South India)* In: V. Nath & A. K. Asthana, eds. Current trends in Bryology, Bishen Singh Mahendra Pal Singh, Dehra Dun pp. 255 - 267.

Madsen, G.C. and Pates, A.L. 1952. Occurrence of anti-microbial substances in chlorophyllose plants growing in Florida. Botanical Gazette. 113: 293 – 300

Mägdefrau, K. (1982). Life-forms of bryophytes. pp. 45-58. In Smith, A. J. E. (ed.). *Bryophyte Ecology.* Chapman and Hall. Cambridge, Cambridge University Press.

Mäkinen, A. (1987). Use of Hylocomium splendens for regional and local heavy metal monitoring around a coal-fired power plant in southern Finland. *Symposia Biologica Hungarica. Budapest* 35: 777 – 794.

Maniselvan, P. and S.S. Kumar. (1998). *Preliminary survey of moss flora of Kodaikanal* – I. Res. Bull. Panjab Univ. 48: 21 – 24.

Maniselvan, P. and S.S. Kumar. (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. (2006). Bryophytes of Chinnar Wildlife Sanctuary (South India) - a preliminary account. *Geophytology,* 36 (1&2): 7 - 15.

Manju,C.N., Rajesh, K. P and Madhusoodanan, P.V. (2008) . Checklist of the bryophytes of Kerala, India. *Tropical Bryology Research Reports*, 7:1 - 24.

Manju, C. N., Rajesh, K. P. and Madhusoodanan, P.V. (2009a). Contribution to the bryophyte flora of India: the Aralam Wildlife Sanctuary in the Western Ghats. Archive for Bryology, 42: 1 - 12.

Maschke, J. (1981). Moose als Bioindikatoren von Schwermetall Immissionen. Bryophytorum *Bibliotheca 22. Cramer, Vaduz*. pp – 492.

Mc Cleary, J.A., Sypherd P.S. and Walkington, D.L. (1960). Mosses as Possible Sources of Antibiotics, *Science*. 131: 108

Merkuria, T., Steiner, U., Hindorf , H., Frahm, J. P. and Dehne H. W. (2005). Bioactivity of Bryophyte extracts against Botrytis cinerea, Alternaria solani *Journal of Applied Botany and Food Quality*, 79: 89 - 93.

Miller H. and Miller H.G. (1979). Make ye the bryophytes. *Horticulture*. 57(1): 40 - 50.

Mishler, B. D. and Churchill, S. P. (1985). Transition to a land flora : phylogenetic relationships of the green algae and bryophytes. *Cladistics*, 1: 305 - 28. monitoring agents of pollution. *NeBIO*, 1(1), 35 - 39.

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

Montagne, J.P.F.C. (1842). *Cryptogamme Nilgerienses plantarum cellularium in montibus peninsulae Indicae musci*. Ann. Sci. Nat. Bot.2, 17: 243 – 256.

Müller, C. (1853). Musci neilgherrensis. *Bot. Zeitung (Regensburg)* 11: 17 – 21, 33 – 40; 57, 62.

Nair, M.C. and P.V. Madhusoodanan. (2001). Contribution to the bryophyte flora of Eravikulam National Park, Kerala. *J. Econ. Tax. Bot*. 25: 569 – 574.

Nair, M.C. and P.V. Madhusoodanan. (2002). Studies on the bryophyte flora of Kerala (south India) – An introduction. *J. Econ. Tax. Bot.* 26: 697 – 708.

Nath, V,. Bansal, P. and Chturvedi, S. K (2011). A study on the epiphytic bryophytes diversity on Thuja orientalis in Ngaland (North eastern hills). *Journal of plant taxonomy,* 18(2):163-167.

Nath, V. and A.K. Asthana (1998). Diversity and distribution of genus *Frullania Raddi* in South India. *J. Hattori Bot. Lab*. 85: 63 – 82.

Nath, V. and Asthana, A. K. (2005). *Studies on Indian Bryophytes*; National Botanical Research Institute, pp: 277 - 288.

Nath, V., Asthana, A.K. and Singh, A.P. (2000). Role of bryophytes in soil management and rock brinding .*Geophytollogy*. 28(1&2): 95 - 100.

Newton, A. E., Cox, C. and Duckett, J.G. (2000). Evolution of the major moss leneages. *Byologist,* 103: 187 - 211.

Nimis, P. L., Scheidegger, C. and Wolseley, P. A. (2002). Monitoring with lichens. Kluwer Academic Publishers, Dordrecht, *The Netherlands*. pp - 408.

Pant G., S.D.Tewari, Pargaien M.C. and bisht. L.S. (1986). Bryological activities in north-west Himalaya-II. A bryophyte foray in the ascot region of district Pithoragarh (Kumaun Himalayas). *The Bryological Times*, 39: 2 - 3.

Pant G. and Tewari S.D. (1989).Various human uses of bryophytes in the Kumaun region of northwest Himalaya. *Bryologist*., 92: 120 - 122.

Pócs, T. (1982). Tropical forest bryophytes Smith, A.J.E. *Bryophyte Ecology*. pp: 59 -104.

Pócs, T. (1980). The epiphytic biomass and its effect on the water balance of two rain forest types in the Uluguru Mountains (Tanzania, East Africa). Acta Botanica Academiae Scientiarum Hungaricae. *Budapest* 26: 143 - 167.

Pòcs, T., (1982). Tropical forest bryophytes. In Smith, A.J.E. (Ed.),*Bryophyte Ecology*. Chapman and Hall, London. pp. 59–104.

Pouliot, R., Hugron, S. and Rochefort, L. (2014). Sphagnum farming: a long term study on producing peat moss biomass sustainably. *Ecological Engineering*, 74, 135 – 147.

Pressel, S., Bidartondo, M. I., Ligrone, R. & Duckett, J. G. (2010). Fungal symbioses in bryophytes: New insights in the Twenty First Century. *Phytotaxa*, 9: 238 - 253.

Rao, D. N. (1982). Responses of bryophytes to air pollution. Pp. 445 - 471. *In Bryophyte Ecology* (ed A. J. E. Smith) Chapman and Hall. London and New York.

Renzaglia, K. S., Schuette, S. and Duff, R. J. (2007). Bryophyte phylogeny: Advancing the Molecular and Morphological frontiers. *Bryologists*, 110: 179 - 213.

Ribeiro-Filho, A.A., Funch, L.S. and Rodal, M.J.N. (2009). Composição florística da floresta ciliar do rio Mandassaia, Parque Nacional da Chapada Diamantina, Bahia, Brasil. *Rodriguésia,* 60: 265 - 276.

Richards, W.P. (1984). The ecology of tropical forest bryophytes. pp: 1233 - 1270. In Schuster, R.M. (ed.). *New Manual of Bryology*. Japan, Hattori Botanical Laboratory.

Richardson, D.H.S. (1981). *The Biology of Mosses*. Blackwell, London.

Ruhling, A. and Tyler, G. (1968) An ecological approach to the lead problem, *Botaniska Notiser* 121, 321–342.

Ruhling, A. and Tyler, G.(1969), Ecology of heavy metals – a regional and historical study, *Botaniska Notiser.*122, 248 – 259.

Sabovljevic A., Sokovic M., Sabovljevic M., Grubisic D. (2006). Antimicrobial activity of Bryum argenteum. *Fitoterapia*, 77, 144 - 145.

Sahu, V., Asthana, A.K., Nath, V. and Yunus, M. (2007). Bryophytes: A Useful Tool in Heavy Metal Monitoring. *Archives of Environmental News, Newsletter of ISEB India*, Vol. 13(4).

Sanderson, M. J. (2003). Molecular data from 23 proteins do not support a precambriam origin of land plants. *American Journal of Botany*, 90: 954 - 6.

Sathish, S. S., Thamizharasi, T., Palani, R., Vijayakanth, P. and Vimala, A. (2014). Checklist of Mosses (Bryopsida) of the Kalrayan hills in the Eastern Ghats of Tamil Nadu, India. *International Journal of Research in Engineering and Bioscience*, 2 (1): 28 - 33.

Schwarz, U. and Frahm, J. P. (2013). A Contribution to the Bryoflora of the Western Ghatsin Karnataka State, India. *Polish Botanical Journal* 58(2): 511 - 524.

Schwarz, U. (2013). An Updated Checklist of Bryophytes of Karnataka. *Archive for Bryology*, 181: 1 - 42.

Sharma, O.P., (2014). Diversity of Microbes and Cryptogams: Bryophyta. Published by *MC Graw Hill Education India* Pvt. Ltd., New Delhi. Pp. 353 - 359.

Sharma, S. K. and Choyal, R. R. (2011).Distribution of Moss in the Topography of Kangra District (H.P). *Indian Journal of Fundamental and Applied Life Sciences*, 1 (2): 154 - 156.

Singh and Nath (2007). Hepaticae of Khasi and Jaintia Hills: Eastern Himalayas: Bishen Singh Mahendra Pal Singh. pp 20 - 233

Singh S.K. and Singh D.K. (2009).Hepaticae and Anthocerotae of Great Himalayan National Park and its environs (HP), India: In 2009, Government of India, Botanical Suvey of India. Pp. 1 - 418.

Singh, M., Govindarajan, R., Nath, V., Rawat, A.K.S., Mehrotra, S.(2006). Antimicrobial, wound healing and antioxidant activity of Plagiochasma appendiculatum Lehm. et Lind. *Journal of Ethnopharmacology*, 107, 67 – 72.

Singh, A.P. and Nath, V. (2007). Hepatacae of Khasi and Jaintia Hills :Eastern Himalayas.

Singh, D. K. (1997). Liverworts. In: *V. Floristic Diversity and conservation Strategies in India I*. Dehra Dun. pp. 235 - 300.

Singh, D. K. and Singh, S. K. (2008). Diversity in Liverworts and Hornworts of Great Himalayan National Park, Western Himalaya, India. *International Association of Bryologists*, 57: 40 - 45.

Singh, M., Govindarajan, R., Nath, V., Rawat, A.K.S., Mehrotra, S. (2006). Antimicrobial, wound healing and antioxidant activity of Plagiochasma appendiculatum Lehm. et Lind. *Journal of Ethnopharmacology,* 107, 67 – 72.

Singh,S.K., and Barbhuiya H.A. (2012). A compendium to Marchantiophyta and Anthocerotophyta of Assam. *Archive for Bryology*.

Singh, S.K., and Barbhuiya H.A. (2008). Diversity in Liverworts and Hornworts of Great Himalayan National Park, Western Himalayas, India. *International Association of Bryologists* 57: 40 - 45.

Spjut, R.W., Cassady, J.M., McCloud, T., Suffness, M., Norris, D. H., Cragg, G. M., Edson, C. F. (1988). Variation in cytotoxicity and antitumor activity among samples of the moss Claopodium crispifolium (Thuidiaceae). *Economic Botany* 42(1): 62 – 72.

Spjut, R.W., Suffness, M., Cragg, G.M. and Norris, D.H. (1986). Mosses, liverworts and hornworts screened for antitumor agents. *Economic Botany 40* (3): 310 – 338.

Srivastava, S. C. (1998). Distribution of Hepaticae and Anthocerotae in India. In: Topics

in Bryology. eds. R. N. Chopra, Allied publisher Ltd. pp. 53 - 85

Stephani, F. (1900 – 1924). *Species Hepaticarum. Vols. 1 – 6. Génève.*

Szweykowski, J., (1984). What do we know about the evolutionary process in bryophytes. *Journal of the Hattori Botanical Lab.* 55, 209 – 218.

Tan, B.C., Sastre-de Jesús, I. and Pócs, T. (1991). Tropical bryology in peril: a survey. Bryological Times; *Newsletter of the International Association of Bryologists*. Utrecht, Penicuik 64: 1 – 6.

Taoda, H. (1972). Mapping of atmospheric pollution in Tokyo based upon epiphytic bryophytes. *Japanese Journal of Ecology* 22: 125 – 133.

Thieret, J.W. (1954). Mosses and liverworts: old and new uses. *Chicago Nat. Hist. Mus. Bull*: 4 -8

Udar, R. and kumar A. (1981). Genus Notoscyphus Mitt. In India. *J. Hattori. Bot. Lab*. 49: 247 – 260.

Udar, R. and U.S. Awasthi. (1982). The genus Drepanolejeunea St. in India. *J. Hattori Bot. Lab.* 53: 419 – 437.

Udar, R. and U.S. Awasthi. (1982). The genus Schiffneriolejeunea Verd.(Hepaticae) in India. *Lindbergia* 8: 55 – 59.

Udar, R. and U.S. Awasthi. (1983). The genus Leucolejeunea Evans. in India. Proc. Indian Natn. Sci. Acad. 49B: 249 – 256.

Udar, R. and V. Chandra. (1964). Exormotheca ceylonensis Meijer - New to Indian flora. *Curr. Sci.* 33: 436 – 448.

Udar, R. (1957). Riccia crozalsii Levier and R. warstorfii Limpr. from India. *Curr. Sci.* 9: 287 – 288.

Udar, R. (1965). Riccia grollei Udar nom. Nov - a correction for Riccia tuberculata Pandé and Udar from India. *Curr. Sci.* 34: 126.

Umadevi M., Sampath Kumar KP., Debjit BS., Duraivel. (2013). Traditionally used anticancer herbs in India. *Journal of Medicinal Plants Studies*, 1(3), 56 - 74.

Valente, E.B. and Pôrto, K.C. (2006). Novas ocorrências de hepáticas (Marchantiophyta) para Estado da Bahia, Brasil. *Acta Botanica Brasilica* 20:195 - 201.

Valente, E.B., Pôrto, K.C., Bôas-Bastos, S.B.V. and Bastos, C.J.P. (2009). Musgos (Bryophyta) de um fragmento de Mata Atlântica na Serra da Jibóia, município de Santa Terezinha, BA, Brasil. *Acta Botanica Brasilica* 23: 369 - 375.

Valente, E.B., Pôrto, K.C. and Bastos, C.J.P. (2011). Checklist of Bryophytes of Chapada Diamantina, Bahia, Brazil. *Boletim do Instituto de Botânica*, 21:111 - 124.

Valente, E.B., Pôrto, K.C. and Bastos, C.J.P. (2013). Species richness and distribution of bryophytes in different phytophysionomies from Chapada Diamantina, Brazil. *Acta Botanica Brasilica.* pp: 27.

Van Reenen, G.B.A. and Gradstein, S.R. (1983). A transect analysis of the bryophyte vegetation along an altitudinal gradient on the Sierra Nevada de Santa Marta, Colombia. *Acta Botanica Neerlandica*, 32: 163 - 175.

Vanderpoorten, A., and Goffinet, B. (2009). Introduction to Bryophytes. Cambridge: Cambridge.

Vashistha, B. D. (1998). *Distribution of Mosses in India. In Topics in Bryology*. Ads. R. N. Chopra. Allied Publishers Ltd, India. pp. 86 - 111.

Vitt, D. H. (1984). Classification of the Bryopsida. In: New Mannual of Bryology, Vol.2, (ed), R. M. Schuster,pp. *Nichinian* . 696 - 759: Hattori Botanical Laboratory.

Vohra, J. N. (1983). Hypnobryales Suborder Leskeineae (Musci) of the Himalayas. *Record of the Botanical Survey of India*. Botanical Survey of India, Hawarah, XXIII: 1 - 336.

Wakuli, W. *et al*., (2003) Catenarin production by isolates of Pyrenophura tritu-repentis and its antimicrobial activity: *J. Phytopathology* : 151 (2) :74.

Wellman, C. H. and Gray, J. (2000). The microfossils record of early land plants. *Philosophical Transaction of the Royal Society of London*, B 355, 717 - 32.

Wellman, C. H., Osterloff, P. L. and Mohiuddin, U. (2003). Fragments of the earliest land plants. *Nature*, 425, 282 - 4.

Williams, P. G., Reginald Appavool M, Lal, N.D., Aravind A., Prakash Williams P.G. (2016) Antibacterial activity and phytochemical analysis of selected bryophytes against penicillin resiatant bacterial pathogens. *South Indian Journal Of Biological Sciences*; 2(3): 360 - 366

Wu, P.C. (1977). Rhodobryum giganteum (Schwaegr.) Par. can be used for curing cardiovascular disease. *Acta Phytotaxonomica Sinica* 15: 93.

Yadav S. (2015). Study on Moss flora of Nilgiri Hills (Tamilnadu) South India: *Thesis* Submitted to the University of Lucknow pp. 1 - 5

Zhu, R. L., Wang, D., Xu, L.,Shi, R. P, Wang, J. and Zheng., M. (2006). Antibacrerial 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 biolosisch akiver Naturstoffe. Angewandte Chemie 103: 134 - 151.

Zechmeister HG, Tribsch A, Moser D, Peterseil J. 2003. Biodiversity 'hot-spots' for bryophytes in landscapes dominated by agriculture in Austria. Agriculture, Ecosystem and Environment 94: 159–167

Zechmeister, H.G., Tribsch, A., Moser, D. and Peterseil, J. (2003). Biodiversuty Hotspots for bryophys in landscapes dominated by agriculture in Australia. *Agriculture, Ecosystem and Environment*. 94: 159 – 165.

BIODATA OF THE CANDIDATE

1. Name : TLANGTHANPUII TLANGTE
2. Present Address : Ramhlun venglai, Aizawl Mizoram
3. E – mail : thanpuiihmar0716@gmail.com
4. EDUCATIONAL QUALIFICATION :-

   Graduate program in Botany;

   Master degree in the subject of Environmental Science, from Mizoram University; Persueing Ph.D program in the Department of Environmental Science, Mizoram University.

   Thesis title: Study of Bryophytes and their Economic importance in Aizawl District, Mizoram
5. List of presentation in conference/symposium/seminar:

   "Diversity assessment of Bryophytes in Hmuifang reserved forest Aizawl District, Mizoram" in Internatinal Conference on Biodiversity, environment and Human Health: Innovations and Emerging Trends (BEHIET 2018). Held on 12^{th} – 14^{th} November 2018, organized at the School of Life Sciences, Mizoram University, Aizawl, Mizoram.

   " Biodiversity Assessment of Bryophytes in Sialsuk Reserved Forest, Aizawl District, Mizoram" in Regional Seminar on Climate Change: Impact, Adaptation & Response in the Eastern Himalayas. Held on 1^{st} and 2^{nd} November, 2018 at Mizoram University.

6. List of Seminar/Symposium/Conference/workshops attended:

"One day workshop on Environmental impact Assessment" organized by State Environmental Impact Assessment Authority and State Environmental Expert Appraisal Committee, Mizoram: Aizawl, held on 11th November 2016.

"National Symposium on Ethnobotanical Importance in North east India" organized by the Department of Environmental Science, Mizoram University, Aizawl in collaboration with Society for Ethnobotanists NBRI, Lucknow and National Medicinal Plants Board, New delhi. Held on 13th – 15th October 2015, at Mizoram University.

"National Seminar on Issues of Wildlife Conservation in India with special reference to Mizoram" held on 24th – 25th April 2014 at Mizoram University, Aizawl, Mizoram.

7. Paper published in peer reviewed journal:

Tlangte, T ., Lalramnghinglova H., Lalnuntluanga., Zohmangaiha., Lalhmangaihzuali S. (2019). Assessment of Bryophytes diversity in Hmuifang Reserved Forest, Aizawl District, Mizoram. *Journal of Emerging Technologies and Innovative Research (JETIR) Vol6, Issue 6.*

8. Tlangte, T ., Lalramnghinglova H., Lalnuntluanga., Zohmangaiha., M.C. Josiah., Lalhmangaihzuali S. (2019). Assessment of Bryophytes diversity in Tawi Wildlife Sanctuary, Aizawl District, Mizoram.*RESEARCH REVIEW International journal of Multidiciplinary. Volume-04. Issue – 07, July 2019.*

PARTICULARS OF THE CANDIDATE

NAME OF CANDIDATE : TLANGTHANPUII TLANGTE

DEGREE : Ph.D

DEPARTMENT : ENVIRONMENTAL SCIENCE

TITLE OF THESIS : "STUDY OF BYOPHYTES AND THEIR ECONOMIC IMPORTANCE IN AIZAWL DISTRICT, MIZORAM"

DATE OF ADMISSION : 28 – 07 – 2014

APPROVAL OF RESEARCH PROPOSAL:

1. BOS : 14 – 05 – 2015
2. SCHOOL BOARD : 19 – 05 – 2015
3. REGISTRATION NO. & DATE : MZU/Ph.D/748/19.05.2015

Head

Department of Environmental Science

ASSESMENT OF BRYOPHYTES DIVERSITY IN HMUIFANG RESERVED FOREST, AIZAWL DISTRICT MIZORAM

[1]Tlangthanpuii Tlangte, [2]H Lalramnghinglova, [3]Lalnuntluanga, [4]Zohmangaiha, [5]Sabrina Lalhmangaihzuali
[1]Research Scholar, [2]Professor, [3]Professor, [4]Research Scholar, [4]Research Scolar, [5]Research Scholar
Department of Environmental Science,
Mizoram University Tanhril-796004, Aizawl, Mizoram, India.

Abstract: The present studies deals with the diversity assessment of diversity of Bryophytes in Hmuifang Reserved forest Aizawl District Mizoram. The study area is situated in the southern part of Mizoram with an average elevation of 1619amsl, about 50 km away from the State capital Aizawl. The collected specimens were dried at room temperature and stored in paper packets, date of collection, locality, type of bryophyte and habitat were recorded in the field notebook. Accordingly, this attempt was made to document detailed account of bryophytes of the study area.The present studies deals with the occurrence of 32 taxa of bryophytes distributed under 23 genera and 19 families have been recorded in Hmuifang Reserved Forest, Aizawl District Mizoram. *Frullania, Pogonatum* and *Bryum* are the most dominant Genus and *Polytrichaceae Bryaceae* and *Jubulaceae* are dominant families. This finding will lead to a better knowledge of Bryophytes and their distribution in Hmuifang Reserved Forest as well as in Mizoram.

Keywords: Bryophytes, Distribution, Hmuifang, Mizoram.

INTRODUCTION:

Bryophytes are one of the richest group of plants in India and occupy a wide range of substrata. A total of 2489 taxa of bryophytes reported from India, comprising 1786 species under 355 genera of mosses, 675 species under 121 genera of liverworts and 25 species under 6 genera of hornworts (Dandotya, 2011). A total of 31 species of bryophytes including 20 liverworts, 2 hornworts and 9 mosses under 17 family and 22 genera are reported for the first time from the Bothamalai hills in the Eastern Ghats of India. All the species reported here are new distributional records of occurrence for the State. The distribution of species at different altitudes and different microclimates were encountered in the hills. Currently the critical habitat of the bryophytes is under threat against the ongoing anthropogenic activities like open cast mining in this region. 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). Jayanta Barukial (2011) has done the enumeration of 127 species of Mosses under 71 genera belonging to 27 families from the Assam Valley Wet Evergreen forests, Assam, India. Manju *et al.*, (2008) have published the checklist of the bryophytes of Kerala, India. In this checklist atotal of 465 bryophyte taxa are accepted, comprising 148 taxa of liverworts, 10 taxa of hornworts and 307 taxa of mosses.Western Ghats (includes Nilgiris, Anamalais, Palnis and Agasthyamalai) and the Eastern Ghats (includes Shervaroys) bryogeographical regions studied by Daniels in 2010.

North Eastern Regions including Mizoram as a biodiversity hotspot harbour the richest Bryophytic wealth among bryogeographical regions of the country. The combination of different factors like climatic, edaphic, temperature, precipitation, humidity, altitude, forest types favors the growth of rich and luxuriant vegetation of bryophytes. It is also considered as centre of speciation. In spite of above facts, there is no floristic account of Bryophytes as well as utilization of plant resources of this region is available. The state of Mizoram is located in the extreme corner of Northeast India in between 21º58' N and 24º36' N latitudes and 92º29' E longitudes and bounded by Assam in the North, Manipur in the Northeast, Myanmar in the East and Bangladesh and Tripura in the West.

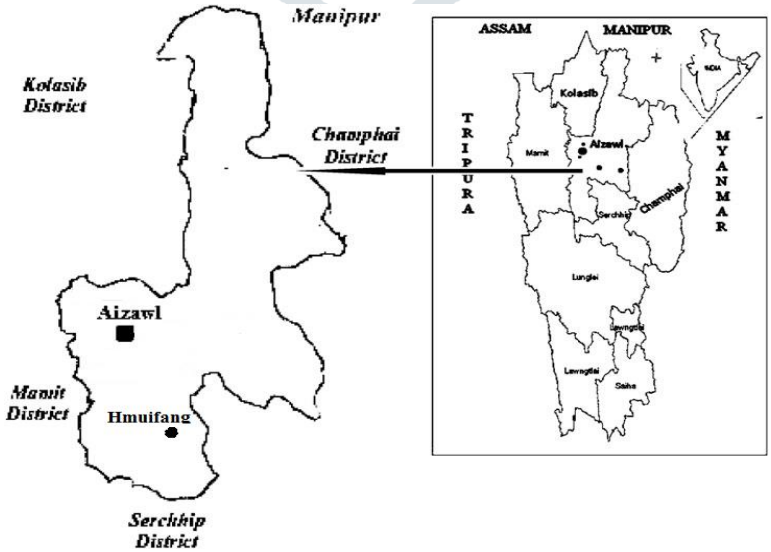

Fig.2. Map of Aizawl district: Showing study site

MATERIALS AND METHOD:

The studies were carryout in Hmuifang Reserved Forest, the plant specimens were collected from different habitats during March, 2016 to November, 2016. Simple methodology was follow to collect the plant specimens. The plant parts were scratched out from their substratum with the help of knife or other sharp material sometimes simply plucked with bare hand. Photograph of each collected sample were taken in the field as authentic evidence. The collected specimens were air dried as soon as possible to avoid damage. The ecological parameters such as, altitude, temperature, humidity, rainfall, was recorded in the field note book. The collected specimens were identified in the Research Laboratory Department of Environmental Science, Mizoram University and were kept in the herbarium packets which are deposited in the cabinet at the Herbarium. The identification of taxa has been done in the laboratory by studying the plant specimens, various relevant literature and publications were also consulted (Bansal and Nath, 2012a, 2012b; Schuster, 1979; Schuster, 1984a; Schuster1984b; Singh and Singh 2003).

RESULT AND DISCUSSION:

During the study period a total of 32 taxa of bryophytes distributed under 23 genera and 19 families have been recorded in Hmuifang Reserved Forest, Aizawl District Mizoram.The study revealed that *Frullania, Pogonatum* and *Bryum* are the most dominant Genus and *Polytrichaceae*, *Bryaceae* and *Jubulaceae* are dominant families. Although bryophytes are oldest among land plants their value is quite unknown to people due to lack of study especially in Mizoram. It has been observed that the selected study site harbors quite diverse and rich bryophytes. This finding will lead to a better knowledge of Bryophytes and their distribution in Hmuifang Reserved Forest as well as in Mizoram.

Table: Lists of Bryophytes species with family, habitat and altitude:

Sl. No.	Name of Species	Family	Habitat	Altitude
1	*Asterella khasiana* (Griff.)Grolle	Aytoniaceae	Tree bark	1619m
2	*Asterella musuriensis*(Kashyap.)	Ayotoniaceae	Tree bark	1610m
3	*Bazzania hainanensis L.-P. Zhou et L. Zhang*	Lepidoziaceae	Tree bark	1542m
4	*Dumortiera hirsuta* (Sw.) Nees	Marchantiaceae	Rock	1600m
5	*Fossombronia cristula* Aust.	Fossombroniaceae	Soil	1700m
6	*Frullania ericoides (*Nees) Mont	Jubulaceae	Soil	1174m
7	*Frullania retusa* Mitt.	Jubulaceae	Rock	1023m
8	*Frullania tamarisci*(L.) Dumort.	Jubulaceae	Soil	1090m
9	*Frullania wallichiana* Mitt.	Jubulaceae	Soil	1150m
10	*Lejunea obfusca* Mitt.	Lejeuneaceae	Soil	1619m
11	*Leucobryum candidum* (Brid. ex P. Breuv.)	Leucobryaceae	Rock	1615m
12	*Marchantia paleacea* Bertol.	Marchantiaceae	Soil	1611m
13	*Marchantia polymorpha Subsp.*	Marchantiaceae	Soil	1620m
14	*Mastigolejeunea humilis*(Gottsche) Schiffn.	Lejeuneaceae	Tree bark	1599m
15	*Meteoriopsis squarrosa* (Hook. Ex Harv.)	Leucobryaceae	Tree bark	1678m
16	*Metzgeria furcata* (L.) Dumort.	Metzgeriaceae	Rock	1590m
17	*Papillaria fuscescens* (Hook.) A. Jaeger	Meteroriaceae	Rock	1595m
18	*Riccia fruitans* L.	Ricciaceae	Tree bark	1614m
19	*Riccia glauca* L.	Ricciaceae	Tree bark	1609m
20	*Solenostoma gracilimum* (Sm.) R.M. Schust.	Solenostomaceae	Tree bark	1200m
21	*Trocholejeunea infustaca (Mitt.) Verd*	Lejeuneaceae	Soil	1600m
22	*Trocholejunea sandvicensis* Mizut.	Lejeuneaceae	Soil	1619m
23	*Atrichum undulatum (Hedw.) P.Beauv*	Polytrichaceae	Soil	1615m
24	*Bryum alpinum* Huds. ex With	Bryaceae	Rock	1605m
25	*Bryum auratum* Mitt	Bryaceae	Rock, soil	1611m
26	*Bryum coronatum* Schwagr.	Bryaceae	Tree bark	1594m
27	*Campylopus pilifer* Brid	Dicranaceae	Tree bark	1501m
28	*Funaria hydrometrica* Hedw.	Funariaceae	Soil	1585m
29	*Pogonatum aloides* (Hedw.) P. Beauv.	Polytrichaceae	Rock, Tree bark	1174m
30	*Pogonatum neesii* (Mull.Hall) Dozy	Polytrichaceae	Soil	1390m
31	*Pogonatum urnigerum* (Hedw.) P. Beauv.	Polytrichaceae	Soil	1592m
32	*Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk	Thuidiaceae	Soil	1612m

CONCLUSION:

During the study period it has been observed that a large number of bryophytes are threatened with ever increasing encroachment upon natural vegetation, huge area are being denuded annually with no control. The continue decrease in forest cover is not contributing to achieving healthy environment for the development and resulting climate change accompanying destruction of vegetation and loss of valuable bryophytic flora. So this study is expected to have an outcome on the distribution, and status of Bryophyte flora of Mizoram. These will ensure the protection and conservation of rare and potentially economic important Bryophyte.

REFERENCES:

[1] Bansal P,. and Nath V.(2012a). A new record of Coronatum Schwaegr. (Bryophytes) in Meghalaya, India. *Taiwania*, 57;294-299.

[2] Bansal P and Nath V.(2012b). Bryum basonii Ren. & Card. new to Eastern Himalaya in new National and regional Bryophytes records 32.J.Bryol.34;231-246.

[3] Barukial, J. (2011). A study of moss diversity in Assam Valley Wet Evergreen Forests. *Indian Journal of Fundamental and Applied Life Sciences* , ISSN: 2231- 6345.

[4] Dandotiya D., Govandapayari H., Suman S., Uniyal PL (2011). Checklist of bryophytes of India. Archive for Bryology, 88.

[5] Daniels, A.E.D. (2010). Checklist of the bryophytes of Tamil Nadu, India. *Archive for bryology*, pp:65.

[6] Dash, P. K.., Sahu, D. K. and Saxena, D. K. (2009). Bryoflora of Baphlamali Hill in Eastern Ghatts of Orissa, India. *Newsletter*, 15(1):3-8.

[7] Manju,C.N., Rajesh, K. P and Madhusoodanan, P.V. (2008) . Checklist of the bryophytes of Kerala,India.*Tropical Bryology Research Reports*, 7:1-24.

[8] Schuster R.M. (1979). The Phylogeny of the Hepaticae in: Bryophyte Systematics, Systematic Association Special 14 Edited by Claker IGC and Duchett JG, Figure 1-2, 41-82.

[9] Schuster R.M. (1984). Evolution, phylogeny and classification of the Hepaticae. *New Manual of Bryology Michinan,* Japan, 892-1070

[10] Singh S.K. and Singh D.K. (2003). Contribution to Bryoflora of Great Himalayan National Park, Kullu, Himachal Pradesh, India-II, Hepaticae. *Phytotaxonomy*, 3:35-52

RESEARCH REVIEW JOURNALS
Volume-04
Issue-07
July-2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com[Peer Reviewed Journal]

Assessment of Bryophytes Diversity in Tawi Wildlife Sanctuary, Aizawl District Mizoram

*[1]Tlangthanpuii Tlangte, [2]H Lalramnghinglova, [3]Lalnuntluanga, [4]Zohmangaiha, [5]Sabrina Lahmangaihzuali, [6]Josiah M.C Vabeikhokhei

[1]Research Scholar, Department of Environmental Science, School of Earth Sciences and Natural Resource Management (India)
[2]Professor, Department of Environmental Science, School of Earth Sciences and Natural Resource Management (India)
[3]Professor, Department of Environmental Science, School of Earth Sciences and Natural Resource Management (India)
[4]Research Scholar, Department of Environmental Science, School of Earth Sciences and Natural Resource Management (India)
[5]Research Scholar, Department of Environmental Science, School of Earth Sciences and Natural Resource Management (India)
[6]Research Scholar, Department of Environmental Science, School of Earth Sciences and Natural Resource Management (India)

ARTICLE DETAILS

Article History
Published Online: 15 July 2019

Keywords
Bryophytes, Distribution, Mizoram.

***Corresponding Author**
Email: thanpuiihmar0716[at]gmail.com

ABSTRACT

The present studies deals with the diversity assessment of diversity of Bryophytes in Tawi Wildlife Sanctuary Aizawl District Mizoram. In the present investigation a total of 32 taxa of bryophytes distributed under 23 genera and 19 families have been recorded in Tawi Wildlife Sanctuary, Aizawl District Mizoram. Frullania, Pogonatum and Bryum are the most dominant Genus and Polytrichaceae, Bryaceae and Jubulaceae are dominant families. The study area is located in the southeastern part of Aizawl District, Mizoram at 23º32′ 02′ ′ and 92º56′ 48′ ′, with an altitudinal ranges, from 500m – 1890m above the sea level. Accordingly, an attempt was made to document detailed account of bryophytes of the study area. This finding will lead to a better knowledge of Bryophytes and their distribution in Tawi Wildlife Sanctuary as well as in Mizoram.

1. Introduction

Bryophytes are one of the richest group of plants in India and occupy a wide range of substrata. A total of 2489 taxa of bryophytes reported from India, comprising 1786 species under 355 genera of mosses, 675 species under 121 genera of liverworts and 25 species under 6 genera of hornworts (Dandotya, 2011). A total of 31 species of bryophytes including 20 liverworts, 2 hornworts and 9 mosses under 17 family and 22 genera are reported for the first time from the Bothamalai hills in the Eastern Ghats of India. All the species reported here are new distributional records of occurrence for the State. The distribution of species at different altitudes and different microclimates were encountered in the hills. Currently the critical habitat of the bryophytes is under threat against the ongoing anthropogenic activities like open cast mining in this region. 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). Jayanta Barukial (2011) has done the enumeration of 127 species of Mosses under 71 genera belonging to 27 families from the Assam Valley Wet Evergreen forests, Assam, India. Manju *et al.,* (2008) have published the checklist of the bryophytes of Kerala, India. In this checklist atotal of 465 bryophyte taxa are accepted, comprising 148 taxa of liverworts, 10 taxa of hornworts and 307 taxa of mosses.Western Ghats (includes Nilgiris, Anamalais, Palnis and Agasthyamalai) and the Eastern Ghats (includes Shervaroys) bryogeographical regions studied by Daniels in 2010.

North Eastern Regions including Mizoram as a biodiversity hotspot harbour the richest Bryophytic wealth among bryogeographical regions of the country. The combination of different factors like climatic, edaphic, temperature, precipitation, humidity, altitude, forest types favors the growth of rich and luxuriant vegetation of bryophytes. It is also considered as centre of speciation. In spite of above facts, there is no floristic account of Bryophytes as well as utilization of plant resources of this region is available. The state of Mizoram is located in the extreme corner of Northeast India in between $21^0$58' N and $24^0$36' N latitudes and $92^0$29' E longitudes and bounded by Assam in the North, Manipur in the Northeast, Myanmar in the East and Bangladesh and Tripura in the West.

2. Materials and Methods

The studies were carry out in Tawi Wildlife Sanctuary, the plant specimens were collected from different habitats during March, 2016 to November, 2016. Simple methodology was follow to collect the plant specimens. The plant parts were scratched out from their substratum with the help of knife or other sharp material sometimes simply plucked with bare hand. Photograph of each collected sample were taken in the field as authentic evidence. The collected specimens were air dried as soon as possible to avoid damage. The ecological parameters such as, altitude, temperature, humidity, rainfall, was recorded in the field note book. The collected specimens were identified in the Research Laboratory Department of Environmental Science, Mizoram University and were kept in the herbarium packets which are deposited in the cabinet at the Herbarium. The identification of taxa has been done in the laboratory by studying the plant specimens, various relevant literature and publications were also consulted (Bansal and Nath, 2012a, 2012b; Schuster, 1979; Schuster, 1984a; Schuster1984b; Singh and Singh 2003).

3. Results

During the study period a total of 32 taxa of bryophytes distributed under 23 genera and 19 families have been recorded in Tawi Wildlife Sanctuary, Aizawl District Mizoram. The study revealed that *Frullania, Pogonatum* and *Bryum* are the most dominant Genus and *Polytrichaceae*, *Bryaceae* and *Jubulaceae* are dominant families. Although bryophytes are oldest among land plants their value is quite unknown to people due to lack of study especially in Mizoram. It has been observed that the selected study site harbors quite diverse and rich bryophytes. This finding will lead to a better knowledge of Bryophytes and their distribution in Tawi Wildlife Sanctuary as well as in Mizoram.

Sl.no	Name of Species	Family	Habitat	Altitude
1	*Asterella khasiana* (Griff.)Grolle	Aytoniaceae	Tree bark	1619m
2	*Asterella musuriensis*(Kashyap.)	Ayotoniaceae	Tree bark	1610m
3	*Bazzania hainanensis L.-P. Zhou et L. Zhang*	Lepidoziaceae	Tree bark	1542m
4	*Dumortiera hirsuta* (Sw.) Nees	Marchantiaceae	Rock	1600m
5	*Fossombronia cristula* Aust.	Fossombroniaceae	Soil	1700m
6	*Frullania ericoides (*Nees) Mont	Jubulaceae	Soil	1174m
7	*Frullania retusa* Mitt.	Jubulaceae	Rock	1023m
8	*Frullania tamarisci*(L.) Dumort.	Jubulaceae	Soil	1090m
9	*Frullania wallichiana* Mitt.	Jubulaceae	Soil	1150m
10	*Lejunea obfusca* Mitt.	Lejeuneaceae	Soil	1619m
11	*Leucobryum candidum* (Brid. ex P. Breuv.)	Leucobryaceae	Rock	1615m
12	*Marchantia paleacea* Bertol.	Marchantiaceae	Soil	1611m
13	*Marchantia polymorpha Subsp.*	Marchantiaceae	Soil	1620m
14	*Mastigolejeunea humilis*(Gottsche) Schiffn.	Lejeuneaceae	Tree bark	1599m
15	*Meteoriopsis squarrosa* (Hook. Ex Harv.)	Leucobryaceae	Tree bark	1678m
16	*Metzgeria furcata* (L.) Dumort.	Metzgeriaceae	Rock	1590m
17	*Papillaria fuscescens* (Hook.) A. Jaeger	Meteroriaceae	Rock	1595m
18	*Riccia fruitans* L.	Ricciaceae	Tree bark	1614m
19	*Riccia glauca* L.	Ricciaceae	Tree bark	1609m
20	*Solenostoma gracilimum* (Sm.) R.M. Schust.	Solenostomaceae	Tree bark	1200m
21	*Trocholejeunea infustaca (Mitt.) Verd*	Lejeuneaceae	Soil	1600m
22	*Trocholejunea sandvicensis* Mizut.	Lejeuneaceae	Soil	1619m
23	*Atrichum undulatum (Hedw.) P.Beauv*	Polytrichaceae	Soil	1615m
24	*Bryum alpinum* Huds. ex With	Bryaceae	Rock	1605m
25	*Bryum auratum* Mitt	Bryaceae	Rock, soil	1611m
26	*Bryum coronatum* Schwagr.	Bryaceae	Tree bark	1594m
27	*Campylopus pilifer* Brid	Dicranaceae	Tree bark	1501m
28	*Funaria hydrometrica* Hedw.	Funariaceae	Soil	1585m
29	*Pogonatum aloides* (Hedw.) P. Beauv.	Polytrichaceae	Rock, Tree bark	1174m
30	*Pogonatum neesii* (Mull.Hall) Dozy	Polytrichaceae	Soil	1390m
31	*Pogonatum urnigerum* (Hedw.) P. Beauv.	Polytrichaceae	Soil	1592m
32	*Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk	Thuidiaceae	Soil	1612m

Lists of Bryophytes species with family, habitat and altitude:

4. Conclusion

During the study period it has been observed that a large number of bryophytes are threatened with ever increasing encroachment upon natural vegetation, huge area are being denuded annually with no control, even in and around the Sanctuary. The continue decrease in forest cover is not contributing to achieving healthy environment for the development and resulting climate change accompanying destruction of vegetation and loss of valuable bryophytic flora. It has also been observed that the reason for lack of study in the field of Bryophytes in Mizoram is lack of exert in the field, and only a small number of educational and research Institution with good laboratory facilities in India. So this study is expected to have an outcome on the distribution, and status of Bryophyte flora of Mizoram. These will ensure the protection and conservation of rare and potentially economic important Bryophyte.

References

1. Bansal P,. and Nath V.(2012a). A new record of Coronatum Schwaegr. (Bryophytes) in Meghalaya, India. *Taiwania*, 57;294-299.
2. Bansal P and Nath V.(2012b). Bryum basonii Ren. & Card. new to Eastern Himalaya in new National and regional Bryophytes records 32.J.Bryol.34;231-246.
3. Barukial, J. (2011). A study of moss diversity in Assam Valley Wet Evergreen Forests. *Indian Journal of Fundamental and Applied Life Sciences* , ISSN: 2231- 6345.
4. Dandotiya D., Govandapayari H., Suman S., Uniyal PL (2011). Checklist of bryophytes of India. Archive for Bryology, 88.
5. Daniels, A.E.D. (2010). Checklist of the bryophytes of Tamil Nadu, India. *Archive for bryology*, pp:65.
6. Dash, P. K.., Sahu, D. K. and Saxena, D. K. (2009). Bryoflora of Baphlamali Hill in Eastern Ghatts of Orissa, India. *Newsletter*, 15(1):3-8.
7. Manju,C.N., Rajesh, K. P and Madhusoodanan, P.V. (2008). Checklist of the bryophytes of Kerala, India. *Tropical Bryology Research Reports*, 7:1-24.
8. Schuster R.M. (1979). The Phylogeny of the Hepaticae in: Bryophyte Systematics, Systematic Association Special 14 Edited by Claker IGC and Duchett JG, Figure 1-2, 41-82.
9. Schuster R.M. (1984). Evolution, phylogeny and classification of the Hepaticae. *New Manual of Bryology Michinan,* Japan, 892-1070
10. Singh S.K. and Singh D.K. (2003). Contribution to Bryoflora of Great Himalayan National Park, Kullu, Himachal Pradesh, India-II, Hepaticae. *Phytotaxonomy,* 3:35-52

ABSTRACT

STUDY ON BRYOPHYTES AND THEIR ECONOMIC IMPORTANCE IN AIZAWL DISTRICT, MIZORAM

TLANGTHANPUII TLANGTE

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Submitted in partial fulfillment of the requirement of the Degree of

Doctor of Philosophy in Environmental Science

Mizoram University, Aizawl.

STUDY OF BRYOPHYTES AND THEIR ECONOMIC IMPORTANCE IN AIZAWL DIDTRICT, MIZORAM

Abstract:

Bryophyta, a division of plant kingdom, includes mosses and allied plants; commonly describe as liverworts. Mosses are very small plants, at times microscopic, differentiated into stem and leaves. Liverworts are macroscopic plants which are thalloid as well as leafy. Bryophytes are essentially small plants from a few millimeters to a few centimeters. Exceptionally, some of the mosses attain giant proportion (70 – 100 cm) and there are some giant thallose liverworts. They are widely distributed and generally confine at an altitudinal ranges between 1000 – 8000 m. A total of 2489 taxa of bryophytes reported from India, comprising 1786 species under 355 genera of mosses, 675 species under 121 genera of liverworts and 25 species under 6 genera of hornworts (Dandotya, 2011). Bryophytes are threatened partly because of their morphology and reproduction rates. They are fragile organisms, sensitive to drought, and have a relatively low growth rate and therefore desiccate quickly during periods of dry weather. They are highly vulnerable to disturbance and also extremely sensitive to pollution as they lack a cuticle. Bryophytes are also threatened because of their lack of "image" within the sphere of nature conservation. They are not large, charismatic species, and this, coupled with a lack of understanding of how they contribute towards ecosystem functioning, often results in their being overlooked by the general public and conservation groups.

The present study was carried out from 2015 to 2018, in the selected study Area Aizawl District, Mizoram which is located at Latitude 23.7, Longitude 92.7,

owing to its representation on tropical, sub-tropical and temperate climatic conditions, these different combinations of forest types, different adaphic factor and climatic factor, different temperature and altitude is expected to have the greatest diversity and abundant vegetation of bryophytes. It is one of the eight districts of Mizoram in India. The District is bounded on the North by Kolasib district, on the west by Mamit district, on the south by Serchhip district and on the east by Champhai district. The total forest cover is 86.5 % of the total geographical Area including very dense forest (18 Sq.Km) moderately dense forest (1092 Sq.Km) and Open Forest (1984 Sq.Km). The average annual rainfall ranges from 2179 mm – 2712 mm during the year of 2015 - 2017, the state of Mizoram receives an adequate amount of rainfall since the area falls under the influence of the south – west monsoon, the highest rainfall occurs during the month of June to September. The specimens were collected mostly during the Month of June – September, since they are most abundant during the rainy season. During winter and summer the specimens were all dried up in most of the study area, so the best collecting season is the rainy season.

During the study period from 2015 to 2018 a total of 40 specimens were identified which are collected from the different study sites, of which 21 species of 12 genera and 10 families are under liverworts and 20 species of 14 genera and 10 families are under mosses. The present reports on the study of bryophytes in Aizawl Dist. Mizoram shows the occurrence of 40 taxa belonging to 10 orders i.e Marchantiales, Jungermaniales, Metzgeriales, Porellales, Polytrichales, Bryales, Dicranales, Funariales, Hypnales and Orthotrichales. The study revealed that, *Frullania* and *Bryum* are the most dominant genus and Jubulaceae and Bryaceae are

the most dominant family. In the group of Liverworts, the order Marchantiales (4genera and 6species) and Jungermaniales (3 genera and 8 species) are the largest family, followed by order Metzgeriales (2genera and 2 species) and Porellales (1genera and 2 species). In the group of mosses the order Dicranales (4 genera and 5species) followed by Bryales (2 genera and 6 species), Hypnales (3genera and 3 species), Polytrichales (2 genera and 3 species), Funariales (1genera and 1species), Orthotrichales (1 genera and 1 species). It has been observed that the selected study area inside Aizawl district harbours quite diverse and rich bryophytes associated with suitable environmental conditions and different physiographic condition enable and support the natural habitat for rich diversity of bryophytes. This finding will lead to a better knowledge of Bryophytes and their distribution in Mizoram. And at the same time will help in encouraging more research work in the field.

Bryophytes are used in medicines, decoration, horticulture, agriculture, fuel in industries and as ecological indicators. Although bryophytes are the oldest among land plants, their values are quite unknown to people due to lack of study and lack of information, they are widely used as bioindicators of environment for their unique capacity to absorb the pollutants and very definite responses as some species are particularly sensitive to pollutants and exhibit visible injury symptoms even in the presence of very minute quantities of pollutants. Bryophytes are predominantly accepted soil additives because of their remarkably high water holding capacity and high water retention capacity they are widely used by home gardeners for moisture retention in their garden. They are also used as a green house plants, potted ornamental plants and seedlings, and also in the garden for soil moisture retention.

During the study period it has been observed that, a large number of bryophytes are exposed to an ever increasing encroachment on the natural vegetation. Vast areas are being denuded yearly due to increased in urbanization and pressures imposed by population growth, anthropogenic activities, land use and different kinds of developmental activities. Bryophytes especially mosses have high water retention capacity, which provide microhabitat for other plants and organisms, their role in the ecosystem is reasonably important. Deforestation has an impact on achieving healthy environment and resulting climate change associated with destruction of vegetation and loss of precious bryophytic flora. It consequently, appears that a wide-ranging decline has occurred, the main cause of which definitely is the growing level of deforestation all over the State. So, there is an imperative need to carry out an efficient floristic study on the bryophytes of Mizoram. It has been observed that, the information collected on the economic importance of bryophytes from the primary sources are minimal due to negligence of the study on this group of plants. The reason for lack of study and negligence in the field of bryophytes research in Mizoram is lack of expert in the field, less number of educational and research Institutions with good laboratory facilities and lack of awareness towards this group of plants, which resulted in less interest on the research for this group of plants. The present study is the first attempt to investigate the economic uses of bryophytes in Mizoram. The plant specimens were collected from the study area during the month of July to September of the study period where rainfall is highest during these months and at the same time the best collecting season of the year. During the post rainy season most of the plant species were dried up.

Rainy season and post – rainy season have the highest and abundant distribution of bryophytes.

Bryophytes play an important role in nutrient cycling, soil formation; provide microhabitat for other plants and animals. In other countries they are broadly used for different purposes like pollution monitoring, the moss Sphagnum due to its high level of water holding capacity is a good material for delivery of plants, fresh vegetables and flowers, and widely used by home gardener. In France the industry of moss, manufacture moss carpets in different sizes. Developed countries like Finland, Sweden, Ireland, Germany, Poland and Russia where liverworts and mosses have been extensively tried and used as a fuel.

Hmuifang Reserved forest where some part of the area are still covered with virgin forests and received adequate amount of rainfall with the highest diversity of the plant species. The temperature ranges between 20°C - 29°C during summer and winter temperature ranges from 7°C - 21°C and having the highest altitude (1619 m) among selected study sites, followed by Tawi Wildlife Sanctuary which is located in the South eastern part of Aizawl, Mizoram with an altitudinal range between 500m – 1178 m. Aizawl to Sairang roadside recorded the least number of species, where temperature ranges from 11°C - 32°C with an altitude of 200 – 600 m, and the soil frequently shows high degree of pollution attributed to road traffic movement, unscientific dumping of garbage, road construction and other developmental activities which do not support luxuriant growth of the plant species. All the plant specimens were found to be present in the altitude between 290 m to 1619 m. The result shows that the distributions of the plant species more abundant in the higher altitude within the study areas. Common bryophytes species used by the local people

include *Bryum, Mnium, Philonotis spp., Poltrichum spp.,* for healing burns, bruises and wounds. *Marchantia polymorpha* are used to cure fresh wounds and cuts, poisonous snake bite and insects bites. The species *Frullania tamarici* are used for antiseptic activity, *Frullania ericoides* are used for nourishment of hair, and some dried mosses are also used as a fire starter.

In Mizoram, only little information on their economic importance is known and their value is still unknown due to lack of information and knowledge on the plants. The protection of bryophyte is essential in view of their critical role in ecosystem. So the present study is expected to have an outcome on the distribution, and status of Bryophytes flora of Mizoram. These will ensure the protection and conservation of rare and potentially economic important Bryophytes.