CHAPTER 1

INTRODUCTION

1.1 Brief account on lichen

North-East India have interesting climatic, geographic conditions and supports a wide variety of flora that includes both higher plants as well as lower cryptograms of which lichens are unique group of the later (Awasthi 1961). Lichen constitute about 8% of earth's surface (Ahmadjian 1995). Lichenogeographically, India is divided into eight regions viz. Western Himalaya, Eastern Himalaya, Western dry region, Gangatic plain, Central India, Western Ghats, Eastern Ghats and Deccan plateau and Andaman and Nicobar Islands. Among these, the Western Ghats, the Eastern Himalayas and North-East India are regarded as biodiversity hotspot both for higher plants as well as lower cryptogams including lichen. The diversity and luxuriant growth of lichen vegetation depends on the geography, climate, and varying topography of the region (Nayaka and Asthana 2014). Light intensity, altitude, environmental health of a region, sufficient moisture often favour the growth of lichen besides the pH, nutrient status, water holding capacity, buffer capacity of the host plant also determine the growth of the lichen (Gupta *et al.* 2013). The Eastern Himalayan vegetation of lichen may be grouped into four major types and conserved under (i) Tropical lichen vegetation (ii) Sub-tropical lichen vegetation (iii) Temperate lichen vegetation and (iv) Sub–alpine and Alpine lichen vegetation (Sinha and Singh 2005).

Worldwide record of lichen biota is about 25,000 species under 300 genera (Soundararajan *et al.* 2019). Number of lichen species in India is represented by 3028 species under 469 genera and 88 families (ILS e Letter 2021). However it is increasing perpetually as there are innumerable reports on the exploration of lichen diversity from various parts of the country. Therefore, an updated checklist of lichen with its distribution is imperative. The highest lichen diversity and number of endemic species are reported from the Eastern Himalayan region and Western Ghats in India (Singh and Sinha 1997).

The term 'lichen' with its Greek origin means the apparent growth on the bark of olive trees. Theophrastus, the father of Botany, introduced the term 'lichen' and this group of Cryptograms to the world (Nayaka 2005). Simply lichen is a symbiotic association of two organisms, an alga and a fungus. Lichen symbiosis is re-defined as "a self-sustaining ecosystem formed by the interaction of an exhibitant fungus and an extracellular arrangement of one or more

photosynthetic partners and an indeterminate number of other microscopic organisms", (Hawksworth and Grube 2020).

The algal partner by absorbing carbon-di-oxide and moisture from the atmosphere through mycobiont tissue produces food. On the other hand, the mycobiont partner being heterotrophic, absorbs food from the photobiont partner (Awasthi 2000). Almost 90% of the thallus is predominated by mycobiont and provides shape, structure, colour and partially contributed by photobiont. Generally in most of the lichens green alga act as the phtobiont partner. Fungal partner is represented by 95%, 3%, 2% of Ascomycetes, Basidiomycetes and Deuteriomycetes respectively (Nayaka 2005). Near about 80,000 species of fungi are available in nature and approximately 17% of these are lichenized, forming symbiosis with green algae or with cyanobacteria. Cyanobacterium and green alga are the photobiont partner. The outer visible part of the lichen thallus is the fungal hyphae which holds within algal cells. Therefore lichens are placed under kingdom Mycota and the fungi involved in the thallus formation are termed as lichenized fungi (Kumar 2000).

Lichens grow on diverse substrates and may be corticolous (on trunk and bark), ramicolous (on twig), lignicolous (on wood), saxicolous (on rocks and boulders), muscicolous (on moss), terricolous (on soil), foliicolous (epiphyllous) (Nayaka 2005). Morphologically lichen thallus shows variation in growth forms viz. leprose lichen (powdery), crustose lichen (crust like), foliose lichen (flat, dorsiventral, lobed margin), fruticose lichen (bushy, shruby), squamulous lichen (scale like).

Lichens are attached to the substratum by some special structures called rhizines. Some vegetative structures associated with lichen thallus used for gaseous exchange are breathing pores, cyphellae and pseudocyphellae. Lichens may reproduce vegetatively by fragmentation, isidia, soredia; asexually by formation of conidia, oidia; sexual reproduction occurs in some ascolichens and basidiolichens and produces ascospores and basidiospores respectively.

Lichens are both ecologically and economically very important. They contribute to the forest nitrogen fixation as they have cyanobacterial symbiotic partner. Lichens are pioneers of colonization because crustose lichen species such as *Lecanora* sp., *Verrucaria* sp. grow foremost on bare rocks. *Rhizocarpon* sp. is suitable for the lichenometry purpose. *Ramalina* sp., *Usnea* sp. and *Physcia aipolia* are found to be most sensitive to pollutants like SO_2, NO, NO_2, O_3, HF and other gasesous pollutants of an area and results in bleaching of chlorophyll-a of the photobiont

partner which interrupts the photosynthesis and results in the death of lichen thallus. *Cetraria richardsonii, Xanthoparmelina conspersa, Cladonia* sp. accumulate radionuclides are harmful as they may pass over through food chain.

Besides they have folk uses, monitoring air pollution and dating of rocks, used as food, fodder, dyes, perfumes, medicines (Sinha and Singh 2005). *Lecanora esculenta, Parmotrema abessinicum* are consumed by human as food; *Phaeophyscia* sp., *Evernia mesomorpha, Usnea* sp. are consumed by different insects and other animals; *Lobaria pulmonaria, Xanthoria parietina, Peltigera aphthosa, Parmelia saxatilis, Usnea* sp. are some important lichens used as medicine to cure different types of diseases. *Roccella fuciformis, Pertusaria* sp., *Parmotrema* sp., *Parmelia saxatilis, Letharia vulpina, Xanthoria parietina* are used to produce dyes due to presence of secondary metabolites like erythrin, lecanoric acid, gyrophoric acid and evernic acid. *Evernia mesomorpha, E. prunastri, Pseudevernia furfuracea, Lobaria pulmonaria, Ramalina* sp. are used in perfumery industry.

Lethal lichens, *Letharia vulpina, Vulpicidia pinastri* contain vulpinic acid and pinastric acid respectively which cause toxicity to central nervous system (Awasthi 2000).

Lichens are known to produce approximately 1050 secondary metabolites (Stocker- Wörgötter 2008) known as lichen substances. These metabolites are mainly produced by fungal partner and accumulate on the outer surfaces of hyphae. The lichen thallus constitute about 30% of their bioactive compounds (Kosanić and Ranković 2010). Due to vast geographic area and rich lichen diversity in India there is great scope for execution of lichens for their effective phyto-molecules. Lichens are source of unique secondary metabolites however not much work has been done so far for their economic uses in India. The reason behind is their low biomass and slow growth rate in nature. This problem could be solved by in-vitro lichen culture which is initiated recently in India. Suitable laboratory conditions such as added sugars, nutrient medium, pH, light, temperature, stress are required for the production of specific lichen secondary metabolites. Sometimes lichen tissue culture can produce lichen bioactive metabolites but the chemistry is dissimilar from the secondary metabolite of the corresponding natural lichen (Yadav *et al*. 2021).

Lichen substances are derived from three different metabolic pathways:

i. **Acetate– polymalonate pathway:** This includes most of the common lichen metabolites such as secondary aliphatic acids, esters and related derivates, mononuclear phenolic compounds, depsides, tridepsides and benzyl esters, depsidones and diphenyl esters,

depsones, dibenzofurans, usnic acids and derivates, anthraquinones and biogenetically related xanthones, chromones, naphthoquinones.

ii. **Mevalonic acid pathway:** Includes secondary metabolites like di-, ester, triterpenes, steroids.

iii. **Shikimic acid pathway:** Includes lichen substances terphenyl quinones, pulvinic acid derivate.

These lichen metabolites have several biological activity such as antiviral, antifungal, antibiotic, antitumor, allergenic, plant growth inhibitory, anti-herbivore, ecological roles, enzyme inhibitory (Karagöz *et al*. 2009).

Most lichen substances are known to have antimicrobial activity. Some of these compounds include usnic acid, phenolic compounds, triterpenes, steroids, anthraquinones, depsides, depsidones and dapsones.

Lichen diversity of Dhubri district have not been properly explored. The economy of the district is mainly dependent on agriculture with paddy as the main source of income followed by Jute and Mustard. Crop yield, growth and development loss is due to the result of phytopathogens attack (Berger *et al*. 2007). With the rise in the emergent of resistant strains of pathogens, there is always a desire to explore or use compounds of biological origin that are more effective and sustainable towards such pathogens.

Therefore, the present study was taken with the following aim and objectives:

1.2 Aim and Objectives

The aim of the present study was to explore and document the lichen diversity of Dhubri district with the following objectives:

1. To enumerate the lichen diversity of Dhubri district, Assam
2. Phytochemical screening of some of the selected macrolichen
3. Screening of antimicrobial activity of some selected macrolichen against some selected phytopathogens infecting economically important crop plants.