CHAPTER - I

INTRODUCTION :

Higher fungi including both ascomycetes and basidiomycetes is an interesting group of fungi. The study of higher fungi has been made since long back on various aspects.

In 1931, Butler and Bisby published an unique work - "Fungi of India" in which complete references to fungi particularly from Indian literature was indicated. Additional supplementary lists were published by Mundkar (1938), Ramakrishnan and Subramanian (1952), Chandra (1964), Tilak and Rao (1968), Mukherjee and Juneja (1974), and others. Thind (1961) worked on the Clavariaceae of India and Bakshi (1971) on Indian Polyporaceae growing on trees and timbers. Description of higher fungi of Bengal by Bose (1920-23), Higher fungi of Punjab Plain by Ahmed (1945), Fungus Flora of Sikkim Himalayas and Calcutta and Suburbs by Banerjee (1946-47), Fungi of Delhi by Chona and Kakria (1958), Taxonomic
studies on South Indian Agaricaceae by Manjula (1980), Polyporaceae of Lokra Hills (Assam-old) by Bose (1937), Fungi of Assam by Bhattacharjee and Barua (1953), Roy (1965-68), Islam (1975), Saikia (1986) etc. are some of the works done at the level of Province.

The study of Fungi at district level is lacking. Islam (1975) studied Higher Fungi of Sibsagar district. But, the study of higher fungi of Dibrugarh District has not been made yet. Hence, an effort has been made in the present investigation to study the higher fungi of Dibrugarh District, which has not hitherto been studied from this area in detail.

The undivided Dibrugarh district (old) is situated in extreme north-eastern corner of Assam with geographical demarcation in between 94°44' and 95° E. longitude and 27°3'45" and 28° N. latitude. It comprises of three sub-divisions namely - (1) Dibrugarh, (2) Tinsukia and (3) Sadiya. The total area of the district is about 7,0239 km². The river Brahmaputra flows through the district making the land alluvial. Abounding in dense forests, rivers, hills, dales and valleys with the mighty Brahmaputra fed by its tributeris Dihang, Dibang, Luhit, Buri-Dihing the district presents an enchanting topographical spectacle.
Table - 1
Climatic data of Dibrugarh District

<table>
<thead>
<tr>
<th>Months</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Rainfall</th>
</tr>
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<tr>
<td></td>
<td>Max°C</td>
<td>Min°C</td>
<td>Max.</td>
</tr>
<tr>
<td>January</td>
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<td>9.0</td>
<td>88</td>
</tr>
<tr>
<td>February</td>
<td>24.0</td>
<td>11.1</td>
<td>88</td>
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<tr>
<td>March</td>
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<td>15.5</td>
<td>84</td>
</tr>
<tr>
<td>April</td>
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<td>17.5</td>
<td>86</td>
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<td>88</td>
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<tr>
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<td>20.5</td>
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</tr>
<tr>
<td>November</td>
<td>26.0</td>
<td>14.0</td>
<td>89</td>
</tr>
<tr>
<td>December</td>
<td>23.0</td>
<td>10.5</td>
<td>91</td>
</tr>
</tbody>
</table>
OMBROTHERMIC DIAGRAM FOR DIBRUGARH DISTRICT

LEGEND

TEMPERATURE : •---• MAX•--• MIN

HUMIDITY : ----- MAX•...• MIN

RAINFALL : 

![Graph showing temperature, humidity, and rainfall over months with bar and line charts indicating data trends.]
The climatic factors of the district are high humidity, frequent rainfall and moderate temperature without extremes of heat or cold.

The district enjoys a tropical monsoon climate. Moreover located at the funnel head of the Brahmaputra valley it is encircled on three sides by hills and mountains and as such the amount of rainfall decreases from north-east and east to the south-east. The total annual rainfall of the district stands at 204.0 cm with a total number of 132 rainydays.

The rainfall is high and prolonged, taking down the effect of the tropical warmth. The maximum average annual temperature is 27.7°C, August being the hottest (32.0°C) month and the minimum average annual temperature is 17.8°C , January being the coldest (9.0°C) month. (Table 1 and Fig.1)

The moderate effect of the climate is strengthened by the presence of extensive forests, tea-gardens and vast-vegetation, covering throughout the district. All these, however, have made the atmosphere sultry. The relative humidity in the district as a whole is high and stands at about 86% during summer season. On the basis of temperature, humidity and rainfall, three seasons in a year can be distinguished in the district.
(1) Cool season - From October to February.
(2) Pre-monsoon - From March to May.
(3) Monsoon - From June to September.

Basing on the extent and distribution of rainfall it appears that November - March are comparatively dry with a characteristic vegetation whereas the period April-October contributes towards a rainy season flora depending on the extent of the wetness of the soil.

**Topography and Soil:**

The soils of the Dibrugarh district are alluvial, deposited by the river Brahmaputra and its tributaries, and can be broadly classified as - old alluvium and new alluvium. The old alluvial soil contains pebble and gravel with loose sand and clays. The new alluvium, on the other hand, consist of sand, silt and clay. In certain parts both the old and new alluvia are so combined that it is difficult to distinguish them.

Moreover, the old alluvial soil is acidic with soluble magnesium and calcium. The pH value is 4'2 - 5'5 with very low quantity of exchangeable calcium which varies from 0'1 - 5 mg per 100 gms. of soil.
The new alluvial soil is comparatively less acidic. Its pH value varies from 5.5 percent to slightly alkaline. The soils are rich in available \( \text{PO}_4 \), \( \text{K} \) and \( \text{Ca} \) (6 to 21 mg. per 100 gms of Soil.), but its \( \text{N}_2 \) content is somewhat medium, being 0.1%. It is to be noted that both two types of soils are suitable for the growth of different types of fungi.

The above topographical and climatic features of Dibrugarh district exert great influence on the growth of varied flora which are the chief hosts of fungi - lower as well as higher.

Flora:

The vegetation of Dibrugarh district is diverse and is very interesting. Forests present a three storeyed appearance. The first canopy includes valuable timber trees such as Shorea assamica, Artocarpus chaplasha, Magnolia sphenocarpa, Dysoxylum procera etc. The middle canopy consists of several medium sized trees, such as Ficus religiosa, Syzigium jamboos, Mesua sp., Mangifera indica, Albizzia procera, Anthocephalus cadamba, Bombax ceiba etc. The lower canopy is made up of several climbers, shrubs, herbs, lianes, epiphytes, orchids etc. Inferior quality canes are also found in low-lying areas. Bambusa sps. such as Dendrocalamus hamiltonii and Bambusa tulda occur
plentifully in higher plateau. Moreover, another important feature of the vegetation of Dibrugarh district is the presence of numerous tea-gardens specially in plains.

The trees are used mainly for timber purposes and hence trees are felled and cut into blocks and left in the field for considerable period. Likewise, Bambusa sps., Calamus sp., Saccharum and Phragmites sp. are also used after being stored for sometime. The logs of wood and canes are the good substrates for the growth of different fungi (Butler and Bisby, 1960). Fungi may attack tree as parasites or attack wood or felled timber as saprophytes. Thus, wood and the timber derived from it are the potential food source for micro-organisms.

Many valuable timber trees of Dibrugarh district like - Artocarpus integrifolia, Tectona grandis, Cedrella toona etc. are often subjected to decay by various wood rotting fungi such as Fomes senex, Trametes persooni, Irpex destruens, Ganoderma applanatum, Polyporus sps., Polystictus sanguincus, Stereum hirsutum, Trametes corrugata, Trametes lactinea, Lentinus sps. etc. causing great economic loss to the forest wealth.
Bamboo commonly known as 'Poor-man's timber is often attacked by several types of fungi. Most of these are - *Schizophyllum commune*, *Auricularia auricula judae*, *Polyporus sp*, *Hypoxylon rubiginosum*, *Xylaria hypoxylon*, *Xylaria mellisii*, *Rosellinia congesta* etc.

The majority of the members of higher fungi grow saprophytically on dead stumps, branches, twigs, posts of different plants and destroy them by the process of rotting. Some of them are also parasitic causing serious diseases on certain economically important plants. *Exobasidium vexans* Masse, causes blister blight on the leaves of *Camellia sinensis*; *Phellinus pectinatus*, *Phellinus senex* etc. are some of the parasitic fungi attacking common trees. *Phellinus lamaeensis* (Murr.) Sacc. and Trott. causes brown root-rot of *Dalbergia sissoo*, *Camellia sinensis*, *Albizia procera* etc. *Xylaria hypoxylon* (L. ex Fr.) Grev. causes black root rot of apple. In addition to the specialised types of root pathogens of special importance are the root diseases of tea occurring in the district viz. (1) Charcoal stump root-rot by *Ustulina zonata* and *U. densta*, (2) Brown root rot by *Phellinus lamaeensis*, *P. noxius*, (3) red root rot by *Poria hypolaterita* (4) Black root rot by *Rosellinia arcuata*, (5) Tarry root rot by
**Hypoxylon ascarodes** (6) Purple root rot by **Helicobasidium compactum**. Most of the species attack those hosts which are already infected by other fungi, then they live upon them and eventually cause decay of the host.

The nature of growth and distribution of different types of fungi is diverse and varies from place to place. The study of ecological distribution of fungus flora, particularly the higher type is an interesting one. Rea (1914) commented on the fact that the distribution of fungi is dependent on the plant association growing in a particular area and expressed the view that - "It is this plant association whether alive or dead that determines the distribution of our fungi". Wilkins and Patrick (1939), Rhodes (1951), Parker-Rhodes (1956), Grainger (1946), Hass (1933) and several others studied the distribution of higher fungi in different situations. Parker-Rhodes (1956) studied the distribution of fungi in a small wood and commented - "Statistical analysis of the distribution of Basidiomycetes in a small wood (32 Acres) shows significant features of non-uniform distribution". Islam (1983) studied the distribution of wood inhabiting fungi of Assam by applying poisson's rule.

Decay in wood is caused mainly by the members of Polyporaceae (Bakshi, 1971), but the infection court
is first established by fungi or micro-organisms other than Basidiomycetes in general (Blanchette and Shaw, 1978, Shigo and Sharpe, 1968 and 1970).

Once wood has been formed in the growing tree, it can be subjected to fungal attack at any time. It may decay as a dead standing tree, or a fallen tree, as a log after the tree has been felled while lying in the forest awaiting extraction, during extraction to the mill for conversion into timber, during transport as a log or milled timber, during seasoning, in merchant's yard after seasoning at the building or manufacturing site. It may also decay in service as a finished product, be it solid wood as railway sleepers, transmission poles, fence posts, roof trusses, floor boards, external joinery, furnitures and ship building or reconstituted as beams, plywood, chip-board and other board materials. The critical factor in every case is the presence of moisture content and hence dry wood (with a moisture content less than 20% m.c.) is immune to microbial attack.

In standing trees, the sapwood is considered to be much more resistant to decay than the heart wood. Hollow trees are not uncommon in the woodlands where the dead heart wood has been destroyed but the living sapwood has responded to invading organisms and
overcome them. On the other hand, once the tree has been felled and the living cells in the sapwood die, the wood becomes an inert substrate, which makes no response of any sort to invading organisms. The difference between sapwood and heartwood then changes completely, the sapwood becoming highly susceptible to decay because of the stored food reserves and residual protein in the parenchyma and an absence of toxic extractives in the walls. The heart-wood, without stored food reserves and often containing toxic extractives, is usually more resistant.

In considering post-harvest deterioration, much of the decay may be a continuation of infection carried over from the standing tree but in all instances, green timber, which is held for any length of time, will be at risk by decay organisms.

As soon as any tree is felled the sapwood is readily colonized by a wide range of fungi. The earliest colonizers are usually those fungi that obtain nourishment from residual food materials in the sapwood rather than those which degrade the cell walls. This situation is almost exactly parallel in the infection wounds (Shigo 1972) and the colonization of sound timber when placed in the ground (Levy 1980), or when it becomes exposed to wetting in a situation such as
external window joinery (Carey 1980). Some of these early colonizers are stainers, which give rise to a blue or grey discolouration in the sapwood.

Carey (1980) in an extensive survey of exposed painted simulated joinery components has shown that an ecological sequence of colonization by micro-organism exists starting with bacteria, moulds and stainers and climaxing in the final decay by basidiomycetes. This undoubtedly is a major contributory factor in the colonization and decay process.

Though the members of the Basidiomycetes have been considered to be the primary invaders and decayers of wood (Snell 1922, Davidson et al 1938, Findlay 1940, Silverberg 1953, Nobles and Frew, 1962) are unable to utilize wood until it has been altered by other organisms including Hyphomycetes, Bacteria and Yeasts (Shigo and Sharon, 1968 and 1970, Shortle and Cowling 1978, Blanchette and Shaw, 1978). It has also been pointed out by plant pathologists that destruction of wood is the result of successive attack by a number of different organisms. Reports have also been made by Savory (1954a and b) and Merill et al (1964) on the decay and breakdown of timber by some of the members of Ascomycetes both in natural and laboratory conditions.
In the process of decay, the pioneer organisms viz, bacteria and non-hymenomycetes, must alter the hardwood before Hymenomycetes can infect (Shigo and Sharon, 1968 and 1970). Therefore, an examination of the role of bacteria and non-hymenomycetous fungi in the process and their intimate associations at various stages might prove to be an important factor in the process of discoloration and decay of wood. Bacteria, yeasts and Basidiomycetes were closely associated during decay. Blanchette and Shaw (1978) stated that 200% or more fungal growth was observed in treatments combining bacteria, yeasts and a basidiomycetes than a single basidiomycetes.

Decay of wood may occur in three types - white rot, brown rot and soft-rot. The white rots degrade both cellulose and lignin and brown rots slightly modify lignin but destroy cellulose. White rots bleach the wood as decay progresses, whereas the brown rots leave the lignin as a brown brittle, friable residue (Campbell 1952, Bavendamm 1928). Both white rot and brown rot are caused by a large number of Ascomycetes and Basidiomycetes. "Soft-rot", producing softening of wood surfaces when dry and small square cracking of the surface in dry condition is recently has been known to be of importance.
The gross effect of the action of wood-rotting organisms is to lower the mechanical strength of wood by destruction of the main-wall component responsible for its property, namely cellulose. This loss of mechanical strength is however low in white rots as compared to that of brown-rots.

During the incipient stage of infection, the change in colour of the wood is seldom noticeable, but when the decay approach towards the advanced stage, marked changes in the colour of the host are developed.

Zonelines, coloured zones or pseudosclerotial plates are found in the wood tissue due to the infection of one or more pathogens is another peculiarity of wood decay. "Presence of narrow, dark lines in wood indicates attack and decay by wood-rotting fungi and are the sheets of fungal mycelium composed of characteristics swollen hyphal cells" (Lopez - Real, 1975). The zone lines may be formed due to (i) antagonism of the mycelia of two different fungi in the substratum, (ii) action of the mycelium of single pathogen.

During infection, anatomical changes in the wood structure also occur. Hyphae are observed in almost all the cells in the decay of hard wood. Some fungi
of white rot and brown rot decay types apparently penetrate through pits instead of producing bore-holes in early stages (Bayliss, 1908, Cartwright, 1930, Cowling et al. 1961). In most of these cases, both brown and white rot fungi eventually produce bore-holes in later stages of decay. It has been suggested that the number of bore holes may be an indicator of the stage of decay (Zycha and Brand, 1959). In addition to, forming bore holes, perpendicularly to the axis of the cell, hyphae of brown rot fungi have been observed to grow longitudinally within the $S_2$ layer (Meier, 1955) and cavities of axial orientation have been observed in both white rot and brown rot (Courtois, 1963 b, Wilcox et al. 1968). Savory (1954 a) showed that soft rot fungi grew in the $S_2$ layer of the secondary cell wall forming chains of the cavities with painted ends which were arranged in a helix parallel to the orientation of the cellulose microfibrils.

The most important of all is that infection develops greater porosity which makes the wood to absorb water more making the wood more susceptible to all biological attack.

That, the fungi get their nutrition from the host and in the mechanism of parasitism or saprophytism, the fungi develop a great variety of enzymes leading to
the dissolution of cell-wall and other cell inclusions have been worked out since the time of Borquelot and herissey almost hundred years ago. Later works till date (Ayessa and Papavizas, 1965; Shewale and Sadana, 1978; Chacko et al, 1978; Das et al 1978; Singh and Kunene, 1980) form the basis for better understanding of the system as well as of metabolism of the fungi (wood rotting). "A wood-rotting fungus should be an organism capable of utilizing sound unaltered wood as an energy source by means of enzymatic degradation of components of wood cell-wall" (Gilbertson, 1980).

Different enzymes are responsible for the breakdown of various constituents of the cell-wall and different terms have been ascribed to them. "Cellulase" is responsible for the hydrolysis of cellulose and is supposed to be completed in two steps. Some wood-rotting Basidiomycetes produce extracellular "Phenoloxidases" detectable by the formation of coloured oxidation products in media containing phenols can decompose lignin. Several wood-destroying fungi produce pectic enzymes (pectinases) responsible for the breakdown of pectin and is regarded to be formed in different forms like protopectinase, pectin-methyl-esterase, polygalacturonase etc.
Dibrugarh district of Assam, the study area of the present work, with diverse types of timber trees, are the chief hosts of different types of fungi and the nature of distribution along with the ecological adaptation, particularly of higher fungi growing in varied substrata has hardly been studied so far. Hence the aim of the present investigation is (i) to enumerate the types of higher fungi occurring in the district, (ii) to study their nature of growth and distribution, (iii) the impact of climatic factors (rainfall, temperature and humidity) on the growth of higher fungi on wood, (iv) the effect of certain physical factors and to study the histopathology of certain infected hosts and (v) the impact of microfungi on the growth of higher fungi on wood lying in soil and biochemistry of wood decomposition.