STUDIES ON THE WOOD ROTTING FUNGI OF MEGHALAYA

ABSTRACT

BY

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ABSTRACT

The present study was carried out in the eastern part of Meghalaya covering various forests within the districts of East Khasi Hills, West Khasi Hills, Jaintia Hills and Ri Bhoi. The study was conducted in the state of Meghalaya which lies between 25°02' and 26°07'N latitude and 89°49' and 92°50' E longitude with a geographical area of 22,429 sq. km, situated in northeast India . The elevation ranges from 60 to 1,950 msl.

The wood rotting fungi were collected from the different sites which were located within the area with geographical position in between the latitude 25 °N - 26 ° N and longitude 91° 40' E - 92° 30"E, with altitudinal range from 604 – 1945 msl in the region.

The present work was undertaken with the aim to generate a baseline data on the general distribution and diversity of the wood rotting fungi in Meghalaya. The study will also include the taxonomical study of the collected specimens and the decomposition of two common woods by selected species of the wood rotting fungi. The present work was carried out under the following heads:

1. Distribution and Diversity of the wood rotting fungi in the eastern districts of Meghalaya
2. Taxonomy of the wood rotting fungi in Meghalaya
3. Diversity of the wood rotting fungi in disturbed and undisturbed sacred groves
4. Wood decay by selected species of wood rotting fungi

A broad based collection of the fungal fruiting bodies was done from different forests stands in the districts of Ri-Bhoi, Jaintia Hills, East Khasi Hills and

West Khasi Hills of Meghalaya during the period June 2002 – December 2004 involving three wet seasons. The collections were made from Byrnihat, Dawki, Jarain, Lawbyrtun, Lumsymper, Laitsohum, Laitkor, Mawiong, Mawlai, Mawblei, Mawlasnai, Umroi, Swer sacred grove, Sohrarim sacred grove, Nongkrem sacred grove, Mawphlang sacred grove, and Jowai sacred grove. The study did not include small or inconspicuous sporocarps. The wood rotting fungi were collected from the different collecting sites with altitudinal ranging from 604 – 1945 msl in the region.

The herbarium specimens were maintained with plastic bags kept in paper bags and the bottled specimens were intact with the collection number, date and details of the habitat and site of collection. This will form a part of the collection of herbarium specimen at the Department of Botany, NEHU and will be used for future reference.

During the period altogether 54 specimens could be identified according to standard macroscopic and microscopic characteristics from the collection sites. Out of the 54 specimens or morphotypes, 5 species belonging to 4 genera and 4 families from the Ascomycetes and 49 species belonging to 34 genera and 17 families from the Basidiomycetes could be identified. The family Polyporaceae with 24 species was found to be the most dominant, followed by the Hymenochaetaceae (6 species), Ganodermataceae (3 species), Stereaceae (3 species) Hapalopilaceae (2 species) and the Xylariaceae (2 species). One species each from the families Auriculariaceae, Bulgariaceae, Fistulinaceae, Fomitopsidaceae, Gloeophyllaceae, Helotiaceae,

Strophariaceae, Nidulariaceae, Tricholomataceae, Meruliaceae, Pleurotaceae, Pyrenemataceae, Schizophyllaceae, Sparassidaceae and Tremellaceae were also obtained. The genus with highest number of species represented are the polypore members- *Microporus, Polyporus, Trametes,* the Ganodermataceae member- *Ganoderma,* the Hymenochaete member- *Phellinus* and the Stereaceae member- *Stereum* with 3 species respectively.

The frequency of occurrence in the collection sites were calculated for the duration of the collection period and was observed to be 41.17% for *Earliella scabrosa, Hirshioporus abietinus, Schizophyllum commune* and *Trametes versicolor,* 35.29% for *Fomitopsis pinicola* and *Polyporus xanthopus*, 29.41% for *Fistulina hepatica, Nidula niveotomentosa, Stereum hirsutum, S, ostrea* and *Trametes hirsuta,* and 23.52% for *Ganoderma applanatum, Cyclomyces tabacinus* and *Pleurotus ostreatus* respectively. These species were observed to be the most abundantly distributed in comparison to the other species in all of the collection sites.

The habitats of the wood rotting fungi vary from living to dead fallen minute twigs, small and large branches to the most massive of tree trunks. The identification of the host tree in case of several year old fallen trees was extremely difficult. The majority of the hosts were mainly of angiospermic wood and few species from coniferous wood. Gymnospermic wood of *Pinus kesiya* and angiospermic wood such as those of *Alnus nepalensis, Alstonia scholaris, Ardisia flouribunda, Artocarpus chaplasha, Betula alnoides, Carpinus viminea, C. semiserrata, Cassia fistula, Castanopsis tribuloides, C. indica, Cinnamomum*

pauciflorum, C. parthenoxylon, Corylopsis himalayana, Elaeocarpus lancifolius, Erythroxylon kuntiana, Eurya accuminata, Exbucklandia populnea, Ficus clavata, F. elastica, F. trachycarpa, Grevillea robusta, Ligustrum rubustrum, Manglieta insignis, Myrica esculenta, Prunus cerasoides, Pyrus pasha, Quercus dealbata, Q. fenestrata, Q. serrata, Q. griffithi, Rhododenron arboretum, Schima wallichi, Shorea robusta, Syzigium tetiagons, Vaccinium griffithianum, Viburnum colebrookianum, and *V. foetides* were some of the main host trees that were encountered during the study.

For the taxonomical study, collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literatures (Overholts, 1953; Ryvarden and Johansen, 1980; Gilbertson and Ryvarden, 1986; Bakshi 1971; Rattan, 1977; Roy and De, 1996; Sharma, 2000; Leelavathy and Ganesh, 2000; Ainsworth & Bisby, 2001). Nomenclature, taxonomic position and author names followed the databases: Index Fungorum- IFS (http://www.indexfungorum.org), the International Plant Names Index – IPNI (http://www.ipni.org) and MycoBank (http://www.mycobank.com). The genera and species are listed alphabetically and compiled based on an intensive search of literature records. Comparison was also done with some of the materials at the Mycology Herbarium and National type collection of Forest Research Institute (FRI), Dehra Dun. The host trees were identified with the help of experts. Voucher specimens are housed at the Microbial Ecology Laboratory, Department of Botany.

The species that was studied along with their family are as below:

Ascomycetes: Bulgariaceae – *Bulgaria inquinans*, Helotiaceae – *Chlorociboria aeruginosa*, Xylariaceae – *Xylaria hypoxylon, X. polymorpha*, Pyrenemataceae – *Scutellinia scutellata.*

Basidiomycetes : Auriculariaceae – *Auricularia auricula*, Hapalopilaceae– *Bjerkandera adusta, Ischnoderma resinosum*, Polyporaceae –*Coriolopsis telfarii , Daedalea confragosa, Earliella scabrosa, Fomes fomentarius F. geotropus, Hexagonia apiara, H. tenuis, Hirshioporus abietinus, Irpex consors, Laetiporus sulphureus, Lenzites betulina, Microporus flabelliformis, M. quarrei, M. xanthopus, Polyporus brumalis, P. tenuiculus, P. tuber-aster, Rigidiporus microporus, Skeletocutis amorpha, Pycnoporus sanguineus, Trametes hirsuta, T. tephroleucus, T.versicolor, Trichaptum byssogenum,* Fistulinaceae- *Fistulina hepatica,* Fomitopsidaceae-*Fomitopsis pinicola,* Ganodermataceae-*Ganoderma applanatum, G. australe, G. lucidum,* Gloeophyllaceae - *Gloeophyllum striatum,* Strophariaceae –*Hypholoma fasciculare,* Hymenochaetaceae-*Cyclomyces tabacinus, Inonotus dryadeus, I. rheades Phellinus adamantinus, P. gilvus, P. wahlbergii,* Nidulariaceae-*Nidula niveotomentosa,* Tricholomataceae- *Omphalotus olivascens,* Meruliaceae- *Phlebia tremellosus,* Pleurotaceae- *Pleurotus ostreatus,* Schizophyllaceae- *Schizophyllum commune,* Sparassidaceae- *Sparassis crispa,* Stereaceae- *Stereum complicatum, S. hirsutum, S. ostrea,* Tremellaceae- *Tremella mesenterica.* The habitat or hosts range from live and dead trees.

For the diversity of wood rotting fungi in disturbed and undisturbed sacred groves two sacred forests were Nongkrem sacred grove or locally called as 'Law Lyngdoh Nongkrem' is a disturbed sacred grove and covers an area of 6 ha. It is about 14 km south west from Shillong an altitude of 1786 msl. and is situated at 91° 54' 40" E latitude and 25° 29' 30" N longitude. Mawphlang sacred grove or locally called the 'Law Lyngdoh', 'Umrisaw', 'Mawkhan', 'Ryngngi', 'Laitsohphoh', etc., is one of the few sacred groves that remains undisturbed. It is about 25 km south-east of Shillong covering an area of 75 ha at an elevation of 1842 msl and lies at 91°56' E latitude and 23°34'N longitude.

The study compared the wood rooting fungi richness based on equal sampling areas (comparable to species density; *sensu* Hurlbert, 1971). Three permanent areas or plots were selected in each of the disturbed and undisturbed forest in which a single 100 m long and 25 m wide transects was laid at random during each visit to record the presence and absence of the wood rotting fungi (Senn-Irlet and Bieri, 1999). Each forest was visited at least more than three times during a period of 6 months from Jan- June and from July to December for 24 months. All sporocarps and clusters of sporocarps of the same species of the wood rotting fungi on a log or tree were counted as one occurrence, independent of number of sporocarps.

Species Richness

The species accumulated at each sampling was noted and the cumulative species richness of wood rotting fungi in both the sacred groves was calculated at an interval of six months from January to June and from July to December for the two

year study periods 2003-2004. The species accumulation graph was then plotted as number of species accumulated within each sampling time of 6 months interval.

Species diversity

Index of species diversity of the wood rotting fungi was calculated using the Shannon and Simpson index of diversity as suggested by Lande (1996) and Magurran (2004).

Shannon index: $H = -\sum(p_i \ln p_i)$

Simpson index: $D = \sum n_i(n_i-1) / N(N-1)$

Where, *ln* is the natural log function and p_i is proportion of the number of i^{th} species to total number of individuals, n_i is the abundance of the i^{th} species, N the total number of all the species.

A total of 42 number of the wood rotting fungi were identified, wherein the disturbed sacred grove housed 19 species and the undisturbed sacred grove housed 36 species and the two sacred groves share together 13 number of the wood rotting fungi (Table 4.1). It was observed that the species accumulation curves continued to increase with each sampling intervals and were not reaching their asymptotes (Fig. 4.1). The number of wood rotting fungi and plant species and species/ha from the two study sites is listed in Table 4.2. The undisturbed sacred grove had a greater species richness with values of 48/ha for the wood rotting fungi and 67/ha for the host trees while the disturbed forest had a value of 25/ha and 47/ha respectively (Table 4.2). The graph (Fig. 4.2) also shows that the undisturbed sacred grove had a

higher species assemblage than the disturbed sacred grove for both the wood rotting fungi (36 and 19) and tree species (56 and 35).

The wood rotting fungi that were common to both the forest were *Earliella scabrosa, Fistulina hepatica, Ganoderma applanatum, G. australe, Hypholoma fasciculare, Inonotus tabacinus, Laetiporus sulphureus, Microporus xanthopus, Phellinus gilvus, Schizophyllum commune, Stereum ostrea, Trametes versicolor* and *Tremella mesenterica* (Table 4.1). About 35 tree species were found in the disturbed sacred grove among which the dominant trees are *Cinnamomum glanduliferum, Elaeocarpus lancifolius, Eurya japonica, Eleagnus pyriformis, Lithocarpus dealbatus, Myrica esculenta, Pinus kesiya and Schima wallichi.* The undisturbed sacred grove was found to house about 56 tree species among which the dominant trees were *Eleocarpus lancifolius, Engelhardtia roxburghiana, E. spicata, Exbucklandia populnea, Quercus dealbata, Q. griffithii, Q. glauca, Pyrus pashia, Rhododendron arboreum* and *Symplocos chinensis* (Table 4.3).

Species diversity

Species diversity of the wood rotting fungi was found to be higher in the undisturbed than the disturbed sacred grove. The Shannon's diversity index H was found to be 2.68 and 3.36, and the Simpson's diversity index *D* was 12.87 and 26.23 in both the disturbed and undisturbed sacred groves respectively (Table 4.4).

A study was conducted to investigate the decay potential of four commonly occurring wood rotting fungi *Trametes versicolor* (L.: Fries) Pilát, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *Polyporus brumalis* (Pers.) Ex Fries and *Earliella scabrosa* (Pers.) R.L. Gilbertson and Ryv of the region on woodblocks of *Pinus*

kesiya and *Michelia champaca,* the two most important sources of timber in the region.

The pure cultures of the common wood rotting fungi *Trametes versicolor* (L. Fries) Pilát, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *Polyporus brumalis* (Pers.) Ex Fries and *Earliella scabrosa* (Pers.) R.L. Gilbertson and Ryv were maintained in the laboratory using 2% malt extract agar (MEA) medium (Griffith and Boddy, 1990).

Wood Block Assay for estimation of decay potential

The method is based on that of Cartwright and Findlay (1958), Chee *et al.*(1998), Fryar *et al.* (2001) and the European standard EN 113 (1996) and modified as necessary

Experimental woodblocks (1.5 x 1.5 x 1.5 cm) were prepared from the outer heartwood (adjacent to sapwood) of matured and carefully selected 25-30 year old *Pinus kesiya* Royle ex Gordon and *Michelia champaca* trees. The wood blocks with knots, visible decay, stains, etc., were rejected. Each wood block was then weighed and serially numbered for easy identification. The wood blocks of *P. kesiya* weighed 1.46 g (± 0.14) and *M. champaca* weighed 1.74 (± 0.13) respectively. Three replicates were taken for each sample.

The woodblocks were sterilized carefully so as to avoid contamination from any microorganisms present in the wood prior to inoculation by the test fungi. The wood blocks were oven-dried at 110°C for 24 hrs, each wood block was then weighed, marked and then immediately kept inside carefully sealed conical flasks

and sterilized in an autoclave for 2 hrs and kept ready to be aseptically transferred to the conical flasks containing the cultured test fungi (Plate 5.1-5.26).

The following parameters were taken into consideration for the study – Weigth loss, Lignin content, Moisture content and pH.

Estimation of the decay potential

Experiment on the effect of the wood rotting fungi *Trametes versicolor.*, *Hirschioporus abietinus*, *Polyporus brumalis* and *Earliella scabrosa* on the selected two common timber trees of the region *Pinus kesiya* and *Michelia champaca* was done. The assessment of the degree of their effectiveness over a period of 300 days is depicted in the Tables 5.1- 5.4 and in the Figs. 5.1- 5.4.

Weight loss

It was observed that the test fungi have shown a positive effect on the woodblocks of P. *kesiya* and *M. champaca* (Fig.5.1, Table 5.1). The weight loss effected by *T. versicolor* was maximum on both woodblocks where it was 67.24±0.94% on *P. kesiya* and 34.53±0.67% on *M. champaca* at 300 days.

Similarly the other test fungus *E. scabrosa* also showed a similar effect where it was 45.07±1.67% and 24.35±0.46% respectively on the two test woodblocks of *P kesiya* and *M. champaca.* The percentage weight loss was however lesser in case of woodblocks treated by the other two test fungus where it was 28.08±1.89%, 12.34±0.25% for *P. brumalis* and 13.36±1.79%, 8.57±0.40% for *H. abietinus* on the two test woodblocks of *P. kesiya* and *M. champaca* respectively. The control replicates also indicated minute weight loss with maximum of 8.72±2.19 and

8.22±0.08 on the test woodblocks of *P. kesiya* and *M. champaca* respectively after 300 days of the incubation period

Lignin content

There was also a decrease in lignin content of the wood with increase in time (Fig.5.2, Table 5.2). The loss in lignin content after 300 days was maximum in the woodblocks treated with *T. versicolor* which showed significant decrease as shown by the remaining lignin content of 6.31±0.48% and 8.21±0.43 % for *P. kesiya* and *M. champaca* respectively. Similarly, as shown by the weight loss the other test fungi *E. scabrosa* is the other species that showed significant decrease in the lignin content with mean values of upto 7.26±0.23% and 7.49±0.20% for woodblocks of *P. kesiya* and *M. champaca* respectively. The remaining lignin content in woodblocks of *P. kesiya* and *M. champaca* treated with *P. brumalis* were 9.78±0.24% and 8.51±0.31% respectively and least decrease was observed in those treated with *H. abietinus* where it was 10.86±0.26% and 8.51±0.31% respectively in the two test woodblocks. Control samples remained almost the same with values of 15.02±0.25% and. 12.16±0.46% respectively for the two test woodblocks *P. kesiya* and *M. champaca.*

Moisture content

The moisture content of the wood showed increasing trend with time (Fig.5.3, Table 5.3). As the wood is inoculated on the test fungi growing on the growth medium, some of the water is soaked up by the wood from the medium and also with the help of the fungal mycelium. This is indicated by comparison with control samples. The moisture content after 300 days is maximum for those treated with *T.*

versicolor where it was 82.11±1.55% and 75.93±0.66% for woodblocks of *P. kesiya* and *M. champaca* respectively. *E. scabrosa* is the next species with mean values of 71.08±0.66% and 66.63±0.99% followed by *P. brumalis* with 67.27±0.88% and 48.17±1.19%, *H. abietinus* with 63.81±0.73% and 53.87±0.70% and control samples with 57.10±0.56% and 42.68±1.49% for woodblocks of *P. kesiya* and *M. champaca* respectively.

Wood pH

The pH of the wood showed a tendency towards acidity (Fig.5.4, Table 5.4). The pH at 300 days was 3.70±0.10 and 4.24±0.23 for *T. versicolor,* 3.32±0.12 and 3.92±0.20 for *E. scabrosa,* 4.20±0.20and 4.53±0.17for *P. brumalis*, 6.14±0.34 and 6.52±0.29 for *H. abietinus* and 5.9 and 6.2 for the control samples with woodblocks of *P. kesiya* and *M. champaca* respectively.

The correlation coefficient of the physico-chemical characteristics affected by the different wood rotting fungi on the two woodblocks of *P. kesiya and M. champaca* was analyzed. It was observed that in the woodblocks of *P. kesiya,* weight loss was positively correlated with the pH in control sets($r = 0.90$, $P \leq 0.001$) and *H. abietinus* ($r = 0.62$, $P \leq 0.05$), moisture content in *T. versicolor* ($r = 0.91$, $P \leq 0.001$), *H. abietinus* ($r = 0.78$, $P \leq 0.001$), *P. brumalis* ($r = 0.74$, $P \leq 0.01$), *E. scabrosa* ($r = 0.77$, $P \leq 0.01$). It showed a negative correlation with lignin in *T. versicolor* ($r = -0.91$, $P \leq 0.001$), *H. abietinus* ($r = -0.96$, $P \leq 0.001$), *P. brumalis* ($r = -0.83$, $P \leq 0.001$) and *E. scabrosa* ($r = -0.96$, $P \leq 0.001$), and with pH in *P. brumalis* ($r = -0.76$, $P \leq 0.01$) and *E. scabrosa* ($r = -0.95$, $P \leq 0.001$). Lignin concentration showed a positive

correlation with pH in *P. brumalis* (r = -0.68, P≤0.05), *E. scabrosa* (r = -0.89, P≤0.001). It showed a negative correlation with moisture in *T. versicolor* (r = -0.82, P≤0.01), *H. abietinus* (r = -0.74, P≤0.01), *P. brumalis* (r = -0.83, P≤0.01) and *E. scabrosa* (r = -0.68, P≤0.05). Moisture content showed a positive correlation with pH in *H. abietinus* (r = 0.61, P≤0.05). It also showed a negative correlation with pH in *T. versicolor* (r = -0.62, P≤0.05) and *E. scabrosa* (r = -0.86, P≤0.001) (Table 5.5).

It was observed that in the woodblocks of *M. champaca*, weight loss was positively correlated with the moisture content in the control sets (r = 0.66, P≤0.05), *T. versicolor* (r = 0.82, P≤0.01), *H. abietinus* (r = 0.80, P≤0.01) and *E. scabrosa* (r = 0.79, P≤0.01), pH in control sets(r =0.65, P≤0.05). It showed a negative correlation with lignin in control sets (r = -0.72, P≤0.05), *T. versicolor* (r= -0.90,P≤0.001), *H. abietinus* (r = -0.92, P≤0.001), *P. brumalis* (r = -0.95, P≤0.001), *E. scabrosa* (r = -0.90, P≤0.001), and with pH in *T. versicolor* (r = -0.96, P≤0.001), *P. brumalis* (r = -0.82, P≤0.01), *E. scabrosa* (r = -0.95, P≤0.001). Lignin concentration showed a positive correlation with pH in *T. versicolor* (r = 0.89, P≤0.001), *P. brumalis* (r = 0.77, P≤0.01), *E. scabrosa* (r = 0.86, P≤0.001). It also showed a negative correlation with moisture in *T. versicolor* (r = -0.82, P≤0.01), *H. abietinus* (r = -0.72, P≤0.05), *P. brumalis* (r = -0.67, P≤0.05), *E. scabrosa* (r = -0.84, P≤0.001), and with pH in control sets (r = -0.65, P≤0.05). Moisture content showed a positive correlation with pH in *H. abietinus* (r = 0.79, P≤0.01) and negative correlation with pH in *T. versicolor* (r = -0.79, P≤0.01) and *E. scabrosa* (r = -0.77, P≤0.01) (Table 5.5).

dedicated in loving memory
of my beloved father

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THESIS
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DECLARATION

NORTH-EASTERN HILL UNIVERSITY

May 2010

I, Mr. **John Zothanzama Sailo**, hereby declare that the subject matter of this Thesis entitled "Studies on the Wood Rotting Fungi of Meghalaya" is the record of work done by me, that the contents of this Thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the Thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the *North-Eastern Hill University* for award of the degree of Doctor of Philosophy (Ph.D.) in Botany.

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CONTENTS

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Shillong

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(John Zothanzama Sailo)

List of Tables

List of Figures

List of Plates

Chapter I
INTRODUCTION

I.1. Introduction

Fungi are among the most important organisms in the world because of their vital role in ecosystem functions (Mueller and Bills, 2004). Fungi normally inhabit the different parts of a plant body such as roots, stem and leaves. Some may be harmless saprophytes while others may be weak or dangerous pathogens. A good number of these fungi produce large and conspicuous fruiting bodies and often also called as macrofungi (Arnolds, 1992; Hawksworth *et al.,* 1995; Richards and Murray, 2002; Bates, 2006). The fungi that inhabit and grow on wood have been interchangeably referred to by different workers as the wood rotting fungi (Dix and Webster, 1995; Demetriou *et al.,* 2000, Barassa *et al.,* 2006), wood-decaying fungi (Pearce 1990; Grand and Vernia, 2002) and wood inhabiting macrofungi (Nobles, 1965; Bader *et al.,* 1995; Mswaka and Magan, 1998; Lindblad, 2000) depending on their mode of existence in the wood as saprophytes or parasites.

The wood rotting fungi are key functional components of forest ecosystems (Brown *et al.,* 2006) and their study have received less attention than animals and plants, although they are omnipresent and highly diverse in nature (Piepenbring, 2007). These organisms are of particular interest not only in their own right, but also they are crucial to the creation of habitat for other organisms and for nutrient and carbon cycling (Swift, 1977). Old living trees, commonly referred to as veteran, old growth, mature or commercially over-mature trees, provide diverse structural and functional components of the forest landscape (Franklin *et al.,* 2002). As trees age,

they develop a multitude of features, including dead tops, hollows, decayed wood, crevices, sloughed bark and large diameter branches, each with important functional roles and habitat values. Many Northern Hemisphere studies document the finding that mature trees support a large proportion of total forest biodiversity. This ranges from arboreal, hollow-dwelling mammals and birds through to more cryptic fungi, lichens, bryophytes and invertebrates (Andersen and Ryvarden 2001; Nordén and Paltto 2001; Nilsson *et al.,* 2002; Penttilä *et al.,* 2004).

The fungi are essential, yet little understood and often overlooked components of healthy ecosystems. Ignorance of the fungi, which is the second most diverse group of organisms after the insects, is revealed by the fact that only 5–10% of the existing fungal biodiversity has been discovered and described (Hawksworth, 1991). The number of existing fungi worldwide has been estimated to be 1.5 million species (Hawksworth 2004). One-third of the fungal diversity of the globe exists in India and of this, only 50% are characterized until now (Manoharachary *et al.,* 2005). Having a stable and accepted estimate of the taxonomic diversity for fungi is necessary to enable fungi to be included in considerations of biodiversity conservation, land-use planning and management (Mueller and Schmit 2007). The current human resources in fungal systematics are extremely low at a time when the needs are urgent (Burdsall, 1990; Hawksworth, 1993; Hawksworth and Ritchie, 1993). Vogt *et al.*, (1992) stated that one basic way of surveying macrofungi is based on the presence of the sporophores or fruiting bodies. Studies based on fruiting bodies have been widely used and are useful first indicators of polypore diversity in a forest (Bader *et al.,* 1995 and Lindblad, 2000). The current and most reliable methods

used to identify wood-rotting fungi are by morphological attributes observed with bright field and phase contrast microscopy (Bigelow *et al.*, 1998). Sporophores develop diagnostic characters, which aid in the identification of the species. The variously sized fruit bodies (basidiocarps, basidiomata) are either pileate, shelf-shaped, bracket-like, coral-like, or resupinate. Shape and size of the pores are distinguishing features (Ryvarden and Gilbertson, 1993, 1994). Beside fungi with annual fruit bodies, species with perennial basidiomes produce new hymenial layers each year and may become very large, hard and woody.

Wood rotting fungi bring about significant weight loss and structural change on woody tissues. There are three main types of decay fungi which are distinguished by the wood components that they degrade (Dix and Webster, 1995). White rot fungi have the ability to degrade cellulose, hemicellulose and lignin resulting in the wood that is often fibrous with a bleached appearance (Kirk *et al.*, 1978 and Evans *et al.*, 1991). Brown rot fungi degrade only the polysaccharide components and residual wood is a brown lignin framework that is characterized by cubical shrinkage and wood collapse (Bakshi, 1976; Kirk and Fenn, 1982 and Dutton *et al.*, 1993). Soft rot fungi can degrade only cellulose and hemicellulose. They can tolerate very wet conditions and the rot is characterized by loss in mechanical strength and the wood becomes wet and spongy (Dix and Webster, 1995). White-rot and brown-rot are mostly caused by members of the Basidiomycotina and some members of the Ascomycotina, whereas the soft-rot is mainly caused by members of the Ascomycotina and Deuteromycotina (Dix and Webster, 1995). Among the wood rotting fungi, the Basidiomycotina members belonging to the Aphyllophorales,

commonly known as the 'Polypores' are among the major wood decaying organisms involved in the wood decay process and they play an important role in the nutrient cycle in forest ecosystems (Kuffer and Senn-Irlet, 2005).

Lignocellulose in wood is a heteropolymer consisting mainly of three components: cellulose, hemicellulose and lignin (Fengel and Wegener, 1989; Eaton and Hale, 1993). There is significant interest in the enzymes responsible for lignocellulose degradation in terms of understanding their ecological role and also in the biotechnology potential of enzymes involved in this process (Reddy, 1994). Decay study of woody substrate by fungi using mean percentage weight loss was used by Carranza-Morse and Gilbertson (1989). Weight loss measurement using wood block assay method have been employed to measure the decay potential of wood-decaying fungi by Chow *et al.,* (1993 and 1994) and Chee *et al.,* (1998).

To date, there are no reports on the study of the wood rotting fungi in Meghalaya. Thus, the present work was undertaken with the aim to generate a baseline data on the general distribution and diversity of the wood rotting fungi in Meghalaya. The study will also include the taxonomical study of the collected specimens and the decomposition of two common woods by selected species of the wood rotting fungi. The present work was carried out under the following heads:

1. Distribution and Diversity of the wood rotting fungi in the eastern part of Meghalaya
2. Taxonomy of the wood rotting fungi in Meghalaya
3. Diversity of the wood rotting fungi in disturbed and undisturbed sacred groves
4. Wood decay by selected species of wood rotting fungi

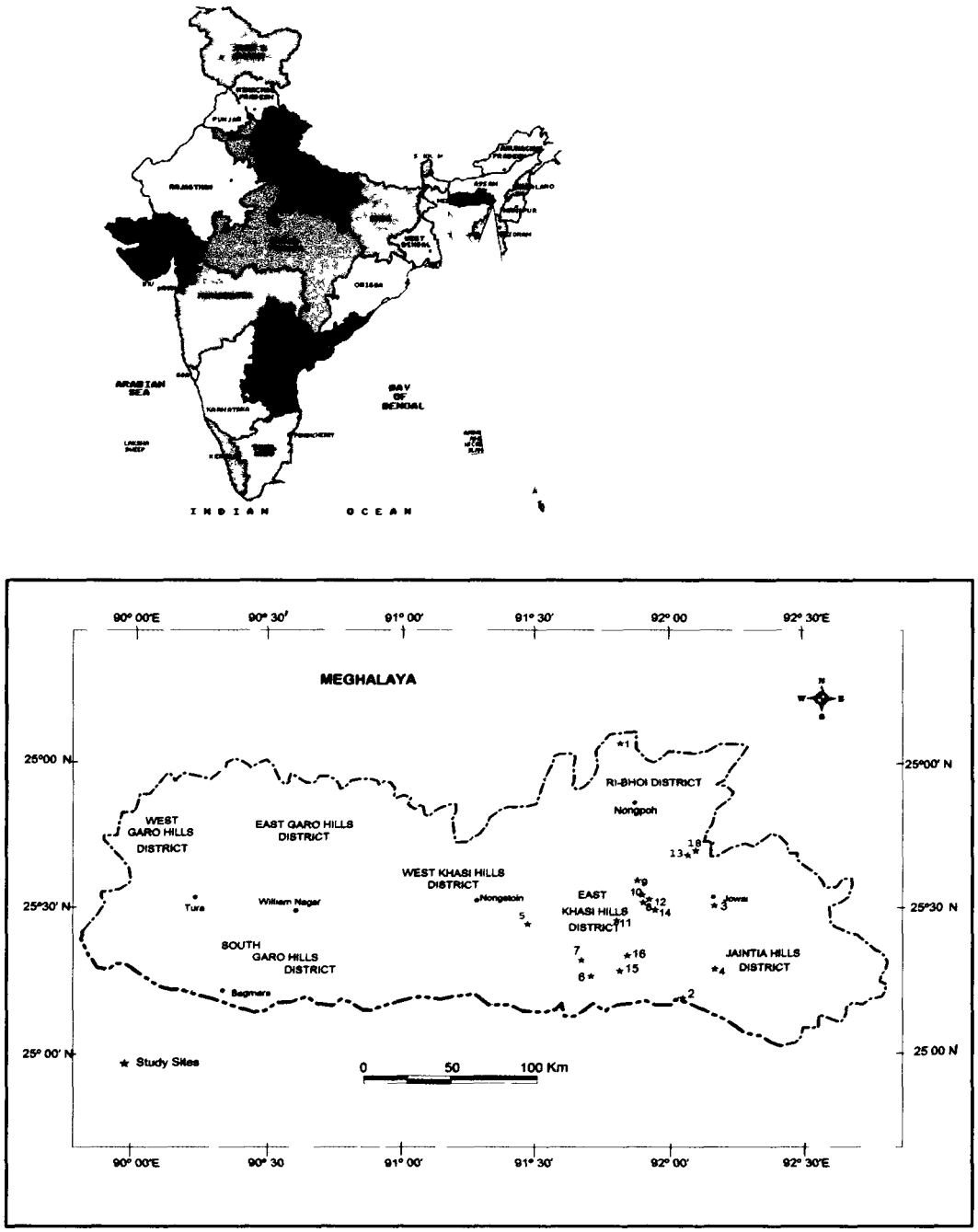


Fig. 1.1 Map of Meghalaya showing geographical position in North East India.

Chapter II

DISTRIBUTION AND DIVERSITY OF THE WOOD ROTTING FUNGI IN THE EASTERN DISTRICTS OF MEGHALAYA

II.1. Introduction

The importance of fungal biodiversity in ecosystems is well-documented (Lodge, 1996; Molina *et al.,* 2001; Rossman and Farr, 1997). Recent studies have emphasized fungal biodiversity in unique ecosystems and within unique geographical areas (Esqueda *et al.,* 2003; Gilbertoni and Calvacanti, 2003; Keller and Skrabal, 2002, Mueller and Mata, 2001, Riccardi and Bashore, 2003, Rossman *et al.,* 1998). Such studies provide a basic foundation of data that can aid future researchers in knowing what species of fungi are present as well as their distribution within defined areas.

Threats to our natural areas come from several sources, including urban development, pollution, extraction of natural resources (logging, mining, and so forth), and recreational usage. As a result, there has arisen a recent need for biodiversity assessment to evaluate the fates of ever-decreasing natural habitats (Hawksworth, 1991; Cannon, 1997; Rossman and Farr, 1997). It is known that the species of lignocellulolytic basidiomycetes are extremely abundant in all forest types and that they are the major wood decomposers in most ecosystems (Fryar *et al.,* 1999). An increased understanding of the diversity and general distribution of these fungi will contribute to the knowledge of the local biota of a region and will greatly strengthen initiatives to protect and use sustainably the natural resources (Rossman *et al.,* 1998).

Although macrofungi have perhaps the longest history of diversity studies of any group of fungi, they are nevertheless understudied over most of the world. Taxonomic obstacles and the absence of long-term studies prevent conclusive answers even to basic questions about the number of species at a specific location or whether diversity is greater in one type of forest than in another (Lodge *et al.*, 2004). More data are available from North America and Europe than from any other region, but knowledge of macrofungal diversity is incomplete even for these regions. The macrofungi putatively comprise 10% of total fungal diversity (Rossman, 1994) and it is estimated that 16–41% of macrofungi have been described to date (Mueller *et al.*, 2007).

One of the principal reasons for the lack of information is the formidable difficulty that fungi present to ecological study (Cannon, 1997). Most species are cryptic, rarely or never forming sporocarps, and most species of tropical fungi are undescribed (Hawksworth, 2001). North eastern region of India is unique in many respects such as rich floristic composition, high annual precipitation, undulated topography and varying types of forest ecosystems. The region experiences high rainfall of a monsoonic type which is followed by a dry winter and a brief summer. It is known to possess diverse forest types from Tropical Evergreen forests to Moist Alpine Shrub Forest and occupy 59.9% of its geographical area which is much higher than an all India average of 28%. The state of Meghalaya in particular is endowed with rich natural vegetation which ranges from tropical to sub-tropical type of vegetation or evergreen to mixed deciduous types of forests.

In this chapter, the wood rotting macrofungi in the eastern districts of Meghalaya were studied with an attempt to ascertain their state of diversity and distribution in the region.

II.2. Study Area, Climate and Vegetation

The study was conducted in the state of Meghalaya which lies between 25°02' and 26°07'N latitude and 89°49' and 92°50' E longitude with a geographical area of 22,429 sq. km, situated in northeast India. The elevation ranges from 604 to 1,950 msl (Plate. 2.1).

Meghalaya was carved out of Assam to become an autonomous district on April 2, 1970. It was declared a full fledged state of the Indian Union on January 21, 1972. The state of Meghalaya comprises Khasi, Garo and Jaintia hills. The state has a 496 km long international boundary with Bangladesh in the south and west. It is bordered by Assam in the north and east. The eastern part is bound by the Karbi Hills which is a continuation of the Meghalaya plateau. On all other sides of the state lies an extensive plain drained by the river Brahmaputra (in the north and west) and the river Surma and its tributaries (in the south).

Physiography

Based on the physiography, the state may be divided into (i) western region, (ii) central and eastern region, (iii) northern undulating hills, and (iv) southern precipitous zone. The western region includes the East and West Garo Hills districts and western parts of the West Khasi Hills district. The central and eastern region includes the eastern part of West Khasi Hills, East Khasi Hills, Ri-Bhoi and Jaintia Hills districts. The northern region is characterized by undulating hills towards the

north with altitude ranging between 300 and 1600 msl, while the southern part is a high precipitous zone. The central upland zone constitutes the highest elevation zone of the Shillong plateau.

Climate

The climate of the state is monsoonic and is directly influenced by the southwest monsoon and the northeast monsoon with distinct warm-wet and cold-dry periods. The climatic variables like temperature, rainfall and humidity vary widely from place to place in the state due to the wide variation in topography. Based on the climatic conditions, the year may be divided into summer, rainy, autumn and winter seasons.

Summer season: The period between May and October is warm-wet period with relatively higher temperature, monsoon showers with occasional thunderstorms and high wind velocity. The rainy season commences with the onset of the southwest monsoon in May and continues up to September. Three fourth of the total annual rainfall is received during this period (Fig. 2.1).

Autumn: A brief autumn follows the rainy season during October and November during which rainfall and temperature sharply declines. The cold-dry period extends from November to February

Winter: The winter season extends from December to February where morning fog and frost, and dry weather are the characteristic features during this period.

Spring: The period from Middle of February to April covers the spring season which experiences very high wind velocity with lesser humidity and moderate temperature.

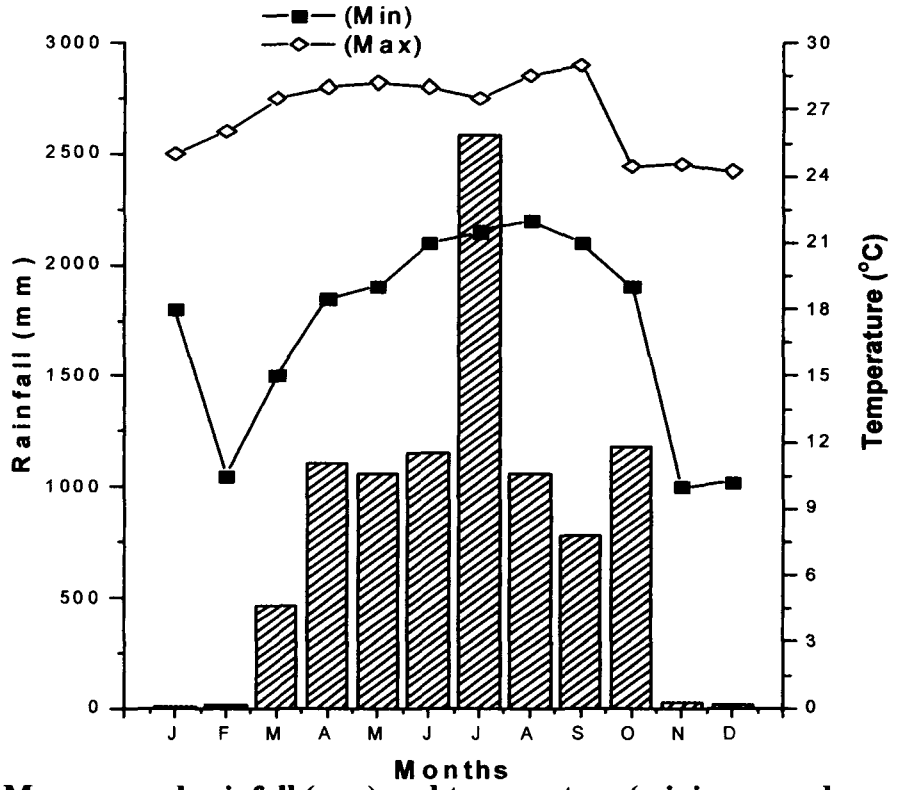


Fig.2.1 Mean annual rainfall (mm) and temperature (minimum and maximum) of eastern part of Meghalaya including datas from Jaintia Hills, East Khasi Hills, West Khasi Hills and Ribhoi district recorded from Hydromet Division, India Meteorological Department for the period 2002-2004.

The western and southern parts of the state are warmer than the central upland where mean minimum temperature stands at 20°C. Average maximum and minimum temperatures and annual rainfall in the state varies from 5°C to 32°C, and 4,000 mm to 11,436 mm, respectively. Cherrapunjee and Mawsynram, located in the southern part, receive the highest rainfall.

Vegetation

According to the State of Forest Report (FSI, 2005), the actual forest cover of the state is 15,988 sq. km. This accounts for around 75.7% of the state's geographic

area. Per capita forest area in the state is 0.64 hectares compared to the national average of 0.11 hectares. However, the total recorded forest area is 9,496 sq. km. The area of reserved and protected forests under the control of the state government is only 1,124 sq. km. The Unclassed Forests, managed by Autonomous District Councils, village durbars and other traditional institutions, and private owners cover an area of 8,372 sq. km. The forests of Meghalaya can be broadly grouped into tropical, subtropical and temperate types. The Indian Institute of Remote Sensing have classified the vegetation of Meghalaya into tropical evergreen, tropical semi-evergreen, tropical moist deciduous, subtropical broad leaved, subtropical pine and temperate forest types, grasslands and savannas.

The state of Meghalaya is a part of Indo-Myanmar biogeospherical region, which is one of the mega biodiversity regions of the world. The floral diversity of Meghalaya is quite rich. It harbours about 3,331 species of plants and contributes about 18% of the total flora of the country, including 1,236 endemic species (Khan *et al.,,* 1997). About 37.11% (1236 species) of the total flora of the state is endemic (Khan *et al.,,* 1997). 133 species of the endemic and threatened species are mainly confined to the protected forests/sacred groves. According to Takhtajan (1988), the flora of the Khasi and Jaintia hills is most richly saturated by eastern Asiatic elements, and the area is one of the most important centers of survival of the tertiary flora of eastern Asia. The high taxonomic diversity and the high concentration of endemic and rare species in Meghalaya are due to its geographical proximity to the species-rich Eastern Himalayas, South Central China, Myanmar and Malaya and the

favorable climatic conditions of the area and protection afforded to the protected forests /sacred groves through ages on the grounds of religious belief and taboos.

Forest

The forests of Meghalaya were classified by Kanjilal *et al.* (1934); Champion and Seth (1968); Balakrishnan (1981); Haridasan and Rao (1985); Rao and Hajara (1986) and Chauhan and Singh (1992).

The tropical forest occurring below 1000 msl may be either evergreen or semi-evergreen type depending on the dominance of evergreen and deciduous trees on the canopy. The subtropical forest found above 1000 msl is either broad-leaved or needle-leaved. Small pockets of subtropical evergreen broad-leaved forest are found where rainfall is relatively high and soil moisture condition remain favorable for most part of the year while those areas which receive relatively low annual rainfall support semi-evergreen forest. Pine forests have developed as a stable secondary community on the disturbed evergreen and semi-evergreen subtropical broad-leaved forest sites which are seasonally dry and nutrient poor.

The primary tropical and subtropical forests of the state have been destroyed to a large extent by age-old practice of shifting agriculture, which is extensively practiced in the state even today. As a result of this and other human activities, extensive degradation of the forest has taken place in the state. The degraded forest lands support a variety of successional communities ranging from weed-dominated communities on recently abandoned jhum fields to pine forest and grassland on frequently burnt and nutrient deficient sites.

The major forest types of Meghalaya are tropical moist deciduous, subtropical evergreen, subtropical semi-evergreen and subtropical pine forests.

Tropical moist deciduous forest

This forest type is represented by sal-bearing forest at low elevetional areas of Garo hills, where annual rainfall is less than 150 cm. Along with *Shorea robusta*, other tree species found in these forests are *Bauhinia variegata, Calliandra* sp., *Callicarpa arborea, Cordia grandis, Dillenia scabrella, Dysoxylum binectariferum, Embelica floribunda, Lagestroemia parviflora, Mallotus phillippensis, Picrasma javanica, Schima wallichii, Styrax serrulatum, Stercula villosa, Tectona grandis,* and *Terminalia myriocarpa.* The under storey is composed of *Ardisia nerifolia, Clerodendron viscosum, Digitaria* sp., *Desmodium* sp., *Eupatorium adenophorum, Gleichenia* sp., *Melastoma malabathrium, Pongamia* sp., *Psychotria monticola, Sabia purpurea,* and *Vandelia* sp.

Subtropical evergreen forest

It generally occurs above 1200 msl where average annual rainfall ranges between 300 and 500 cm and temperature shows a noticeable difference between summer and winter season. The ground frost is common in December and January. The trees are generally short statured not exceeding >25 m height. Buttressed trunks and lianas are rare. Stratification is indistinct in the valleys, but it is clear at hilltops. The shrubby and herbaceous layers are clearly seen in these forests. Epiphytes, mosses and liverworts are abundant. The forest floor is spongy due to the presence of thick litter layers and a dense network of fine roots.

Tall scattered trees of *Betula* sp., *Castanopsis sp., Engelhardtia spicata, Exbucklandia populnea, Ficus elastica, Lithocarpus elegans, Manglieta insignis* and *Prunus nepalensis* constitute the canopy layer of the forest. Occasionally, *Schima wallichi* is also seen. *Daphne involucrate, Helicia nilagirica, Ligustrum robustum, Michelia punduana, Symplocos racemosa, Quercus glauca, Vernonia volkamerifolia, Viburnum foetidum,* and *V. simonsi,* are common in the sub-canopy layer. Tree ferns are commonly found in the forest.

The common shrub species found in the forest include, *Ardisia* sp., *Baliospermum micranthum, Camellia caudata, Clerodendron* sp., *Eurya japonica, Goniothalamus sesquipedalis, Ixora subsessilis, Neillia thorsiflora, Psychotria* sp., *Sarcandra glabra, Sarcococca saligna, Saurauria sp.,* and members of Acanthaceae and Araliaceae.

Sub tropical semi-evergreen forest

The altitudinal limits of distribution and climatic conditions prevailing in the subtropical semi-evergreen forest area are similar to those of evergreen forests. A transitional zone between tropical and subtropical forests is distinguishable at certain places between 1000-1400 msl.

The common canopy (25 m height) species are *Castanopsis indica, Diospyros undulata, Elaeocarpus floribundus, Engelhardtia spicata, Ficus altissima, Meliosma wallichii, Sapindus rarak, Paramichelia baillionii,* and *Vitex glabrata.* The sub-canopy in the forest is composed of small trees of *Casearia vareca, Micromelum integrimum, Photinia arguta, Symplocos cochinchinensis, Quercus semicarpifolia. Vitex vestita* and *Xylosma controversum.* Lianas are represented by *Celastrus*

campionii. Mucuna macrocarpa, Tetrastigma obovatum and the common shrubs species are *Boehmaria glabra, Clerodendron* sp., *Crotolaria assamica, Desmodium* sp. and *Maesa tetrandra.*

Subtropical pine forest

The forest is confined to the central upland of Shillong plateau between 1000-2000 msl. The climatic conditions are similar to those of evergreen and semi-evergreen forests. It occurs in Khasi and Jaintia hills above 800 msl, either as pure or mixed stands on nutrient-poor soil. The forest is exposed to annual winter fire when ground vegetation is almost completely dry. Besides annual fire, other biotic disturbances such as fuel wood collection, timber extraction and grazing are common in the forest.

The average height of pine trees ranges between 20 and 35 m, however, on degraded sites the height may be less. Few scattered trees of broad-leaved species are often associated with pine. A few small trees or large shrubs are found scattered in the forest forming the sub-canopy layer. Annual fire prevents establishment of shrubs and other woody elements. However, weeds and perennial grasses form dense undergrowth during monsoon.

Pine forest is very poor in tree species content. At places it forms a mixed stand with *Alnus nepalensis, Exbucklandia populnea. Lyonia ovalifolia, Schima wallichii, Prunus cerasoides, Prunus undulata, Rhododendron arboretum, Rhus javanica, Quercus dealbata, Q. glauca,* and *Q. griffithii.* The shrubby undergrowth includes *Bidens pilosa, Desmodium sp., Eupatorium sp., Lantana camara, Myrsine semiserrata, Osbeckia crinita, Rubus ellipticus, R. khasianus,* and *R. rugosus.*

II.3. Review of Literature

It is known that outright destruction of our natural areas is leading to an ever increasing decline in biodiversity worldwide (Kishbaugh & Yocam, 2000), including fungal species (Bunyard *et al.,* 1996). The macrofungi are those that form macroscopic sporocarps (Arnolds, 1992). According to Watling (1995) macrofungi include most Basidiomycetes (excluding rusts, smuts and yeasts), some Ascomycetes (e.g. *Peziza*) and Myxomycetes (e.g. *Fuligo*). Although it is a somewhat arbitrarily defined polyphyletic group, it is of potential use for rapid assessment of fungal diversity because of the conspicuous nature of macrofungi (Balmford, Lyon and Lang, 2000).

It is known that the species of lignocellulolytic basidiomycetes are extremely abundant in all forest types and that they are the major wood decomposers in most ecosystems (Fryar *et al.,* 1999). Bisby (1933) stated that the range of fungal distribution is controlled to a large extent by the distribution of their hosts rather than the climatic factors. Bondartsev (1953) has correlated the distribution of pore fungi with the geographical location of the area that ultimately governs its vegetation. He found less number of polypores in high altitude forest having low temperature during summer and less rainfall in the area. However, many workers have emphasized the role of climatic factors such as moisture, temperature and biotic factors apart from the nature of the substrate.

The duration of the study period for a complete inventory of a region is not clearly known. According to Tofts and Orton (1998), many years of intensive surveys

may be required to describe the macrofungal communities of a particular area adequately.

The wood rotting fungi belonging to the Polyporaceae family have been studied by various workers in India (Bose, 1919 and 1937; Banerjee, 1956; Bakshi, 1971; Thind, 1973; Singh, 1987; Roy and De, 1996; Sharma, 2000; Leelavathy and Ganesh 2000; Bisht and Harsh, 2001). Harsh and Bisht (1982) and Mehrotra *et al.* (1983) determined the role of altitude in the distribution of wood- decaying fungi in the Kumaon Himalayas, whereas Sehgal *et al.* (1966) and Bakshi (1971) studied the role of temperature as a factor in the distribution of the wood rotting fungi. Tiwari *et al.*, (1989) studied the occurrence and distribution of wood-decaying fungi in eastern suburbs of Jabalpur. In North East India, Jamaluddin *et al.* (2004) studied the occurrence and distribution of wood decaying fungi in Lower Assam, and some studies on fungal and polypore diversity have been done in Arunachal Pradesh (Singh, 1987; Bisht and Harsh, 2001; Deb and Singh, 2008).

Wood rotting fungi can be mostly seen when reproductive structures – the sporocarps are produced in the form of cups, truffles, conks, and mushrooms. Timing of sporocarp formation (and hence organism detection) is species specific, occurring when nutritional and environmental conditions (temperature, light, pH, moisture) are appropriate during particular seasons of the year (Hunt & Trappe, 1987; Luoma, 1991).

II.4. Materials and Methods

Survey and collection of wood rotting fungi

A broad based collection of the fungal fruiting bodies was done from different forests stands in the districts of Ri-Bhoi, Jaintia Hills, East Khasi Hills and West Khasi Hills of Meghalaya during the period June 2002 – December 2004 involving three wet seasons. The study did not include small or inconspicuous sporocarps.

During the study period different forests were visited a number of times within four districts of the State i.e. Ri-Bhoi District, Jaintia Hills District, East Khasi Hills District and West Khasi Hills District. Collections were done from - Byrnihat, Dawki, Jarain, Lawbyrtun, Lumsymper, Laitsohum, Laitkor, Mawiong, Mawlai, Mawblei, Mawlasnai, Swer sacred grove, Umroi, Sohrarim sacred grove, Nongkrem sacred grove, Mawphlang sacred grove, and Jowai sacred grove (Fig.2.2, Table II.1).

The percentage frequency of occurrence of each fungal species was calculated using the formula as (Zak and Willig, 2004):

$$\text{Frequency (\%)} = \frac{\text{Number of sites in which species is present}}{\text{Total number of sites}} \times 100$$

Preservation of the wood rotting fungal collections

The fruit bodies were kept in plastic bags and brought to the laboratory. Close-up images of the specimens were taken again in the laboratory. All necessary measurements and detailed observation of the fruitbodies were further made and the materials were then preserved by air drying and liquid preservation. In air drying, the

fungal sporocarps are mounted on iron nets placed at a fair distance from an electric heater blower and then dried at about 50- 70°C. This method is used for hard fruiting bodies. The soft fruiting bodies were preserved as bottled specimens in FAA solution on plastic jars. The air dried specimens were kept in plastic bags with naphthalene balls wrapped in cotton wool to keep away harmful insects. The plastic bags were then kept in paper bags and these along with the bottled specimens were given collection numbers with dates and details of the habitat and site of collection. The representative portions of each specimen were also used for microscopic studies.

Identification of the wood rotting fungi and host trees

Fruit bodies were photographed in the field and all important morphological characters were noted. Microscopic details of various representative areas of the fruitbody, hyphal system and spores were studied. 5% KOH and lactophenol were used as general mounting media. Phloxine and Cotton blue stains were routinely used. Collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literatures (Overholts, 1953; Ryvarden and Johansen, 1980; Gilbertson and Ryvarden, 1986; Bakshi 1971; Roy and Dey 1996; Sharma, 2000; Ainsworth and Bisby, 2001). Comparison was also done with materials at the Mycology Herbarium and National type collection of Forest Research Institute, Dehra Dun. The host trees were identified in the field or laboratory and also with the help of experts.

II.5. Results

Plate 2.1 shows the sites of collection of the wood rotting fungi. Table 2.1 shows the altitudinal range of the study sites along with their geographical coordinates. The wood rotting fungi were collected from the different collecting sites with altitudinal range from 604 – 1945 msl in the region (Table 2.1)

Altogether 54 specimens could be identified according to standard macroscopic and microscopic characteristics from the collection sites of which 5 species belonged to 4 genera and 4 families from the Ascomycetes and 49 species belonged to 34 genera and 17 families from the Basidiomycetes (Table 2.2). The family Polyporaceae with 23 species was found to be the most dominant, followed by the Hymenochaetaceae (6 species), Ganodermataceae (3 species), Stereaceae (3 species) Hapalopilaceae (2 species) and the Xylariaceae (2 species). One species each from the families Bulgariaceae, Pyrenemataceae, Auriculariaceae, Fistulinaceae, Fomitopsidaceae, Gloeophyllaceae, Helotiaceae, Strophariaceae, Nidulariaceae, Tricholomataceae, Meruliaceae, Pleurotaceae, Schizophyllaceae, Sparassidaceae and Tremellaceae were also obtained. The genera with highest number of species represented were the polypore members *Microporus, Polyporus, Trametes,* the Ganodermataceae member *Ganoderma*, the Hymenochaetaceae member *Phellinus* and the Stereaceae member *Stereum* each genus with 3 species.

The percentage frequency of occurrence of the wood rotting fungi collected at the different sites were calculated and it was observed that the highest frequency of occurrence was observed in case of *Earliella scabrosa, Hirshioporus abietinus,*

Schizophyllum commune and *Trametes versicolor* with 41.17% followed by 35.29% for *Fomitopsis pinicola* and *Polyporus xanthopus*, 29.41% for *Fistulina hepatica, Nidula niveotomentosa, Stereum hirsutum, S, ostrea* and *Trametes hirsuta,* and 23.52% for *Cyclomyces tabacinus, Ganoderma applanatum,* and *Pleurotus ostreatus*. These species were observed to be the most abundantly distributed in comparison to the other species in all of the collection sites. The species with the lowest percentage frequency of occurrence with 5.88% was observed in case of *Chlorociboria aeruginosa, Coriolopsis telfarii, Ganoderma lucidum, Gloeophyllum striatum, Hexagonia apiara, Inonotus dryadeus, I. rheades, Ischnoderma resinosum, Lenzites betulina, Microporus flabelliformis, M. quarrei, Omphalotus olivascens, Phellinus adamantinus, Polyporus tuberaster, Pycnoporus sanguineus, Rigidiporus microporus, Scutellinia scutellata, Trametes tephroleucus, Xylaria hypoxylon, X. polymorpha* (Table II.3).

The habitats of the wood rotting fungi varied from living to dead fallen minute twigs, small and large branches to the most massive of tree trunks. The identification of the host tree in case of several old fallen trees was extremely difficult. The majority of the hosts were mainly of angiospermic wood and few species from coniferous wood. Gymnospermic wood of *Pinus kesiya* and angiospermic wood such as those of *Alnus nepalensis, Alstonia scholaris, Ardisia flouribunda, Artocarpus chaplasha, Betula alnoides, Carpinus viminea, C. semiserrata, Cassia fistula, Castanopsis tribuloides, C. indica, Cinnamomum pauciflorum, C. parthenoxylon, Corylopsis himalayana, Elaeocarpus lancifolius,*

Erythroxylon kuntiana, Eurya accuminata, Exbucklandia populnea, Ficus clavata, F. elastica, F. trachycarpa, Grevillea robusta, Ligustrum rubustrum, Manglieta insignis, Myrica esculenta, Prunus cerasoides, Pyrus pasha, Quercus dealbata, Q. fenestrata, Q. serrata, Q. griffithi, Rhododenron arboretum, Schima wallichi, Shorea robusta, Syzigium tetiagons, Vaccinium griffithianum, Viburnum colebrookianum, and *V. foetides* were some of the main host trees that were encountered during the study (Table II.3).

Table 2.1. Collection sites with altitudes and geographical coordinates

Collection Site		Altitude (msl)	Latitude and Longitude
East Khasi Hills District:	Lumsymper	1640 m	91° 44' E, 25°15' N
	Laitsohum	1660 m	91° 40' E, 25° 24' N
	Laitkor	1800 m	91°54' E, 25°30' N
	Mawiong	1195 m	91°54' E, 25° 37' N
	Mawlai	1430 m	91°52' 45" E, 25°35' 50" N
	Mawphlang	1900 m	91°55' E, 25°34'N
	Mawblei	1750 m	91° 54' 40" E, 25° 33' 50" N
	Nongkrem	1786 m	91° 54' 40" E, 25° 29' 30" N
	Sohrarim	1640 m	91° 44' E, 25° 15' N
	Swer	1945 m	91° 48' 15" E, 25° 25' N
West Khasi Hills District:	Lawbyrtun	1312 m	91° E, 25° N
Ri-Bhoi District:	Byrnihat	604 m	91°40' E, 26° N
	Mawlasnai	890 m	92° 30"E, 25° N
	Umroi	890 m	91° 57'E, 25° 43'40" N
Jaintia Hills District:	Jowai	1300 m	92° E, 25° N
	Jarain	1331m	92° 30"E, 25° N
	Dawki	980 m	92° 01'E , 25° 11' N

Table 2.2. List of taxa collected from all the study sites of Eastern Districts of Meghalaya

Ascomycetes	
Bulgariaceae –	*Bulgaria inquinans*
Helotiaceae –	*Chlorociboria aeruginosa*
Xylariaceae –	*Xylaria hypoxylon, X. polymorpha*
Pyrenemataceae –	*Scutellinia scutellata*
Basidiomycetes –	
Auriculariaceae –	*Auricularia auricula*
Hapalopilaceae –	*Bjerkandera adusta, Ischnoderma resinosum*
Polyporaceae –	*Coriolopsis telfarii , Daedalea confragosa, Earliella scabrosa, Fomes fomentarius, Hexagonia apiara, H. tenuis, Hirshioporus abietinus, Irpex consors, Laetiporus sulphureus, Lenzites betulina, Microporus flabelliformis, M. quarrei, M. xanthopus, Polyporus brumalis, P. tenuiculus, P. tuber-aster, Rigidiporus microporus, Skeletocutis amorpha, Pycnoporus sanguineus, Trametes hirsuta, T. tephroleucus, T.versicolor, Trichaptum byssogenum*
Fistulinaceae-	*Fistulina hepatica*
Fomitopsidaceae-	*Fomitopsis pinicola*
Ganodermataceae-	*Ganoderma applanatum, G. australe, G. lucidum*
Gloeophyllaceae -	*Gloeophyllum striatum*
Strophariaceae –	*Hypholoma fasciculare*
Hymenochaetaceae-	*Cyclomyces tabacinus, Inonotus dryadeus, I. rheades Phellinus adamantinus, P. gilvus, P. wahlbergii*
Nidulariaceae-	*Nidula niveotomentosa*
Tricholomataceae-	*Omphalotus olivascens*
Meruliaceae-	*Phlebia tremellosus*
Pleurotaceae-	*Pleurotus ostreatus*
Schizophyllaceae-	*Schizophyllum commune*
Sparassidaceae-	*Sparassis crispa*
Stereaceae-	*Stereum complicatum, S. hirsutum, S. ostrea*
Tremellaceae-	*Tremella mesenterica*

Table 2.3. Family, host plant, site of occurrence , altitudinal distribution and frequency of occurrence of the wood rotting fungi in Eastern Districts of Meghalaya.

Sl. No	Fungal Species	Family	Common host tree	Site of occurr-ence	Altitudinal range (msl)	Freq. of Occu-rrence (%)
1	*Auricularia auricula*	Auriculariaceae	Unidentified Dead wood	1, 2, 17	604-1945	17.64
2	*Bjerkandera adusta*	Hapalopilaceae	Unidentified Dead wood	5, 6	1312-1640	11 76
3	*Bulgaria inquinans*	Bulgariaceae	*Lithocarpus dealbatus*	12, 13	890-1750	11.76
4	*Chlorociboria aeruginosa*	Pezizaceae	Unidentified Dead wood	12	1750	5 88
5	*Coriolopsis telfarii*	Polyporaceae	Unidentified Dead wood	4	1331	5.88
6	*Cyclomyces tabacinus*	Hymenochaetaceae	*Myrica esculenta*	11, 14, 16, 17	890-1945	23.52
7	*Daedalea confragosa*	Polyporaceae	*Quercus serrata, Rhododenron arboreum*	9,11	1195-1900	11 76
8	*Earliella scabrosa*	Polyporaceae	*Quercus dealbata* and *Pinus kesiya*	1, 2, 9, 10, 11, 12, 14	604-1900	41.17
9	*Fistulina hepatica*	Fistulinaceae	*Quercus dealbata, Castanopsis indica*	7, 11, 14, 15, 16	1640-1945	29 41
10	*Fomes fomentarius*	Polyporaceae	*Quercus glauca*	11, 17	890-1900	11 76
11	*Fomitopsis pinicola*	Fomitopsidaceae	*Pinus kesiya*	3, 6, 8, 9, 10, 12	1300-1800	35.29
12	*Ganoderma applanatum*	Ganodermataceae	*Myrica esculenta, Acer laevigatum*	3, 10, 11, 14	1300-1900	23.52

Sl. No	Fungal Species	Family	Common host tree	Site of occurr-ence	Altitudinal range (msl)	Freq. of Occu-rrence (%)
13	G. australe	Ganodermataceae	Quercus griffithii, Engelhardtia spicata.	3, 11, 15	1300-1900	17.64
14	*G. lucidum*	Ganodermataceae	Unidentified Dead wood	8	1800	5.88
15	*Gloeophyllum striatum*	Gloeophyllaceae	*Prunus jenkensii*	10	1430	5.88
16	*Hexagonia apiara*	Polyporaceae	Unidentified Dead wood	3	1300	5.88
17	*H. tenuis*	Polyporaceae	*Phoebe lanceolata*	1,2	604-980	11.76
18	*Hirshioporus abietinus*	Polyporaceae	*Pinus kesiya*	1, 2, 3, 9, 10, 11, 12	604-1900	41.17
19	*Hypholoma fasciculare*	Strophariaceae	*Syzigium tetiagons, Rhododendron arboreum*	7, 11, 14	1660-1900	17.64
20	*Inonotus dryadeus*	Hymenochaetaceae	Unidentified Dead wood	11	1900	5.88
21	*I. rheades*	Hymenochaetaceae	Fallen dead wood	5	1312	5.88
22	*Irpex consors*	Polyporaceae	*Quercus dealbata, Castanopsis tribuloides*	11, 14	1786-1900	11.76
23	*Ischnoderma resinosum*	Hapalopilaceae	*Pinus kesiya*	14	1945	5.88
24	*Laetiporus sulphureus*	Polyporaceae	Unidentified Dead wood	11, 14	1786-1900	11.76
25	*Lenzites betulina*	Polyporaceae	*Betula alnoides*	1	604	5.88
26	*Microporus flabelliformis*	Polyporaceae	*Neolitsea cassia, Lindera latifolia, Eurya acuminate*	2	980	5.88
27	*M. quarrei*	Polyporaceae	Unidentified Dead wood	2	980	5.88

Sl. No	Fungal Species	Family	Common host tree	Site of occurr-ence	Altitudinal range (msl)	Freq. of Occu-rrence (%)
28	*Microporus xanthopus*	Polyporaceae	*Syzigium tetiagons, Castanopsis tribuloides,*	1, 2, 6, 11, 12, 14	6041900	35.29
29	*Nidula niveotomentosa*	Nidulariaceae	*Ligustrum rubustrum& Pinus kesiya.*	8, 9, 10, 11, 12	1195-1900	29.41
30	*Omphalotus olivascens*	Tricholomataceae	Unidentified Dead wood	14	1786	5.88
31	*Phellinus adamantinus*	Hymenochaetaceae	*Erythroxylon kuntian*	6	1640	5.88
32	*Phellinus gilvus*	Hymenochaetaceae	Unidentified Dead wood	11, 14	1786-1900	11.76
33	*Phellinus wahlbergii*	Hymenochaetaceae	*Syzygium tetiagons* and *Myrica esculenta.*	11, 14	1786-1900	11.76
34	*Phlebia tremellosus*	Meruliaceae	*Betula alnoides* and *Quercus serrata*	11, 15	1640-1900	11.76
35	*Pleurotus ostreatus*	Pleurotaceae	*Cassia fistula, Lindera latifolia Exbucklandia populnea.*	6, 11, 13, 16	890-1945	23.52
36	*Polyporus brumalis*	Polyporaceae	*Lyonia ovolifolia*	13, 17	890	11.76
37	*P. tenuiculus*	Polyporaceae	*Neolitsea cassia*	4, 9	1331-1195	11.76
38	*P. tuberaster*	Polyporaceae	Unidentified Dead wood	11	1900	5.88
39	*Pycnoporus sanguineus*	Polyporaceae	*Shorea robusta*	1	604	5.88
40	*Rigidiporus microporus*	Polyporaceae	*Myrsine semiserrata, Litsea salicifolia, Quercus glauca.*	11	1900	5.88

Sl. No	Fungal Species	Family	Common host tree	Site of occurr-ence	Altitudinal range (msl)	Freq. of Occu-rrence (%)
41	*Scutellinia scutellata*	Pyrenemataceae.	Unidentified dead wood	11	1900	5.88
42	*Schizophyllum commune*	Schizophyllaceae	*Myrica esculenta, Shorea robusta, Pinus kesiya, Prunus cerasoides.*	2,3,6,9 ,11,12, 14	980-1900	41.17
43	*Skeletocutis amorpha*	Polyporaceae	*Symplocos glomerata, Itea chinensis.*	11	1900	5.88
44	*Sparassis crispa*	Sparassidaceae	Unidentified Dead wood	8,10	1430-1800	11.76
45	*Stereum complicatum*	Stereaceae	*Elaeocarpus lancifolius, Phyllanthus glaucus* and *Morus australis.*	10, 11	1430-1900	11.76
46	*S. hirsutum*	Stereaceae	*Artocarpus chaplasha, Pinus kesiya,*and *Docynia indica*	2, 9, 10, 11, 12	980-1900	29.41
47	*S. ostrea*	Stereaceae	*Albizzia odoratissima, Myrica esculenta, Manglieta insignia*	1, 2, 7, 11, 14	604-1900	29.41
48	*Trametes hirsuta*	Polyporaceae	*Quercus dealbata, Cinnamomum pauciflorum and Symplocos glomerata*	1,2,11, 12,14	604-1900	29.41
49	*T. tephroleucus*	Polyporaceae	Unidentified Dead wood	11	1900	5.88

Sl. No	Fungal Species	Family	Common host tree	Site of occurr-ence	Altitudinal range (msl)	Freq. of Occu-rrence (%)
50	*T. versicolor*	Polyporaceae	*Quercus dealbata, Shorea robusta Persea duthieii.*	2,3,6,9 ,11,12, 14	980-1900	41.17
51	*Tremella mesenterica*	Tremellaceae	*Myrica esculenta*	5,8,11, 14	1312-1900	23.52
52	*Trichaptum byssogenum*	Polyporaceae	*Pinus kesiya, Prunus cerasoides* and *Ficus merifolia.*	1,9	604-1195	11.76
53	*Xylaria hypoxylon*	Xylariaceae	*Myrica esculenta* and *Lindera latifolia*	11	1900	5.88
54	*X. polymorpha*	Xylariaceae	*Quercus glauca.*	11	1900	5.88

Collection Sites: 1. Byrnihat, 2. Dawki, 3. Jowai sacred grove, 4. Jarain, 5. Lawbyrtun sacred grove , 6. Lumsymper, 7. Laitsohum, 8. Laitkor, 9. Mawiong, 10. Mawlai, 11. Mawphlang sacred grove, 12. Mawblei, 13. Mawlasnai, 14. Nongkrem sacred grove, 15. Sohrarim, 16. Swer sacred grove, 17. Umroi.

II. 4. Discussion

It was observed that there were maximum representatives of the wood rotting fungi from the family Polyporaceae. This agrees with results of other basidiomycete inventories in both Southern Brazilian subtropical (Drechsler-Santos *et al.,* 2008) and tropical Northeastern Brazilian Atlantic forests (Gibertoni *et al.,* 2004).

The extensive altitudinal and hilly physiography is an important factor for the general diversity of the wood rotting fungi in the region. A great variability of

different characteristics of dead woody debris creating a wide range of niches seems to be a major factor in contributing to the diversity of the wood rotting fungi. A broad diversity of host tree species, of various volumes and diameters, i.e. logs, branches or twigs, and degree of decomposition tend to favour rich fungal communities (Kuffer and Senn-Irlet, 2005).

Considering the large area of the region, it is quite evident that there are wide gaps in our knowledge regarding the diversity of the wood rotting fungi occurring in this region. This study indicates the occurrence of these fungi only in places where collections have been made, and there are vast areas especially in the western region of Meghalaya where no wood rotting fungi has so far been reported.

This preliminary study on the diversity of a particular group of fungi in a selected area only reinforces the often repeated call and attention for more studies on biodiversity, especially in tropical regions. Further investigations, will certainly increase the number wood rotting fungi records of the region and expand the reported species ranges throughout the area.

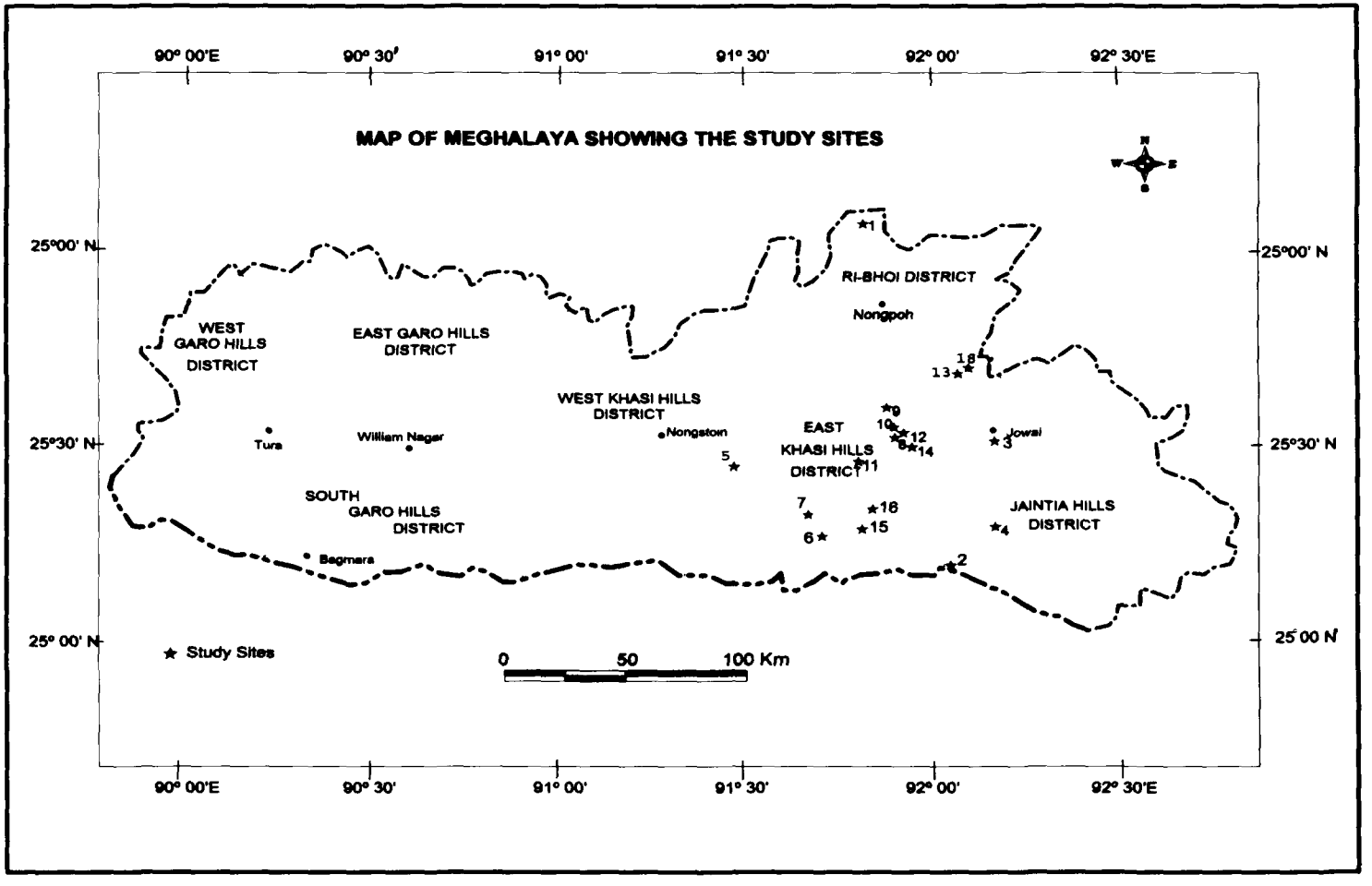


Plate 2.1 Location of the collection sites: 1- Byrnihat, 2- Dawki, 3 - Jowai sacred grove, 4- Jarain, 5- Lawbyrtun sacred grove , 6- Lumsymper, 7- Laitsohum, 8- Laitkor, 9- Mawiong, 10- Mawlai, 11- Mawphlang sacred grove, 12- Mawblei, 13-Mawlasnai, 14- Nongkrem sacred grove, 15- Sohrarim, 16- Swer sacred grove, 17- Umroi.

Chapter III

TAXONOMY OF THE WOOD ROTTING FUNGI

III.1. Introduction

The wood rotting fungi are not a taxonomic group but are used to refer to those fungi that inhabit and grow on wood (Dix and Webster, 1995; Demetriou *et al.*, 2000, Barassa *et al*, 2006) and have been interchangeably used with other terms by different workers. These fungi mainly belongs to two orders, Aphyllophorales and Agaricales of the class Basidiomycetes while a few also belongs to the Ascomycetes (Dix and Webster, 1995). The basidiomycetes members belongsing to the Polyporoid and Corticioid fungi are some of the most common and important wood-inhabiting fungi in forests. These species can account for the majority of fruit bodies found on woody debris (de Vries, 1990), yet they often are overlooked in studies of fungal diversity.

In this chapter, the taxonomy of the wood rotting fungi in the eastern districts of Meghalaya was studied with an effort to compile a taxonomical description of the species of the region.

III.2. Materials and Methods

A fresh collection of fungal fruiting bodies was done in the field. The fruit bodies were photographed in the field and all important morphological characters were noted. Notes on colour and size were taken from fresh specimens and the morphology of the fructification was studied with a hand lens. For microscopic

study, thin sections of dried specimens were taken with the help of a sharp razor blade and mounted in 3% KOH solution and stained in 2% aqueous phloxine. Sections were also mounted in 10% KOH solution, Melzer's reagent , Lactophenol or 60% lactic acid + cotton blue. Phloxine and Cotton blue stains were also routinely used.

Reagents for staining :

Melzer's reagent :	Iodine - 0.5 g, Potassium Iodide (KI) - 1.5 g, Chloral hydrate – 20 g, Distilled water - 20 ml.
Eosin and Phloxine (1 or 2 %) :	1 or 2 g Eosine or Phloxine in 100 ml water
Cotton blue :	Cotton blue in 60% lactic acid
Lactophenol :	5 g lactic acid, 5 g phenol, 10 g glycerine and 5ml water
KOH:	2 -5 % KOH in water

Collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literatures (Overholts, 1953; Ryvarden and Johansen, 1980; Gilbertson and Ryvarden, 1986; Bakshi 1971; Rattan, 1977; Roy and De, 1996; Sharma, 2000; Leelavathy and Ganesh, 2000; Ainsworth and Bisby, 2001).

Nomenclature, taxonomic position and author names followed the databases: Index Fungorum- IFS (http://www.indexfungorum.org), the International Plant Names Index – IPNI (http://www.ipni.org) and MycoBank (http://www.mycobank.com). Comparison was also done with some of the materials

at the Mycology Herbarium and National type collection of Forest Research Institute (FRI), Dehra Dun. The host trees were identified with the help of experts. Voucher specimens were housed at the Microbial Ecology Laboratory, Department of Botany.

III.3. Species description

Ascomycetes

1. *Bulgaria inquinans* (Persoon) Fries. Plate 3.1, 3.2

Fries, E.M., 1822, Systema Mycologicum 2: 166.

Synonym: *Peziza polymorpha* Oeder 1769; *Lycoperdon truncatum* Reich 1792; *Peziza inquinans* Pers. 1794; *Ascobolus inquinans* (Pers.) Nees 1817; *Phaeobulgaria inquinans* (Pers.) Nannf. 1932.

The species belongs to the Phyllum Ascomycotina, Class Ascomycetes, Subclass Leotiomycetidae, Order Helotiales, Family Bulgariaceae.

Sporocarp or fruiting body sessile to substipitate 1.0-4.0 cm broad, at first subglobose to urn-shaped, becoming turbinate, shallowly cupulate above, narrowed below; margin strongly incurved in youth, often distorted from adjacent fruiting bodies, eventually upright with a narrow lip; hymenium shallowly concave, occasionally convex, blackish-brown, smooth, shiny when wet, otherwise dull; outer surface scurfy, dingy-brown; context gelatinous, brown; odor not distinctive; taste not tried. Spores 10.0-16.0 x 6.0-7.0 μm, smooth, thin-walled, elliptical to bean-shaped; often only the upper four spores fully developed, i.e. pigmented brown, the lower spores hyaline; asci uniseriate, apical pore bluing in Melzer's reagent; spores dark-brown in deposit.

Habit and Habitat: Solitary to cluster on hardwood logs; fruiting throughout the rainy season.

Collection Site: Nongkrem sacred grove.

Distribution: In India this species has been reported from dead wood of *Quercus incana* Roxb., Mussoorie, U.P. (Thind and Singh, 1961); dead stem of *Quercus* sp., and P*runus* sp., Darjeeling, West Bengal (Kar and Maity, 1970).

Comments: This species is commonly known as Black Jelly drops. (Seaver, 1978; Dennis, 1981; Breitenbach and Kränzlin, 1984; Medardi, 2006).

2. *Chlorociboria aeruginosa* (Oeder) Seaver ex C.S. Ramamurthi, Korf and L.R. Batra. Plate 3.3, 3.4

Mycologia 49(6): 859. 1957.

Synonym: *Helvella aeruginosa* Oeder 1770; *Chlorosplenium aeruginosum* (Oeder) De Not. 1864.

The species belongss to the Phyllum Ascomycotina, Class Ascomycetes, Subclass Leotiomycetidae, Order Helotiales, Family Helotiaceae.

Fruiting body cup-shaped at first, becoming flattened or disc-shaped; up to 1 cm across; with a centrally attached stipe or stem, smooth or slightly wrinkled; uniformly blue-green. Spores 9-14 x 2-4 μ, more or less spindle-shaped; smooth; with oil droplets at each end. Tomentum on upper surface delicate and composed of roughened cells that look like spiny worms.

Habit and Habitat: Saprobic on well decayed, barkless hardwood logs and sticks, especially those of oaks; evident as green-stained wood year-round, but the fruiting bodies typically appearing during the rainy season.

Collection site: Mawphlang sacred grove

Distribution: In India, recorded on dead wood and stump of Oak tree, Mussoorie, Uttar Pradesh (Thind and Singh, 1961).

Comments: *C. aeruginosa* can easily be confused with its close relative, *C. aeruginascens. C. aeruginosa* tends to be a little smaller and have a centrally attached stipe rather than a laterally attached stipe. The most consistantly reliable differentiation is the larger spores of *C. aeruginosa*: 9-15 X 1.4-2.8 µm versus 5-8 X 0.7-2.8 µm for *C. aeruginascens* (Seaver, 1936; Ramanurthi *et al.*, 1957).

3. ***Scutellinia scutellata*** (L.) Lamb., Fl. Plate 3.5

Myc. Belg. Suppl. 299. 1887.

Synonym: *Patella scutellata* (L.) Morgan.

The species belongss to the Phylum Ascomycotina, Class Ascomycetes, Subclass Pezizomycetidae, Order Pezizales, Family Pyrenemataceae.

Fruiting body minute, 0.5-1.5 cm broad, at first nearly round, becoming disc-shaped, the margin reflexed, sometimes wavy, with long (1-2 mm), stiff, dark-brown to black hairs; fertile upper surface or the hymenium red to orange, smooth; sterile lower surface colored like the hymenium but duller, also hairy, but not so conspicuously as the cup margin; stipe absent; flesh thin. Spores 17-20 x 11-13 µm, elliptical, slightly warted, hyaline, containing one to several oil droplets.

Habitat and Habitat: Gregarious to grouped on moist, well rotted wood, less commonly on soil; fruiting from late winter to spring.

Collection site: Mawphlang sacred grove.

Distribution: In India reported from Amboli , Maharashtra (Patil and Thite, 1978; Patil and Patil, 1984).

Comments: This species is recognized by long, stiff, dark-colored marginal cup hairs and a red to orange hymenium.

4. *Xylaria hypoxylon* (L.: Fries) Grev. Plate 3.6

Flora Edinensis 1: 355. 1824.

Synonym: *Clavaria hypoxylon* L. 1753; *Sphaeria hypoxylon* (L.) Sowerby 1797; *Xylosphaera hypoxylon* (L.) Dumort. 1822.

The species belongss to the Phyllum Ascomycotina, Class Ascomycetes, Subclass Sordariomycetidae, Order Xylariales, Family Xylariaceae.

Sporocarp or fruit bodies erect, tough, pliant, clavarioid in shape, usually branched near the top, occasionally simple, up to 8 cm tall by 3-5 mm broad, often flattened in cross section above, rounded below; the base dark brown to black, often tomentose, branch tips white from asexual spores (conidia) or concolorous with the base and minutely pimpled with perithecial pores; ascospores 10-14 X 4-6 μm, black, smooth, kidney shaped; asexual spores hyaline, smooth, elliptical to elongated; habitat scattered to gregarious to clustered on rotting wood; edibility unknown.

Habit and Habitat: Fruiting bodies are blackish, thin, wiry and branched with white tips. The white tips consist of masses of asexual spores (conidia). As the fruiting body matures, it thickens, becomes all black, and sexual (ascospores) are produced in embedded perithecia. The latter form tiny pores on the surface of the fruiting body. (Dennis, 1981; Breitenbach and Kränzlin, 1984; Medardi, 2006).

Collection Site: Mawphlang sacred grove

Distributon : Found on Sone River, Bihar, old wood in Darjeeling and Calcutta, West Bengal, buried wood, Saharanpur, Uttar Pradesh, branches of Casuarina, Nicobar Island (Berkeley, 1856; Currey, 1874; ,Hennings 1901; Sydow *et al.*, 1911); on *Shorea robusta*, India (Bagchee, 1953); dead wood, (Thite *et al.*, 1978).

Comments: It is commonly called as the Candlesnuff fungus. This species appears to be extremely variable.

5. *Xylaria polymorpha* (Pers. ex Mérat) Greville. Plate 3.7

Flora Edinensis 1: 355. 1824.

Synonym: *Clavaria hypoxylon* L. 1753; *Sphaeria hypoxylon* (L.) Sowerby 1797; *Xylosphaera hypoxylon* (L.) Dumort. 1822.

The species belongss to the Phyllum Ascomycotina, Class Ascomycetes, Subclass Sordariomycetidae, Order Xylariales, Family Xylariaceae.

Fruiting body 3-10 cm tall; up to 2.5 cm across; tough; shaped more or less like a club or a finger but occasionally flattened; usually with a rounded tip; at first

coated with a pale to bluish or purplish dust of conidia (asexual spores), except at the whitish tip, but soon blackish with a pale tip and eventually black overall; surface becoming minutely pimpled and wrinkled with maturity. Flesh: Whitish; very tough. Spores 20-31 x 5-10 μ; smooth; widely fusiform; with straight germ slits extending 1/2 to 2/3 of the spore's length.

Habit and habitat: It is a weak pathogen which enters through wounds. Found on old logs in the shade in rainy season.

Collection Site: Mawphlang sacred grove.

Distribution: In India, it has been reported from Calcutta and Darjeeling, West Bengal (Berkeley, 1856; Currey, 1874); On *Shorea robusta* in Uttar Pradesh and North Bengal (Bagchee, 1953); dead wood in Madyha Pradesh (Saxena and Vyas, 1962)

Comments: Like most wood decay Ascomycota, it causes a soft-rot, but neither a brown rot nor a white rot. This species has a very variable fruiting body, sometimes with many separate "fingers" and sometimes with the fingers fused into something more like a hand. This is actually a "species complex," with a group of closely related species as many as 5 to 10 species under the name *X. polymorpha.*

Basidiomycetes

6. *Auricularia auricula* (L.) Underw. 1902 . Plate 3.73

Underwood, 1902, Memoirs of the Torrey Botanical Club 12:15.

Synonym: *Auricularia auricula-judae* (Bull.) J. Schröt. 1888; *Tremella auricula* L. 1753.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Tremellomycetidae, Order Auriculariales, Family Auriculariaceae.

Basidiocarps tough and gelatinous when fresh, commonly solitary, occasionally gregarious or caespitose becoming variously convoluted upon maturity; yellow-brown to reddish-brown when moist; sessile to substipitate, up to 12 cm broad, 0.8-1.2 mm thick . *Internal structure.* Zona pilosa: Hairs 80-100 μm long; Zona compacta: 60-70 μm wide individual elements not distinguishable; Zona subcompacta superioris: 115-130 μm wide, a dense network giving the zone a somewhat coarsely granular appearance; Zona laxa intermedia: 245-300 μm wide, horizontal in orientation, with numerous small interstices; Zona subcompacta inferioris: 100-120 μm wide, a densely compact layer. Hymenium: about 150 μm thick.

Habit and Habitat: On dead wood of *Shorea robusta.*

Collection site: Byrnihat, Umroi and Dawki.

Distribution: In India reported from dead wood and logs of *Shorea robusta, Bambusa* sp. and *Ficus religiosa,* Calcutta, West Bengal and Sikkim(Banerjee, 1948 ; Banerjee and Ghosh, 1942); dead wood, Mussoorie, U.P.(Butler and Bisby, 1931); tree trunk, Khandala and Bombay, Maharashtra, Bengal, Kashmir and on tea stem, Darjeeling, West Bengal. (Butler and Bisby, 1931).

7. ***Bjerkandera adusta*** (Wild. : Fr.) P. Karst. Plate 3.8, 3.9

Medd. Soc. Fauna Fl. Fenn. 5: 38, 1879.

Synonyms: *Boletus adustus* Wild., Fl. Berl Prodr. p. 392, 1787; *Polyporus adustus* Wild. : Fr., Syst. Mycol. 1: 363, 1821.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Hapalopilaceae

Basidiocarps annual, resupinate, effused-reflexed to pileate, often with imbricate, narrowly elongated pilei; pilei up to 4 cm wide, usually thin and deflexed when dry, up to 8 mm thick at the base, soft and pliable when fresh, hard and brittle when dry, taste slightly bitter; pilear surface white to cream, becoming greyish to blackish along the margin (as of burned), azonate to weakly concentrically zonate, first finely velutinose, later the hyphae agglutinate and the surface becomes smooth to finely scrupose; pore surface grey to black, pores round to angular, 4-6 per mm, more rarely irregular and larger, tubes grey to black, up to 2 mm long, seperated towards the light context by a very thin black zone; context white and fibrous, distinctly thicker than the tubes, up to 6 mm thick at the base, often with thin, black lines reflecting different periods of active growth.

Hyphal system monomitic; generative hyphae with clamps, hyaline, on the surface of the pileus and in the context thick-walled to almost solid with small to large conspicuous clamps, moderately branched, 3-8 um wide, in the trama delicately thin-walled and frequently branched, 2-4 um wide. Basidia clavate, 10-14 x 4-5 um, with four sterigmata. Basidiospores oblong -ellipsoid, 4-5.5 x 2.5-3 um

Habit and Habitat: On dead hardwoods, rarely on conifers.

Collection Site: Lawbyrtun sacred grove, Lumsymper.

Distribution: Cosmopolitan species, quite common, especially in temperate areas. In East Asia known from China, Japan, Taiwan, Far East Russia, Northern Thailand, and Vietnam. In India reported by Murrill (1924), Imazeki *et al.*(1966) and Sharma(1997 and 2000). Occurrence has also been reported from Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh and West Bengal (Roy, 1996).

Comments: The white pilei with blackish pore surface are usually easy to recognize. However, frequently the species is resupinate or only with a weakly developed pileus, more or less dirty whitish. In such cases a section is necessary to reveal the darker coloured tubes. In doubtful cases the wide and thick-walled hyphae with large clamps in the context should be diagnostic. (Ryvarden and Nunez, 2001). According to Leelavathy and Ganesh (2000) however, the specimen collected by them has pore surface not black.

8. *Coriolopsis telfarii* (Kl.) Ryv. Plate 3.10

Norw. J. Bot. 19:230, 1972.

Synonyms: *Coriolopsis telfairii* (Klotzsch) Ryvarden 1972; *Trametes telfairii* (Klotzsch) Corner 1989; *Funalia telfairii* (Klotzsch) A. David and Rajchenb. 1992; *Trametella telfairii* (Klotzsch) M. Pieri and B. Rivoire 2008.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Fruitbody annual, pileate and sessile, resupinate to effused-reflexed, variously connate, pileate forms attached with a narrow lateral base or with a rudimentary stipe, coriaceous while fresh, semi-rigid when dry; effused forms up to 20 x 15 x 0.3 cm, pileate form 4-9 x 3-4.5 x 0.2-0.5 cm. Pileus surface pastel yellowish, lighter towards the margin, hispid to scrupose, soft to touch, concentrically striate or zonate, radially wrinkled, hairs more prominent on the upper ridges; margin lighter, wavy, irregularly spinose, rigid, hairs almost absent. Stipe very small, up to 1 mm long, concolorous with the pileus surface, solid. Pore surface golden blonde to clay, margin slightly greyish orange, uneven, rough; pores large, arranged in somewhat radial rows, absent near the margin, angular to alveolar or irregular, round and regular towards margin, 1-2 per mm; dissepiments projects as irpicoid and rigid structures, 100-150 μm thick; pore tubes yellowish or lighter than the pore surface, inner surface sometimes greyish 1-3 mm long, sunk into unequal depths. Context concolorous with pore tubes, up to 3 mm thick, fibrous, homogenous.

Hyphal system trimitic. Generative hyphae hyaline, thin walled, branched, nodose-septate, common in dissepiments and margin, 2-3 μm in diameter. Binding hyphae hyaline to pale coloured, well branched, non-septate, solid, 2-3(5) μm in diameter. Skeletal hyphae pale coloured, thick walled with narrow lumen, unbranched, non-septate, main stem cylindrical and equal in width, 3.75- 6.5 μm in diameter. Cystidia none. Basidioles clavate, thin-walled, 15-20 x 5-7 μm. Basidiospores not observed.

Habit and Habitat: Lignicolous causing white rot on dead hardwoods.

Collection Site: Jarain

Distribution: Paleotropical species. Occurrence in India has been reported by Sharma (1989 and 2000).

Comments: This species have been recorded in India (Sharma, 1989; Leelavathy and Ganesh, 2000) and was earlier described as *Polyporus zeylanicus* (Bakshi, 1971) and agrees with those described by Ryvarden (1976c) and East African collection by Ryvarden and Johansen (1980) in their macro- and microcharacters. The fungus is easily recognized by the antler-like and forked hairs on the pileus and the large, almost irpicoid pores.

9. *Cyclomyces tabacinus* (Mont.) Pat. Plate 3.11

Essai tax. p. 98, 1900.

Synonym : *Polyporus tabacinus* Mont.Ann. Sci. Nat. Ser. 3, vol 3:349, 1835 (PC'). ; *Polyporus spadiceus* Jungh. Verh. Batav. Genootsch. 17:54, 1838 ; *Polyporus microcyclus* Lv. Ann. Sci. Nat. 3, vol. 2:188, 1844 ; *Cycloporellus barbatus* Murr. Bull Torr. Bot. Cl. 35:397, 1908.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Hymenochaetales, Family Hymenochaetaceae.

Fruitbody annual to perennial, up to 8 cm wide and long, 1-3 mm thick, solitary to densely imbricate or in rows, sessile or more usually fanshaped to flabelliform with lateral tapering base, more seldom orbiculate with central stipelike base, consistency coriceous to brittle when dry. Pileus dark brown to bay or reddish-brown, narrowly concentrically zoned in different shades, almost black when old. Upper surface velvety, tomentose to hirsute, with age glabrous in concentric zones,

finely radiately striate, silky and shining, margin acute, often sterile below and fulvous in young specimens. Pore layer fulvous to dark brown sometimes with a greyish tint. Pores round and entire, when old often lacerate, 8-9 per mm, tubes 0.5-1 mm deep. Context duplex, 0.5-1 mm thick, ferruginous to cinnamon, towards the tomentum separated by one or two (seldom three) dark lines or zones of dark agglutinated hyphae.

Hyphal system monomitic, generative hyphae in the tubes yellowish to brown, thin to thick-walled, simple-septate, 3.5-5 μm in diameter, the pileus tomentum consists of brown thick-walled hyphae, 5-6 μm wide. Setae dark brown, thickwalled and pointed, 25-45 μm x 5-6.5(8) μm, often bent towards the base. Spores elliptical 2.5-3.5 x 1.5-2 μm, hyaline to pale brown, smooth and non-amyloid.

Habit: On dead wood.

Collection site: Mawphlang sacred grove, Nongkrem sacred grove, Swer sacred grove, Umroi.

Distribution: Pantropical and rather common. In India reported by Bakshi *et al.*, (1972) and Sharma(1989).

Comments: The species is easily separated from *Inonotus* species by the thin flabellate fruitbodies with a duplex context, and when fertile, by the small spores as all *Inonotus* species have larger spores and homogenous context.

10. *Daedalea confragosa* Bolt. ex Fries. Plate 3.12, 3.13

Syst. Myc. 1: 336. 1821

Synonyms: *Boletus confragosus* Bolton. 1791; *Daedaleopsis confragosa* (Bolt.: Fr.) Schröt., Krypt. Fl. Schles. 1888; *Trametes confragosa* (Bolton) Rabenh. 1844.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, and Family Polyporaceae

Fruiting body or sporophore sessile or effused-relexed, leathery and watery when fresh, rigid and firm on drying; pileus plane or slightly convex, 2-10 x 3-5 x 0.2-2(-3) cm., grayish, sinereous, smoky umber or brownish, sometimes blackish in extreme age, occasionally somewhat rosy when handled fresh, unchanged on drying, finely pubescent to glabrous or nearly so, sometimes radiately rugose, often multizonate at least towards the margin, and frequently drying rough, the margin thin, acute; context whitish to wood-colored or pale brown, zonate, floccose to corky, 0.2- 1(-2) cm. thick; pore surface whitish to avellaneous, isabelline, or pale brown, sometimes pinkish flesh color where handled, poroid, daedaloid, or lamellate, the tubes 0.1-1.5 cm. long, the mouths subcircular to elongate, daedaloid or lamellate, 0.5-1.5 mm broad, the walls sometimes thick and regular, but often becoming lacerate and sometimes toothed; spores cylindric, smooth, hyaline, 7-9 x 2-2.5 μm; cystidia none, but hyaline or slightly colored, branched, inconspicuous, paraphysis- like hyphae 2-3 μm in diameter present between the basidia, sometimes abundant but usually only occasional and often not easily located; main hyphae simple, with the walls competely thickened, with no cross walls or clamps, 5-12 (-15) μm in diameter; other smaller hyphae 4-6 μm in diameter, considerably branched to form a simple type of hyphal complex.

Habit and Habitat : On dead wood or occasionally from wounds in living deciduous trees, noted on *Acer, Alnus, Betula, Carya, Castanea, Cornus, Crataegus, Fagus, Fraxinus, Gleditsea, Ilex, Liriodendron, Magnolia, Nyssa, Ostrya, Platanus, Populus, Pyrus, Quercus, Salix, Tilia* and *Ulmus.* Rarely on conifers (Overholts, 1953).

Collection Site: Mawiong, Mawphlang.

Distributon : It is found in the USA, Canada(Overholts 1953) and Mexico(Murill, 1915). *Daedaleopsis confragosa* (Bolt.: Fr.) Schroet. Has been reported from India by Imazeki et al. (1966), Thind and Dhanda (1978) and Sharma (1997, 2000).

11. *Earliella scabrosa* (Pers.) Gilb and Ryvarden. Plate 3.14, 3.15

Mycotaxon 22:364, 1985.

Synonym: *Polyporus scabrosus* Pers. in Gaudich., Voy. aut. Monde p. 172, 1827.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, and Family Polyporaceae.

Basidiocarps resupinate, effused reflexed to more rarely distinctly pilete, often eidely effused long fallen logs, tough and coriaceous; pilear surface glabrous, widely concentrically zonate, first white to cream, soon covered by a reddish cuticle starting from the base, inold specimens covering almost the whole surface, in young reflexed specimens often visible only as a narrow zone next to the substrate, when dry the cuticle is often slightly wrinkled, individual pilei up to 1 cm thick at the base and rarely more than 4cm wide; pore surface white to cork-coloured, pores sinuous to semidaedaloid, especially on sloping parts of the basidiocarp, 2-3 per mm, but

individual elongated pores up to 6 mm long, tubes concolorous, up to 5 mm long; context white, tough, up to 3 mm thick, in section with a distinct dark line where covered with the reddish cuticle.

Hyphal system trimitic; generative hyphae with clamps, thin-walled, 1.5-4 um wide, often difficult to find in dry specimens; skeletal hyphae dominant, thick-walled to solid, hyaline, 3-6 μm wide; binding hyphae as skeletal hyphae but branched with tapering side-branches. Basidia clavate, 15-22 μm long, with four sterigmata. Basidiospores cylindrical to oblong-ellipsoid, 7-10.5 x 3-4 μm.

Habit and Habitat : Substrata on dead hardwoods.

Collection Site: Byrnihat, Dawki, Mawiong, Mawlai, Mawphlang sacred grove, Mawblei, and Nongkrem sacred grove.

Distribution: Widespread and common in tropical and subtropical areas, especially in open and degraded forests. In East Asia known from China , Japan, Taiwan, Far East Russia, Northern Thailand, and Vietnam. In India, reported drom Allahabad (Sharma, 2000; Singh *et al,* 2001.)

Comments: Normally this species is easy to recognize because of the effused-reflexed, tough basidiocarps with a reddish cuticle and irregular, elongated and sinuous pores. The hyphae are dextrinoid. (Ryvarden and Nunez , 2001).

12. *Fistulina hepatica* Schaeff. Sibth. 1794. Plate 3.16, 3.17, 3.18

Sibthorp, 1794, Flora oxoniensis

Synonym: *Boletus hepaticus* Schaeff. 1774; *Thelephora bucreas* Spreng. 1806; *Boletus hepaticus* Vent. 1812; *Confistulina hepatica* (Sacc.) Stalpers 1983.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Agaricales, and Family Fistulinaceae.

Sporocarp or fruiting body bracket form, 8-25cm across, 2-6cm thick, usually single, tongue-shaped or semicircular; upper surface pinkish to orange-red and finally purple-brown; rough with rudimentary pores, especially toward the margin; moist to tacky. Tubes up to 15mm deep; arising free, but adhering in maturity; whitish or yellowish. Pores 3 per mm, circular; whitish at first, bruising reddish brown. Stem none or rudimentary; short, thick, blood red. Flesh thick, succulent; mottled, dark flesh-pink with lighter veining, with bloodlike sap; reminiscent of raw meat. Odor pleasant. Taste sourish. Spores ovoid, smooth, 4.5-6 x 3-4μ. Spore deposit pinkish salmon.

Habit and Habitat: On base of living hardwoods, singly or sometimes several in a cluster on the base of living oaks or chestnuts, also dead hardwood stumps.

Collection locality: Laitsohum, Mawphlang sacred grove, Nongkrem sacred grove, Sohrarim, Swer sacred grove.

Distribution: Frequent; common in the East. Common in Europe and found in Australia and North America especially eastern areas (Gilbertson and Ryvarden, 1986; Bougher and Syme, 1998; Bernicchia, 2005). In India it has been recorded by Berkeley (1854) and Sharma (2000).

Comments: Commonly known as the Beefsteak Fungus, it is edible. Infected oak timber has a much richer, darker color and is much sought after by furniture makers.

13. *Fomes fomentarius* (L. ex Fr.) Fr. Plate 3.19

Summa Veg, Scand. 2: 321, 1849.

Synonym: *Boletus fomentarius* L. 1753; *Polyporus fomentarius* (L.) Fr., Syst. Mycol. 1: 374, 1821; *Ungulina fomentaria* (L.) Pat. 1900.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, and Family Polyporaceae.

Basidiocarp perennial, sessile, ungulate, 12-15 x 10-12 x 7-10 cm; upper surface brown to grey or greyish black, crusty smooth, glabrous, older part zonate and sulcate; margin thick, light brown, also zonate, minutely tomentose, context yellowish brown, tough, corky, up to 3 cm thick; hymenial surface greyish when fresh, grey to brown on drying, pores circular, 3-4 per mm, pore tubes dull brown, often plugged with white mycelium, up to 1.5 cm long in each layer.

Hyphal system trimitic. Generative hyphae branched, hyaline, thin-walled, clamped, 1.5-3.5 um wide. Skeletal hyphae thick-walled, much branched, light yellow-brown, tortuous, 1.5-3.5 um wide, yellowish brown in KOH; basidia hyaline, thin-walled, wide at the base; sterigmata 4, smooth, 20-25 x 8-11.5 um; basidiospores hyaline, cylindric, 12-18 x 5-7 um. Cystidioles thin-walled, fusoid. 24-35 x 3.5 - 7.0 um.

Habit and Habitat: Grows on live trees of *Quercus* sp., and is perenial. A single tree may bear many fruiting bodies.

Collection Site: Mawphlang sacred grove and Umroi.

Distribution: America, Australia, China, India, Portugal, former USSR, Yugoslavia. In India it has been reported by several workers (Berkeley, 1854; Llyod, 1914, 1915,

1924; Anon. 1950; Thind and Rattan, 1971; Bakshi *et al.,* 1972; Sharma, 1985 and 1997). Collections from Sonamarg (Jand K), Khasi Hills (Meghalaya), Kumaon (UP), Darjeeling (WB), North West India has also been reported (Roy an De, 1996).

Comments: It is often named as 'horse's hoof fungus' or 'tinder fungus' and causes White rot.

14. *Fomitopsis pinicola* (Swartz: Fries) Karst. Plate 3.20, 3.21.3.22

Krit. Finl. Basidsv., p.306. 1889.

Synonym: *Boletes pinicola* Swartz, Svenska Vetensk. - Akad. Handl. 1810:88, 1810; *Polyporus pinicola* Sw.: Fr., Syst. Mycol. 1: 372, 1821; *Fomes pinicola* (Sw. ex Fr.) Cke., Grevillea 14: 17. 1885.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Fomitopsidaceae.

Basidiocarps perennial, usually sessile, woody, applanate to ungulate, up to 20 x 20 x 10 cm, rarely effused-reflexed to ungulate; pilear surface with reddish brown resinous layer when young, becoming glabrous later and sometimes laccate, greyish to blackish brown, smooth to sulcate; context cream to woody brown, 1-3 cm or more thick; pore surface cream or brownish, darkening when bruised in fresh condition, pors circular, 5-6 per mm, with thick, entire dissepiments, tubes stratified, concolorous with the context up to 6 mm long in each layer, sometimes seperated by a thin layer of context; context cream coloured, corky to woody, azonate to zonate, up to 12 cm thick; unpleasant acid scent when fresh.

Hyphal system trimitic; generative hyphae with clamps, 3-6 um wide; skeletal hyphae thick-walled, hyaline, rarely branched, 3-6 um wide; binding hyphae thick-walled, much branched, up to 4 um wide. Cystidia hyphoid, hyaline, up to 4 um wide, projecting above the basidial layer. Basidia short clavate, 16.0-22.0 x 6.5-8.0 um. Basidiospores hyaline, thin-walled, smooth, ellipsoid-cylindric, 6.0-8.0 x 3.0-4.0 um.

Habit and Habitat: Solitary to scattered on *Pinus kesiya* logs and stumps, less common on hardwoods; fruiting year round; inedible, too woody.

Collection Site: Jowai sacred grove, Lumsymper, Laitkor, Mawiong, Mawlai, Mawblei

Distribution: Circumboreal in the coniferous zone and extends southward to the pine forests in subtropical Central America and East Asia (Nunez and Ryvarden, 2001). In India, it has been reported to occur in the Eastern and Western Himalayas by Roy and De (1996) and Sharma (1997).

Comments: *F. pinicola* conks may grow for many years, each season adding a new layer of tubes. Counting the tube layers, somewhat analagous to counting tree rings, gives a rough idea of the age of the conk. *F. pinicola* is an important decayer of conifer wood. It is generally described as a saprophyte but in some areas is know to attack living trees (Lowe 1957; Overholts 1967; Gilbertson 1974; Gilbertson and Ryvarden 1986; Bernicchia 2005).

15. *Ganoderma applanatum* (Persoon) Patouillard. Plate 3.23, 3.24

Soc. Mycol. France Bull. 5: 67. 1889.

Synonym: *Ganoderma lipsiense* (Batsch) G.F. Atk. 1908 ; *Boletus applanatus* Pers. 1799; *Polyporus applanatus* (Pers.) Wallr. 1833; *Fomes applanatus* (Pers.) Gillet 1878.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Ganodermataceae

Sporocarp or fruiting body perennial,woody, typically sessile, 6-60 cm broad, 5-10 cm thick, fan-shaped to slightly convex, rarely hoof-like, usually solitary; margin rounded early, becoming narrowed at maturity; surface a hard crust, dull grey, grey-brown to brown, irregular, often furrowed, nodulose and zonate, frequently dusted with brown spores. Flesh up to 6.0 cm thick, brown, tough, corky, blackening in KOH; pores 4-6 per mm, white, quickly bruising brown when injured, fading to pale yellowish-buff when dried; tubes multi-seried, 4-13 mm long, brown, each layer separated by a thin layer of tissue; tubes and pores blackening in KOH; spores 6-9.5 x 5.7 μm, broadly elliptical, blunt at the distal end, thick-walled, ornamented with minute spines; spores brown in deposit.

Habit and Habitat: habitat solitary or in small groups on downed logs of both hardwood and *Pinus kesiya*, also on living trees; inedible, woody.

Collection Site: Jowai sacred grove, Mawlai, Mawphlang sacred grove, Nongkrem sacred grove.

Distribution: Worldwide in distribution. It has been reported by several workers in India (Banerjee, 1947; Bagchee and Bakshi, 1950; Anon, 1950; Saxena, 1960; Bakshi *et al.,* 1972; Sharma, 1985; Sharma and Ghosh, 1989).

Comments: It is commonly known as 'Artist's Conk' and is one of the best known shelf fungus. It is distinguished from other woody polypores by a dull grey-brown, bumpy, usually zonate cap, often powdered brown from released spores, and a white pore surface which instantly darkens when injured (Overholts, 1967; Gilbertson and Ryvarden, 1986; Bernicchia, 2005).

16. *Ganoderma australe* (Fr.) Pat. Plate 3.25, 3.26

Patouillard, N.T., 1889, Bulletin de la Société Mycologique de France 5: 71

Synonym: *Polyporus australis* Fr. 1828; *Ganoderma tornatum* (Pers.) Bres. 1912;

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Ganodermataceae

Basidiocarps perennial, pileate, applanate to ungulate, up to 50 cm wide and long and 20 cm thick in compound basidiocarps; pilear surface tuberculate to sulcate or undulating, dark brown and covered with a crust which is black in section and varies from 0.5 mm thick at the margin to 3 mm thick at the base, difficult to crush with a fingernail, margin rounded, whitish in actively growing specimens; pore surface whitish to yellow in growing specimens and then immediately discoloured brown when bruised, in old or hibernating specimens umber to reddish brown, pores circular, 3-4 per mm, dissepiments thick, tubes dark reddish brown and without contextual layers between successive strata, up to 7 cm deep; context homogenous and evenly reddish brown, up to 10 cm thick in large specimens.

Hyphal system amphimitic; generative hyphae with clamps, thin- walled and hyaline, 1, 5-3 um wide; arboriform hyphae dominant, brown to honey yellow, thick

walled to solid, up to 6 um wide, branching at the apex. Basidia broadly clavate, 22-30 x 7-12 um , with four sterigmata. Basidiospores ellipsoid, truncate, yellowish brown, appearing rough, witha thick endosporium and a thin exosporium seperated by interwall pillars, negatice in Melzer's reagent, 8.5- 10(-12) x 5 7.5 um.

Habit and Habitat : Substrata living or dead hardwoods in many genera.

Collection Site: Jowai sacred grove, Mawphlang sacred grove and Sohrarim

Distribution: Widely distributed in temperate and tropical areas. In Eastern Asia known from China, Japan, North Thailand, and Vietnam. In India it has been recorded by Hennings (1901), Butler and Bisby (1931), Leelavathy and Ganesh (2000), and Sharma (2000).

Comments: The species is usually recognized in the field due to its thick black crust and the ungulate, dark brown pileus, tubes and context. *G. applanatum* may be seperated from *G. australe* by its much thinner crust which can be crushed with a fingernail. Microscopically the two species are seperated by spore size. (Nunez and Ryvarden, 2000)

17. *Ganoderma lucidum* (W. Curtis:Fr.) P. Karst.

Karsten, P.A., 1881, Rev. Mcol. 3(9): 17, 1881.

Synonym: *Boletus rugosus* Jacq. 1774; *Grifola lucida* (Curtis) Gray 1821; *Boletus lucidus* Curtis 1781; *Polyporus lucidus* (Curtis) Fr. 1821; *Fomes lucidus* (Curtis) Cooke 1885; *Phaeoporus lucidus* (Curtis) J. Schröt. 1888.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Ganodermataceae

Basidiocarps annual, stipitate, either centrally, but mostly laterally, or reniform to flabelliform with a contracted stipe, up to 15 cm wide and 3 cm thick near the base, coriaceous to woody hard, pileus glossy, smooth, azonate or concenrically sulcate, first yellowish, but soon reddish and in older specimens purplish to almost blackish red, margin obstuse, mostly lighter than the pileus, crust up to 100 um thick, thin and easily crushed by a nail; stipe up to 15 cm long, cylindrical to slightly flattened, up to 2.5 cm wide, often contracted to a very short, almost sessile foot, but a distinct glossy reddish cuticle between the pores and the substrate will mostly indicate a stipitate specimen; pore surface white to cream, ochraceous when old, pores circular, 4-6 per mm, tubes usually not stratified, ochraceous, up to 1 cm long near the base; context fibrous, white to light ochraceous.

Hyphal system amphimictic; generative hyphae with clamps, hyaline, 2-4.5 um wide; arboriform hyphae hyaline to pale yellowish, branched in the distal end, up to 5 um wide; hyphae of the pileus forming an amyloid palisade. Basidia broadly ellipsoid, 12-15 x 9-11 um, with four sterigmata. Basidiospores truncate, obllong with one end distinctly tapering and with an outer hyaline exosporium supported by a finely verrucose, thick-walled inner endosporium, 7-11 x 6-8 um.

Habit and Habitat: Substrata mostly on hardwoods, more rarely on conifers.

Collection Site: Laitkor.

Distribution: Cosmopolitan species, but as the interpretation of the name is very variable, the true distribution in the strict sense is unknown. In East Asia cited from China, Japan, Taiwan, North Thailand, and Vietnam.

Comments: *G. lucidum* has been frequently collected from India (Leelavathy and Ganesh, 2000) and many researchers have studied its sporophore morphology, cultural characters and pathology (Bagchee *et. al.,* 1954; Bakshi 1971; Thind *et.al.,* 1957). Bakshi (1971) and Thind *et al.* (1957) report *G. lucidum* with wider pores than those of the present collection. Many other records have been done outside India (Ryvarden and Johansen, 1980; Nunez and Ryvarden, 2000). The species is easily recognised when it has a red cuticle and a cream context. (Nunez and Ryvarden, 2000).

18. *Gloeophyllum striatum* (Sw.) Murrill

Murrill, W.A., 1905, Bull. Torrey Club 32 (7) : 370. 1905.

Synonym: *Agaricus striatus* Sw. 1788; *Daedalea striata* Fr. 1821; *Lenzites striata* (Fr.) Fr. 1838; *Boletus striatus* (Sw.) Sw. 1806; *Polystictus striatus* (Fr.) Cooke 1886.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Incertae sedis, Order Gloeophyllales, Family Gloeophyllaceae

Pileus membranaceous, flexible, dry, dimidiate to flabelliform, conchate, sessile, sometimes spuriously stipitate, imbricate, laterally connate and broadly attached or umbonate-affixed according to its position on the substratum, 2-6 x 5-8 x0.3-0.5 cm. ; surface anoderm, distinctly tomentose, zonate, opaque, isabelline to umbrinous or cinereous ; margin very thin, fertile, undulate, eroded with age: context very thin, punky, scarcely a mm. thick in most specimens, umbrinous; tubes lamelloid from the first, avellaneous to umbrinous, furrows 1-1.5 mm. broad, 2-4

mm. deep, edges thin, entire to irregularly notched and splitting with age, especially behind : spores oblong, smooth, hyaline, 6-8 X 3-4um.

Habit and Habitat: Dead wood of various kinds.

Collection Site: Mawlai

Distribution : Tropical America, Jamaica.(Murrill, 1908), Eastern Asia (Nunez and Ryvarden, 2000) and India (Sharma, 2000).

19. *Hexagonia apiara* (Pers.) Fr. Plate 3.27, 3.28

Epicr. P. 497, 1838

Synonym: *Polyporus apiarus* Pers. 1826; *Scenidium apiarium* (Pers.) Kuntze 1898.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, and Family Polyporaceae.

Basidiocarps annual to biennial, solitary, applanate, mostly dimidiate with a tapering base, up to 11 cm long, 8 cm wide, and 2 cm thick at the base, corky and coriaceous; pileus reniform, semicircular to flabelliform, applanate to concave, dark cinnamon to umber, almost blackish with age, sometimes distinctly reddish brown, covered with scattered to crowded antler-like, erect black hairs frequently forked in the upper part, with age they wear away and leave a concentrically zonate surface with scattered radial striae, margin sharp and even; pore surface beige to yellowish brown becoming greyish-brown with age, pores angular, somewhat variable, mostly 2-5 mm wide (2-4 per cm). often larger in the centre towards the base of the basidiocarp, tubes beige to greyish, up to 1 cm long; context cinnamon to

ferruginous-brown, black in KOH, 1-3 mm thick, no cuticle present in young specimens, in glabrous ones the upper hyphae agglutinate to a thin, dark cuticle.

Hyphal system trimitic; generative hyphae with clamps, hyaline, 1.5-2.5 um wide; skeletal hyphae dominant, yellowish to pale rusty brown, unbranched, thick-walled but mostly with a distinct lumen, 2.5-6 um wide; binding hyphae hyaline to yellowish, thick-walled to solid, much branched, 1.5-3 um wide. Cystidia absent; cystidia-like hyphae often projecting into the hymenium, arising from skeletal hyphae, but difficult to distinguish properly; hyphal pegs present or absent, cylindrical to conical, 50-200 x 30-80 um, yellowish brown to rusty brown. Basidia mostly collapsed, clavate, 20-30 um long, with four sterigmata. Basidiospores cylindrical, hyaline, 11-15 x 6-8 um.

Habit and Habitat : Substrata on hardwoods of all kinds.

Collection Site: Jowai sacred grove

Distribution : Asian species, known from India and eastward to subtropical China, Japan, Phillipines, Pacific Islands, and Australia. Reported from different parts of India by Bose (1921), Banerjee (1947), Anon. (1950), Llyod (1922), Sundararaman and Marudaranjan (1925), Saxena (1960), Saxena and Vyas (1962), Sharma and Ghosh (1989).

Comments: The species is easy to recognize because of the large, brown basidiocarps with large, angular pores (Nunez and Ryvarden, 2001).

20. *Hexagonia tenuis* (Hook.) Fr. Plate 3. 29

Epicr. Syst. Mycol. 498, 1838.

Synonym: *Boletus tenuis* Hook. 1822; *Scenidium tenue* (Hook.) Kuntze 1898 ; *Favolus tenuis* (Hook.) Fr. 1825; *Polyporus tenuis* (Hook.) Berk. 1839; *Daedaleopsis tenuis* (Hook.) Imazeki 1943; *Pseudofavolus tenuis* (Hook.) G. Cunn. 1965; *Trametes tenuis* (Hook.) Corner 1989.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, and Family Polyporaceae.

Fruit body annual, sessile, effused-reflexed to pileate, when pileate attached with a broad lateral base, solitary to imbricate, rarely connate; applanate to semicircular or flabelliform, thin and coriaceous, flexible, when fresh and dry; 1.5 -6 x 1.3 x 0.2-0.3 cm . Pileus surface bronze to brown; smooth but uneven, glabrous, concentrically striate to rarely zonate, radially wrinkled, sometimes slightly umbonate at the mid-base; margin entire and thin. Pore surface white to greyish white when fresh; greyish beige when dry; pores extending to the margin, large, usually hexagonal and regular, or daedaleoid, 10-12 per cm; pore mouth 650-900 um wide; dissepiments rigid and sharp towards the periphery, 185-250 um thick; tube insides topaz to greyish beige, 1-1.5 mm long, sunk into equal depths, shallow towards the margin. Context topaz while fresh, light orange when dry, homogenous, up to 1 mm thick.

Hyphal system trimitic. Generative hyphae hyaline, thin-walled, branched, nodose-septate, occasional in context, more frequent in dissepiments, 1.75-2.75 um in diameter. Binding hyphae hyaline, thick walled, moderately branched, twisted, infrequent in context and dissepiments, 2-2.5 um in diameter. Skeletal hyphae hyaline, thick-walled with lumen obliterating or narrow, unbranched and non-septate,

usually cylindrical and straight but flexous and slightly twisted towards extremities, dominating, 2.5-3.75 um in diameter. Basidioles numerous, hyaline, cylindro-clavate, thin-walled, 20-27.5 x 6.25-7.5 um. Cystidia none. Basidia not observed. Basidiospores hyaline, cylindrical to sub-allantoid, thin-walled, smooth, 0-2 guttulate, non-amyloid , 9-14(15.5) x 3-4.5 um. Spore print white.

Habit and Habitat : On dead woods.

Collection Site: Byrnihat and Dawki.

Distribution : Globally distributed in Central and South America, Australia, West Indies, Africa, India, Sri Lanka, Phillipines, Fiji, Thailand, Vietnam and New Zealand. In India reported by Llyod (1915), Bakshi (1971), Sharma (1985 and 1997), Roy and De (1996), and Leelavathy (2000).

Comments: The binding hyphae of *Hexagonia* are subhyaline to yellow brown, abundant everywhere and with short coralloid branches which makes it distinct from *Coriolopsis* and *Daedaleopsis.* Decay type is a white fibrous rot.

21. *Hypholoma fasciculare* (Huds.) P. Kumm. 1871 Plate 3. 30

Kummer, P., 1871, Der Führer in die Pilzkunde: 72

Synonym: *Naematoloma fasciculare* (Huds.) P. Karst. 1880

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Agaricales Family Strophariaceae.

Pileus Cap 2-7 cm broad, convex, expanding to nearly plane in age, sometimes with a broad low umbo; margin incurved when young, wavy if clustered, often slightly appendiculate with veil fragments; surface smooth, moist, disc yellow-

orange to tawny-orange, shading to a lighter margin, overlapped caps often patchy purple-brown from shed spores; flesh pale yellow, thin; odor not distinctive; taste bitter; lamellae gills adnate, crowded, narrow, yellow becoming sulphur-green, in age dingy, olive-brown from maturing spores; stipe 2-9 cm tall, 0.4-1.5 cm thick, equal or tapering downward, hollow, often twisted, pale yellow with brown fibrils, bruising brown on handling; partial veil evanescent, usually leaving sparse fragments on the cap margin but sometimes forming a superior fibrillose annular zone; spores 6.5-8 x 3.5-4.5 μm, elliptical, smooth, with an apical pore; spore print purple-brown.

Habit and Habitat: habitat gregarious to clustered on hardwood/conifer logs or stumps, sometimes in grass from buried wood; fruiting from late fall to mid-winter.

Collection Site: Laitsohum, Mawphlang sacred grove, and Nongkrem sacred grove.

Distribution: Worldwide. In India from West Bengal (Berkeley, 1856).

Comments: It is poisonous. Commonly known as Sulphur tuft, *H. fasciculare* forms bright yellow clusters on both hardwood and conifer wood. The sulphur-green gills, slightly appendiculate cap margin in young specimens are important field characters (Smith, 1949 and 1951; Watling and Gregory 1987).

22. *Inonotus dryadeus* (Pers. : Fr.) Murrill

North Am. Flora 9: 86, 1908.

Synonym: *Boletus dryadeus* Pers. 1799; *Polyporus dryadeus* (Pers.) Fr. 1821; *Pseudoinonotus dryadeus* (Pers.) T. Wagner and M. Fisch. 2001.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Hymenochaetales, and Family Hymenochaetaceae.

Basidiocarps annual, sessile, solitary or imbricate, applanate, dimidiate, up to 23 x 35 x 15 cm; pilear surface buff to dark brown, very finely tomentose or glabrous, azonate, becoming rimose with age, margin concolorous or sometimes ivory; pore surface buff, often exuding droplets of amber liquid in fresh specimens, becoming dark brown and cracking with age, pores circular or angular, 4-6 per mm, with thin, entire dissepiments, tubes concolorous with the context, up to 2 cm long; context bright yellowish brown at first to reddish brown in older specimens, soft, fibrous, zonate, cut surface appearing distinctly mottled because of streaks of darker, softer tissue, up to 10 cm thick.

Hyphal system monomitic; generative hyphae simple-septate, in the trama uniformly pale brownish, thin to moderately thick-walled, with rare branching, 5-9 um wide, in the context varying from pale brown and thin-walled to dark brown and thick- walled, with occasional branching, 5-14 um wide, with amorphous matter in some areas. Hymenial setae usually frequent, rare in some specimensm ventricosem usually hooked, 25-40 x 9-16 um. Basidia broadly clavate to ovoid, 14-16 x 9-11 um, with four sterigmata. Basidiospores subglobose, hyalinem smooth, becoming thick-walled, dextrinoid in Melzer's reagent, cyanophilous, 608 x 5-7 um.

Habit and Habitat : Substrata on both conifers and hardwoods.

Collection Site: Mawphlang sacred grove

Disribution: Circumpolar in boreal and temperate areas, in East Asia known from China, Japan and Far East Russia. In India reported by Sharma (1995 and 1997).

Comments: *I. dryadeus* can be readily identified by its large basidiocarps, subglobose, hyaline basidiospores, and strongly ventricose, hooked setae. Basidiocarps typically develop at the base of infected trees or from roots. (Nunez and Ryvarden, 2000).

23. *Inonotus rheades* (Pers.) P. Karst. Plate 3. 31, 3.32

Bidr. Kanned Finl. Natur Folk 37: 70, 1882.

Synonym: *Polyporus rheades* Pers. 1825; *Phylloporia rheades* (Pers.) Teixeira 1992; *Inocutis rheades* (Pers.) Fiasson and Niemelä 1984.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Hymenochaetales, and Family Hymenochaetaceae.

Basidiocarps annual, sessile or effused-reflexed, up to 12 x 8 x 2 cm; pilear surface pale yellowish brown, tomentose at first, sometimes with a rust-coloured deposit of basidiospores, becoming blackened and glabrous with age, margin concolorous, often thinned and deflexed; pore surface yellowish at first, becoming dark reddish brown with age, pores angular, 2-4 per mm, with disspiments that become thin and lacerate, tubes distinct, concolorous with the fibrous context, up to 1 cm long; context bright yellowish brown, lustrous, becoming darker and rusty brown, fainlty zonate, with a hard mycelial core composed of brown tissue with white flecks mixed through it, fibrous context sometimes duplex, entire context upto 2 cm thick.

Hyphal system monomitic; generative hyphae simple-septate, in the trama mostly pale brownish and thin -walled to dark reddish brown and thick walled, rarely branched, with parallel arrangement, 3-7 um wide, these bound together by hyphae that are multibranched, thin to thick-walled, pale to dark brown, 2-4 um wide, others dark reddish brown, thick-walled, contorted or lobed, up to 10 um wide. Setae absent. Basidia clavate, 14-16 x 5-6 um, with four sterigmata, usually obscured by masses of basidiospores. Basidiospores ovoid to broadly ellipsoid, often flattened on one side, pale golden brown, smooth, negative in Melzer's reagent, 5-6 x 3.5- 4 um.

Habit and Habitat : Substrata on fallen dead wood.

Collection Site: Lawbyrtun sacred grove.

Distribution: Throughout the range of *Populus* in North America and Europe, cited for India by Sharma (1997).

Comments: The species is recognised from *I. dryophilus* is both macro- and microscopically similar, but *I. dryophilus* has a larger basisiocarps and basidiospores, and grows on *Quercus* (Nunez and Ryvarden, 2000).

24. *Irpex consors* Berk., Plate 3. 33, 3.34

J. Linn. Soc., Bot. 16: 51 (1877)

Synonym: *Antrodiella zonata* (Berk.) Ryvarden 1992; *Polyporus consors* (Berk.) Teng 1934; *Coriolus consors* (Berk.) Imazeki 1943; *Polystictus consors* (Berk.) Teng 1963; *Trametes consors* (Berk.) A. Mitra 1989; *Cerrena consors* (Berk.) K.S. Ko and H.S. Jung 1999.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, and Family Polyporaceae.

Basidiocarp annual, resupiante to effused-reflexed; pilei small, narrow, imbticate, coriaceous; upper surface tomentose to hirsute, concentrically sulcate, white to orangish; context white, thin; hymenophore poroid to irpicoid, white to grey yellowish or yellowish orange.

Hyphal system dimitic, generative hyphae hyaline, thin-walled, septate; skeletal hyphae hyaline, thick-walled; cystidia elongate-fusiform to clavate, apically encrusted or smooth; basidiospores hyaline, oblong ellipsoid, smooth.

Habit and habitat: Found on dead hardwoods in clusters colonizing almost entire trunk of trees.

Collection site: Mawphlang sacred grove.

Distribution: Globally distributed. In India reported by Lloyd (1898-1925), cultured by Bagchee *et al.,* (1954) and have been reported on *Quercus* sp. of timber, Dehradun, Uttar Pradesh by Bakshi *et al.*(1972).

25. *Ischnoderma resinosum* (Fr.) P. Karst. Plate 3.35, 3.36

Soc. Fauna Fl. Fenn. 5:38, 1879

Synonym: *Boletus resinosus* Schrad. 1794 ; *Ischnoderma benzoinum* (Wahlenb.) P. Karst. 1879; *Polyporus resinosus* (Schrad.) Fr. 1821; *Fomes resinosus* (Schrad.) Bigeard and H. Guill. 1913; *Fomitopsis resinosa* (Schrad.) Rauschert 1990.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Hapalopilaceae.

Basidiocarp annual, single or rarely imbricate, usually dimidiate with a tapering baseor broadly attached, fairly large, up to 12 cm wide, 15 cm long and up to 3 cm thick at the base, first fleshy and sappy, later hard and brittle; pilear surface first finely tomentose and dark brown, when fresh more or less even, later the tomentum disappears in concentric zones, exposing a slightly glossy black resinous crust that shrinks when dried and has numerous radial furrows and some broad sulcate bands, margin even or lobed to incised; pore surface cream coloured, lacerate and resinous when mature, 3-5 per mm, tubes concolorous, up to 1 cm long; context first soft and whitish, with drying and age dark brown in the hard late phase, up to 1 cm thick at the base, darker than the tubes, seperated from the tomentum by a black line.

Hyphal sytem mono-dimitic; generative hyphae with clamps, in the trama straight and slightly thick-walled, 3-5 um wide, in the brown pilear tomentum tortuous, brownish and very thick-walled with a few large, scattered clamps, moderately branched, 4-10 um wide, the context dominated by the same type of hyphae, but hyaline and more frequently clamped, in parts swollen up to 12 um in KOH; skeletal hyphae partly mixed with the generative hyphae in the context, straight or slightly flexuous, very thick-walled and unbranched, 3-10 um wide; distinctive skeletal hyphae observed only in the trama, unbranched, thick-walled to solid and light yellowish at maturity, projecting into the hymenium. Cystidia absent;

hyaline, clavate to fusoid cystidioles variably present in the hymenium. Basidia clavate, 12-18 x 4.5-6 um, with four sterigmata. Basidiospores allantoid, 5-7 x 1.5-2 um with tapering apex.

Habit and Habitat : Substrata on dead conifers, very rarely on hardwoods.

Collection Site: Nongkrem sacred grove.

Distribution: Temperate species, in East Asia known from China, Japan, Far East Russia and Vietnam. In India, reported by Sharma (2000).

Comments: It is similar with *I. benzoinum* and the diagnostic characters are the whitish to light brown context and the resinous pore surface (Nunez and Ryvarden, 2001).

26. *Laetiporus sulphureus* (Fr.) Murr. Plate 3. 37

Mycologia 12: 11. 1920.

Synonym: *Boletus sulphureus* Bull. 1789; *Tyromyces sulphureus* (Bull.) Donk 1933; *Cladoporus sulphureus* (Bull.) Teixeira 1986.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Fruiting body annual, pileate, single or more commonly imbricate as large friutbodies, semicircular to fan-shaped, applanate, up to 20 cm in diameter, single pilei up 5 cm thick, fleshy and succulent when fresh, rather light of weight when dry and chalky friable and rather brittle, scent quite pleasant. Pileus glabrous, azonate, radiate rugose, uneven and slightly undulating, orange to lemon yellow when fresh light ochraceous when dry or dirty brown in old and weathered specimens, margin

more vividly coloured in old and dry specimens. Pore surface sulphureous to citric yellow when fresh, discoloured when touched in fresh condition, when dry either pale citric yellow or in weathered specimens more ochraceous to avallaneous, pores round and entire, 3-5 per mm, tubes concolorous with the pore surface, up to 4 mm deep and tubelayer very thin compared with the thick context. Context up to 3 cm thick at the base, homogeneous, cream to light citric or orange when fresh, crumbly and chalky when dry.

Hyphal system is dimitic, generative hyphae simple septate, 3-20 μm wide, thin-walled and mostly collapsed in dry specimens, in the trama of the tubes more or less parallel, 3-6 μm in diameter, partly thin-walled, partly very thick-walled simulating skeletal hyphae: the thin-walled frequently septate and richly branched, the thick-walled arise abruptly from the thin-walled, they are straight and only rarely branched, septa occur occasionally, up to 70-100 μm between each septum. In the context the generative hyphae are thin-walled, very wide and mostly collapsed, 4-20 μm wide, binding hyphae of a special type dominate the context mostly with numerous small to larger protuberances and strongly branched. Spores broadly ellipsoid to subglobose, smooth, thin-walled and nonamyloid, 5-7 x 3.5-5 μm.

Habit and Habitat : Grows in late summer on logs and stumps of hardwoods

Collection Site: Mawphlang and Nongkrem sacred grove.

Distribution : Globally distributed in Africa, Canada, China, Europe, India, Portugal, USA, Vietnam, Yugoslavia. In India it has been reported by Imazeki *et al.*(1966) and Sharma (2000), and have been reported to occur at Cherrapunjee and

Shillong (Meghalaya) , Bashahr (HP) , Sonamarg(Jand K), Raipur (MP), Chakrata, Kumaon (U.P.) (Roy and De, 1996).

Comments: Causes brown rot. Commonly called as 'Sulphur Shelf' or 'Chicken of the Woods'. The fungus is a brilliant yellow-orange with fleshy shelves and they are unlikely to be mistaken for any other fungus. The brightly-colored shelves persist several weeks, then fade to greyish-white, crumble and fall to the ground. Fruitings repeat year after year from the same stump or log (Smith 1949; Overholts 1967; Gilbertson 1974; Gilbertson and Ryvarden 1987; Burdsall Jr. and Banik 2001).

27. *Lenzites betulina* (Fr.) Fries. Plate 3.39, 3,40

Epicr. p. 405. 1838.

Synonym: *Agaricus betulinus* L. 1753; *Daedalea betulina* (L.) Rebent. 1804.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Fruitbody annual, pileate, sessile, attached with a narrow convergence base, solitary to imbricate dimidiate to flabelliform, applanate, coriaceous while fresh, tough when dry; 3.5-6.5 x 2.5 -4 x 0.3-0.5 cm. Pileus surface yellowish white while fresh, orange grey to more brownish when dry; finely tomentose to hirsute, concentrically zonate and ridged, zonations often close; margin thin, entire and smooth. Pore surface yellowish white to creamy white; mostly lamellate, often daedaleoid in some areas, lamellae regular, length varying, sometimes forked near the margin 1-1.5 per mm, 1.5-3 mm long, up to 450 um thick at the base; edges thin, entire. Context white to creamy white, fibrous, homogenous, 1-2mm thick.

Hyphal system trimitic. Generative hyphae hyaline, thin-walled, branched, septate with clamps, 2-2.5 um in diameter sparsely present in context. Skeletal hyphae hyaline to pale-coloured, thick-walled with broad narrow or obliterate lumen, unbranched, non-septate or rarely simple-septate, 3.5-7.5 um in siameter. Binding hyphae hyaline to pale-coloured, thick-walled with a narrow and distinct lumen, branched, 5-7.5 um in diameter. Binding hyphae in dissepiments more closely branched and projecting into the hymenium with a sharp apices, appearing like cystidia, 5-7.5 um in diameter. Spores 4-6 x 1.5-2.0 μm, smooth, cylindrical to elongate bean-shaped, nonamyloid; spore print white.

Habit and Habitat : Scattered to clustered in overlapping shelves on hardwood logs, but not limited to birch as the the species name would suggest; fruiting from early to late winter.

Collection site: Byrnihat

Distribution: Bakshi (1971) has reported the occurence of this species on a number of hardwoods and conifers from the Himalayan region while Leelavathy and Ganesh (2000) have reported one collection from Kerela. Roy and De, (1996) have also reported the distribution in India from Haryana Pradesh, Madhya Pradesh, W Bengal and Uttar Pradesh.

Comments: Known to cause white rot., *L. betulina* is a polypore that bears spore-bearing surface which is gill-like, not poroid. *L. betulina* is a polypore with the characteristic leathery toughness (Gilbertson and Ryvarden, 1986).

28. *Microporus flabelliformis* (Kl.) Kunt. Plate Plate 3. 41, 3.42

Rev. gen. Pl. 3: 494, 1898.

Synonym: *Microporus affinis* (Blume and T. Nees) Kuntze 1898; *Polyporus flabelliformis* Klotzsch 1833; *Polystictus flabelliformis* (Klotzsch) Fr. 1851; *Coriolus flabelliformis* (Klotzsch) G. Cunn. 1950.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarp annual, stipitate, growing singly or in groups, leathery, hard on drying, flabeliform to semicircular, 3.0 - 8.0 x 0.1-0.4 cm; stalk lateral, smooth, brownish to reddish brown to black brown with an expanded disc at the base, up to 3.0 cm long and 0.5 cm in diameter; pileus surface yellowish brown, pinkish brown, tomentose when young, glabrous with age, narrowly concentrically zonate; margin entirem thin, sterile below up to 2 mm; hymenial surface cream to pinkish, pores circular, 7-8 per mm.

Hyphal system trimitic. Generatice hyphae hyaline, thin-walled to slightly thick-walled, clamped, 2-4 um wide. Skeletal hyphae hyaline, tortuous, 2.5-6.0 um wide, thick-walled showing lumina in context and trama, and up ti 10.5 um wide in tomentum showing wide lumina at the apex. Binding hyphae hyaline, tortuous and much branched but not coralloid, 1.5-3.2 um wide, thick-walled but with lumina, at the base wider up to 6.5 um, almost solid. Basidiospores short-cylindric to ellipsoid, hyaline, thin-walled, 3.0-4.0 x 1.5-2.2 um. Dichophytic elements at the pore mouths of dry sporophores reported by Roy and De (1996)

Habit and Habitat: In small groups on downed logs of both hardwood and *Pinus kesiya*, also on living trees.

Collection Site: Dawki

Distribution: Global - Australia, India, Indonesia, Malaysia, South America, Sri Lanka, West Indies. In India it is reported to occur in Assam, UP, Tamil Nadu, W Bengal, South India and South Andaman (Roy and De, 1996)

Comments: It is inedible, tough and leathery and causes white rot.

29. *Microporus quarrei* (Beeli) Reid. Plate 3.43, 3.44

Microscopy 32:453, 1975.

Synonym: *Polyporus quarrei* Beeli, Bull Jard. bot. Etat Brux. 7:250, 1930.

Tomentoporus quarrei (Beeli) Ryv. Norw. J. Bot. 20:4, 1973.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarp annual, solitary or in small clusters, laterally to centrally stipitate with a circular to semicircular or reniform pileus, up to 10 cm wide, margin strongly curled in dry condition, in regular specimens the pileus is truly infundibuliform, in others the adjacent edges may fuse and develop pseudo-infundibuliform shapes, consistency lignicolous and hard when dry, flexible and tough when fresh. Pileus at first covered by a dense thick tomentum, white on the surface, reddish-brown towards the base, without zones, with age and growth the tomentum attains a more greyish colour and becomes variably zonate in different shades from grey and to reddish-brown in narrow bands, when young the tomentum is soft and adpressed, with age more hispid, in some narrow zones the tomentum wears away and exposes the underlying dark cuticle, in specimens which have grown close beneath larger

specimens, the whole tomentum can attain a reddish-brown colour, in dry specimens there are also some radial furrows or weak undulations which appear to have arisen during the drying, the margin is entire to lobed or weakly incised and deflexed in mature specimens, thin and papery at the margin, up to 2 mm thick at the base. Stipe rudimentary to distinct, 0.5-6 cm long, 3-8 mm thick, more or less circular in section, in fused specimens often forked in the upper part, covered with a grey to dark brown presistent dense tomentum, at the base expanded into a disclike foot, up to 10 mm in diameter, with a distinct dark cuticle in section. The tomentum is always brown next to the cuticle below which the context is reddish-brown to a depth of about 1 mm fading over to pure white in the interior, consistency lignicolous. Pore surface very light cream in young specimens, light greyish with age, pores round and entire, 5-7 per mm, apparently somewhat widened with age, in young specimens scarcely visible to the naked eye, easily seen in older ones, tubes up to 1 mm deep in old and thick specimens, white to light grey. Context duplex, at least in young specimens, the lower part dense and white, upper part more loosely developed and reddish-brown towards the cuticle.

Hyphal system trimitic, generative hyphae thin-walled and with clamps, not easy to find in old specimens, 1.5-3 μm in diameter, skeletal hyphae dominating in the fruitbody,hyaline in the upper part of the tomentum (both on the pileus and the stipe), deeper in the tomentum, in the cuticle and slightly below the cuticle light yellowish brown, thick-walled to solid, 3-8 μm in diameter, rather thinwalled towards the apex which may be slightly swollen, binding hyphae most common in the lower, denser part of the context, thin to thick-walled and moderately branched,

2-4 μm in diameter, in the pore-mouths numerous coralloid hyphae or dichophytic elements In the trama and the tomentum, very few binding hyphae and generative hyphae have been observed. Spores very difficult to observed, cylindrical to oblong ellipsoid, hyaline and thin-walled, 4.5- 6 x 2 μm.

Habit and Habitat: On dry, often hard deciduous wood, preferably trunks lying on the ground in open grassland with scattered trees.

Collection site: Dawki

Distribution: African species known from Angola, Rhodesia, Mozambique,Malawi, Zambia, Zaire, Tanzania and Kenya.

Comments: Usually this species is easy to recognize due to the greyish white, thick and persistent tomentum, occasionally with narrow reddish bands, and the brown to greyish tomentose stipe. Unique is the reddish-brown colour of both the context and the tomentum near the cuticle.

30. *Microporus xanthopus* (Fr.) Kuntze 3.45

Rev. Gen. Pl. 3: 494, 1898.

Synonym: *Polyporus xanthopus* Fr. 1818; *Polystictus xanthopus* (Fr.) Fr. 1851, *Coriolus xanthopus* (Fr.) G. Cunn. 1950, *Trametes xanthopus* (Fr.) Corner 1989.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Fruitbody annual, stipitate, sollitary or in groups, confluent, infundibuliform, coriaceous, petal-like, thin and flexible; 3.5-9 cm in diameter, up to 1.0 mm thick. Pileus surface violet brown to pastel red and its allied shades in concentric bands,

often violet brown at the centre to black towards the margin; radially winkled, occasionallu splitting, glabrous, shiny; margin pale yellow, thin and entire. Stipe central or slightly excentric light orange to light yellow, glabrous, base expanding 0.5 - 2.5 cm long, 2-4 mm thick, solid, stipe-tissue cream to alabaster, smooth, even; pores never decurrent, extending almost to pore mouth 50-65 um wide; dissepiments 50-75(100) um thick; pore tubes concolorous with the pore surface, shallow, up to 0.7 mm long, sunk into equal depths. Context white, up to 1.0 mm thick, homogenous.

Hyphal system trimitic. Generative hyphae hyaline, thin walled, branched, septate with clamps, 1.5 - 2.5 um in diameter, common in dissepiments and growing areas. Binding hyphae pale-colooured, thick-walled with narrow or obliterating lumen, richly branched, interwoven, non-septate, 2.5 -3.75 um in diameter. Skeletal hyphae pale-coloured, thick-walled with narrow or obliterating lumen, unbranched, sterigmata, 3.5 -6.25 in diameter, dominating. Basidia clavate, 4-spored. 10-12 x 3.75-4.25 um; sterigmata straight up to 2.5 um long. Cystidia none. Basidiospores cylindrical, hyaline, smooth, thin-walled, eguttulate, nonamyloid, 5-6.75 x 1.75-2.25 um. Hymenial elements collapsing into honeycomb-like structure.

Habit and Habitat : On dead branches and fallen logs.

Collection Site: Byrnihat, Dawki, Lumsymper, Mawphlang sacred grove, Mawblei, and Nongkrem sacred grove.

Distribution : Globally distributed in Africa, South America, New Guinea, Pacific Islands, Australia, New Zealand, Philippines, China, Singapore, India. In India by Bakshi (1971), from Maharashtra (Thite *et al.*, 1976), Bihar, HP, MP, Maharashtra,

TN, UP, WB, South Andaman and Nicobar Islands (Roy and De, 1996), and Kerela (Sharma *et al.*, 1985; Leelavathy and Ganesh, 2000)

Comments: Decay type caused is white rot.

31. *Omphalotus olivascens* Bigelow, Miller, and Thiers. Plate 3.45

Mycotaxon III (3): 363. 1976.

Synonym: None

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Agaricales , Family Tricholomataceae.

The pileus cap 6-18 cm broad, convex, broadly convex at maturity; margin incurved at first, expanding and becoming wavy, upturned in age; surface smooth, moist, dull orange to orange-brown, developing olive tones; flesh thin, pliant, same color as cap; odor and taste mild; lamellae: gills decurrent, concolorous with cap or lighter, luminescent; veil absent; stipe: 5-15 cm long, 1-4 cm thick, central to off-central, tapering downward, smooth, yellowish-olive, with brown stains at the base; spores: 6.5-8 x 6-6.5 μm, globose to ovoid, smooth, nonamyloid. Spore print cream to pale yellow.

Habit and Habitat : Clustered at the base of hardwood stumps or from buried roots; most common with oaks.

Collection site: Nongkrem sacred grove

Distribution: Global, in India reported from Kerela by Manimohan *et al.*(2002).

Comments: Fruits from late fall through mid-winter; not edible and toxic; causes severe gastrointestinal upsets. Commonly known as the 'Jack O'Lantern' fungus it is

sometimes also called a 'False Chanterelle' because of its yellowish color and decurrent gills. *O. olivascens* is interesting in that the fruiting bodies are luminescent, at least when fresh, with a greenish glow in the dark (Bigelow *et al.,* 1976).

32. *Nidula niveotomentosa* (Hennings) Lloyd Plate 3. 38

Mycol. Writ. 3: 455. 1910.

Synonym: *Cyathus niveotomentosus* Henn. 1898; *Nidula microcarpa* Peck 1902; *Nidula microcarpa* var. rugispora (Ellis and Everh.) V.S. White 1902.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Agaricales, Family Nidulariaceae.

Sporocarp or fruiting body called peridium up to 10 mm tall, 4-7 mm broad, cylindrical, if flaring, abruptly at the apex; outer surface, white, pubescent when young, becoming buff to pale-grey, matted when senescent; mouth fringed, the opening covered by a thin, white, evanescent, cottony membrane (epiphragm), when lost, revealing a glabrous, tan interior and small, brown, peridioles (eggs), 0.5-1.0 mm in diameter, embedded in a mucilaginous gel; spores 6.5-8.5 x 4.5-5.5 µm, broadly ellipsoid to amygdaliform, smooth, thick-walled, hyaline, hilar appendage not evident.

Habit and Habitat : In small groups on twigs and stumps on forest floor, also cosmopolitan, common, scattered to clustered on sticks, wood chips, and other woody debris, both coastal and montane; fruiting from mid to late winter, old fruiting bodies persisting for months.

Collection locality: Laitkor, Mawiong, Mawlai, Mawblei, Mawphlang sacred grove.

Distribution: The species is quite abundant in western North America from British Columbia southward as far as California. In South America it is known from Venezuela, Chile, and Argentina. It occurs also in Japan, New Zealand, and on the Blue Mountain in Jamaica. This species is considered as same to those recorded as *N. emodensis* from Sikkim, India by Llyod (1906), (Brodie, 1975).

Comments: *N. niveotomentosa* is easily recognized when young by its pubescent, white, cylindrical fruiting bodies and small brown peridioles embedded in mucilaginous gel. Older specimens may be matted, pale-grey to brown (Brodie, 1975). The main difference from *N. emodensis* may be attributed to the relatively bigger size of the peridium of *N. niveotomentosa* as described by Llyod (1906) and Brodie(1975).

33. *Phellinus adamantinus* (Berk.) Ryv

Norw. J. Bot. 19:234, 1972

Synonym: *Polyporus adamantinus* Berk. 1854; *Fomes adamantinus* (Berk.) Cooke 1885

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Hymenochaetales, Family Hymenochaetaceae.

Fruitbody perennial, solitary, epixylous, pileate, sessile, laterally attached with a broad base, semi-circular, woody hard, triquetrous; 8.5 x 4.5 x 2.5 cm. Pileus surface yellowish brown, older portions becoming rust brown to dark grey; matted tomentose while fresh, becoming glabrascent, older portions heavily crusted, concentrically zonate; margin rigid smooth and rounded. Pore surface wax yellow,

even and smooth; pores small, extending almost up to the margin, round to somewhat ovate; 5-6 per mm; pore mouth 75-125 um broad; dissepiments 35-100(150) um thick; pore tubes stratified, concolorous or slightly darker than the pore surface, 1.5 - 2 mm long. Context golden yellow with sun yellow strand, darker in KOH, 1-2 mm thick, fibrous, consisting of compac, parallel hyphae.

Hyphal system dimitic. Generative hyphae hyaline to sulphur yellow, thin-walled, sparsely branched, simple-septate, 2.5-3 um in diameter. Skeletal hyphae brownish yellow, thick-walled with broad and distinct lumen, unbranched, infrequently simple -septate, 4.5-5.5 um in diameter. Setae none. Basidia not observed. Basidiospores brownish yellow, globose, thick-walled, smooth, nonamyloid; 4-4.5 um in diameter.

Habit and Habitat : Woody, found on downed logs of both hardwood and *Pinus kesiya.*

Collection site: Lumsymper

Distribution : India, Indonesia, New Guinea. Reported from India by Sharma and Ghosh (1989), Sharma (1995 and 2000), Leelavathy and Ganesh (2000). Bakshi (1971) described it as *F. adamantinus* in the East Himalayan collection.

Comments: Causes White rot type of decay.

34. *Phellinus gilvus* (Schweinitz) Patouillard

Ess. Tax. Hym., p. 97. 1900.

Synonym: *Boletus gilvus* Schwein. 1822; *Fomes gilvus* (Schwein.) Speg. 1898; *Hapalopilus gilvus* (Schwein.) Murrill 1904; *Fomes gilvus* (Schwein.) Lloyd 1912

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Hymenochaetales, Family Hymenochaetaceae.

Sporocarp or fruiting body annual to perennial, sessile, 5-15 cm broad, 1.5-3.0 thick, more or less fan-shaped, often forming overlapping shelves; margin when young, yellowish to yellow-brown, pubescent, elsewhere the cap surface rusty-brown to dark-brown, sometimes zonate, tending to be glabrous, but often bumpy or concentrically furrowed; flesh tough, zonate, yellow to ochraceous brown, darkening in KOH; hymenophore: pores 5-7 per mm, circular, mouths rusty-brown, darkening in KOH; tubes up to 0.7 cm long, if perennial, multi-seried; spores 4.5-5 x 3-3.5 μm, oval to elliptical, smooth, nonamyloid; spores white in deposit; habitat: not edible, too tough.

Habit and Habitat: In small groups or overlapping tiers on dead hardwoods; found year-round, new fruiting bodies and fresh growth appearing after the rainy seasons;

Collection locality: Mawphlang and Nongkrem sacred grove

Distribution: It is of common occurence in India and reported by many workers (Bose, 1937; Thind and Chatrath, 1957; Imazeki *et al.*, 1966; Bakshi, 1971, Sharma, 1995 and 1997; Leelavathy and Ganesh, 2000).

Comments: Causes white rot of commercially important woods. *P. gilvus* is a common wood rotting fungi on oaks (*Quercus*) and tanbark oak (*Lithocarpus densiforus*). It has a preference for hardwoods and have a distinctive yellowish-brown pubescent growing margin with contrasting, furrowed to bumpy, brown cap, and rusty-brown pore surface, making it fairly easy to identify (Overholts, 1967; Gilbertson and Ryvarden, 1987; Larsen and Cobb-Poulle, 1990).

35. *Phellinus wahlbergii* (Fr.) D.A. Reid Plate 3.47

Contr. Bolus. Herb. 7:97, 1975.

Synonym: *Trametes wahlbergii* Fr. 1849; *Polyporus wahlbergii* (Fr.) Lloyd 1917; *Fuscoporia wahlbergii* (Fr.) T. Wagner and M. Fisch. 2001; *Mucronoporus wahlbergii* (Fr.) Zmitr., Malysheva and Spirin 2006.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Hymenochaetales, Family Hymenochaetaceae.

Basidiocarps perennial, pileate, rarely effused-reflexed, solitary or imbricate, up to 10 cm wide, 20 cm long and 5-20 cm thick at the base, applanate, semicircular to elongated and shelf-like, woody when dry; pilear surface reddish brown to umber, tomentose, narrowly banded in concentric sulcate to flat zones, with age some of the zones may become appresed, but some tomentose zones will always remain; pore surface deep rusty to chesnut brown, pores small, 7-8 per mm, tubes concolorous with the pore surface, up to 1.5 cm long; context chestnut brown, up to 5 mm thick, homogenous.

Hyphal system dimitic; generative hyphae simple-septate, thin-walled, hyaline, 2-3.5 um wide; skeletal hyphae golden to pale rusty brown, thick walled, 2-4 um wide. Hymenial setae mostly hooked, some straight, thick-walled, dark brown, subulate, 15-35(40) x 6-9 um. Basidia clavate, 10-14 x 5-7 um, with four sterigmata. Basidiospores subglobose to ellipsoid, thin-walled, hyaline to very pale brown, 4-5 x 3.5-4.5 um.

Habit and Habitat: On hardwoods.

Collection Site: Nongkrem Sacred grove and Mawphlang sacred grove.

Distribution : Widespread in tropical and subtropical zones. In East Asia known from China (Guangxi), Japan (Okinawa), India and Vietnam. In India described by a number of workers (Bakshi, 1971; Sharma , 1995; Leelavathy and Ganesh, 2000)

Comments: The species is recognised by its hooked setae. Macroscopically, the basidiocarps resemble those of *P. torulosus* in having a pubescent to hirsute pilear surface often in concentric bands. *P. setulosus* can be seperated by its larger basidiospores (Nunez and Ryvarden, 2000). Cause white pocket rot of heartwood (Leelavathy and Ganesh 2000). Bakshi (1971) described it as wider pores compared to those of Leelavathy and Ganesh (2000). Leelavathy descriptions were closer to those described by Corner (1932), Cunningham (1965). Lowe (1957) report reddish brown pore surface and Ryvarden and Johansen (1980) reported rusty to chestnut coloured pore surface and smaller pores.

36. *Phlebia tremellosa* (Schrad.: Fr.) Nakasone and Burds. Plate 3.48, 3.49

Nakasone, K.K.; Burdsall Jr, H.H., 1984, Mycotaxon 21: 245

Synonym: *Agaricus betulinus* O.F. Müll. 1777; *Sesia tremellosa* (Schrad.) Kuntze 1891; *Xylomyzon tremellosum* (Schrad.) Pers. 1825; *Merulius tremellosus* Schrad. 1794.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Meruliaceae.

Fruiting body growing flat or partly bent outward to form shelf-like caps, often imbricate (shingled), separable from the wood when fresh, often confluent, usually about 5 cm x 3 cm (but up to 25 cm x 10 cm), and 5 mm thick; if present caps

projecting up to 5 cm, soft and cartilaginous, the upper surface white to pallid, tomentose to hirsute, not zoned or only slightly zoned; spore-bearing outer (or lower) surface translucent, waxy, soft, gelatinous, elastic, when young or fresh pale orange-yellow to deep orange-red, usually blood red when older or dried, the folds narrow, up to 1.5 mm deep, radiating, branching, pleated in network pattern (merulioid) with radial folds dominating, occasionally forming long, nearly rectangular pits, 1 or 2 per millimeter; margin of flat part up to 2 mm wide, waxy, fringed, pale yellow to orange-red, occasionally darker; flesh soft, gelatinous, white to pallid. Spores 3.5-4.5 x 1-1.5(2) um, cylindric, smooth, inamyloid, colorless, often with two droplets; with clamp connections.

Habit and habitat: Fruiting on hardwood and less often conifer wood., associated with a white rot.

Collection site: Mawphlang sacred grove and Sohrarim.

Distribution: Common in North America, from southern United States to tree line in Canada; widespread in Europe; also in Morocco, Brazil, Uruguay, China, India, Japan, Siberia, Tibet, and Pakistan.

Comments: It is also known as *Meruliopsis tremellosus*. The somewhat similar *Meruliopsis corium* lacks clamp connections. *Serpula* species have dark spores (Gibson, 2007).

37. *Pleurotus ostreatus* (Jacq.) P. Kumm. 1871 Plate 3.50

Kummer, P., 1871, Der Führer in die Pilzkunde: 105

Synonym: *Agaricus ostreatus* Jacq. 1774; *Crepidopus ostreatus* (Jacq.) Gray 1821; *Dendrosarcus ostreatus* (Jacq.) Kuntze 1898.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Agaricales, and Family Pleurotaceae

Pileus cap 5-25 cm broad, fan-shaped, broadly convex to sometimes nearly plane at maturity; margin lobed to wavy, especially when young; surface smooth, white to greyish-brown; flesh white, odor of anise; lamellae gills decurrent, white, yellowish in age; veil absent; stipe: often absent, when present, short and thick: 0.5-3.0 cm long, 0.5-2.0 cm thick, eccentric or lateral with dense white hairs at the base; Spores 7.5-9 x 3.5-4.5 µm, smooth, elliptical, nonamyloid. Spore print white; habitat: forming overlapping shelves or clusters on stumps and logs of hardwoods, uncommon on conifers, from early fall to mid- winter; edible, although a few people are allergic to it.

Habit and Habitat: In small groups on hardwood and *Pinus kesiya*, also on living trees.

Collection site: Lumsymper, Mawlasnai, Mawphlang sacred grove, Swer sacred grove.

Distribution: Global, recorded in India by several workers (Anon., 1950), from Kashmir (Murrill, 1924) and Uttar Pradesh (Ghosh, et al., 1974).

Comments: Commonly known as the Oyster Mushroom, *P. ostreatus* is believed to be a species complex. Specimens can be found that vary from white and relatively thin-fleshed to thick fleshed, grey-brown (Watling and Gregory, 1987).

38. *Polyporus brumalis* (Pers.) Fr. 1818. Plate 3.52, 3.53

Fries, E.M., 1818, Observationes mycologicae 2: 255

Synonym: *Boletus brumalis* Pers. 1794; *Polyporellus brumalis* (Pers.) P. Karst. 1879; *Leucoporus brumalis* (Pers.) Quél. 1888; *Leucoporus brumalis* (Pers.) Speg. 1926; *Polystictus brumalis* (Pers.) Fr.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarp annual, usually solitary, sometimes several from a common base, soft coriaceous, centrally stipitate. Stipe up to 3 cm long and 0.6 cm diameter, frequently bulbous at the base and slightly flattened just below the pileus, white to brownish, may be minutely tomentose when fresh. Pileus up to 6 cm in diameter and 0.5 cm tick, circular, convex, usually slightly depressed at the centre; upper surface yellowish brown or purplish brown, glabrous or shortly hispid and often covered with indistinct scales; margin thin, inturned, with or without hairs; context white, suberose, up to 3 mm thick; hymenial surface white, brownish on drying, pores circular, oval, polygonal or varying in shape, 2-3 per mm. pore tubes up to 2 mm long.

Hyphal system dimitic. Generative hyphae clamped, hyaline, thin-walled, branched, usually 2.0- 4.5 um wide but many irregularly inflated up to 10 um; on the pileus surface occur some generative hyphae 2.5-4.5 um wide, thin walled to slightly thick-walled pale brown with black discontinuous deposits on walls and alsi small patches of cuticular-like cell formed of thin-walled closely intertwined hyaline generative hyphae. Gloeopleurous hyphae present, up to 10 um wide. Binding

hyphae hyaline, thick-walled, often solid in old specimens, dendritic, sparingly branched, usually 3.5-6.0 um wide producing whipilke branches, 1.5-2.0 um wide from wider stems up to 15 um wide. Basidia 2-4 sterigmate, clavate, 8.8-17 x 3.5-5.6 um. Basidiospores hyaline, thin-walled, cylindric, with one or more guttulae. 5.5-7 x 2.0-3.0 um. Cystidioles present, 8.4-17 x 3.0-4.2 um.

Habit and Habitat: Solitary but sometimes in groups. Grows mainly on fallen branches and dead wood of hardwoods and rare on conifers.

Collection Site: Mawlasnai and Umroi.

Distribution : Global , in Austria, China, India, Thailand and Yugoslavia. In India from Orissa, Uttar Pradesh and West Bengal (Roy and De, 1996)

Comments: It causes White Rot.

39. *Polyporus tenuiculus* (Beauv.) Fr.

Fries, E.M., 1821, Systema Mycologicum 1: 344

Synonym: *Favolus tenuiculus* P. Beauv. 1806

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarp annual stipitate to substipitate, fleshy when fresh, corky and brittle on drying, solitary or in small clusters with several fruitbodies joined at the base of their stipes ; stipe lateral, corky, solid; pileus 2-8 cm wide and up to 5 mm thick, flabelliform, spathulate and semi-circular; upper surface white, pinkish buff on drying, glabrous, smooth, reflecting the pores below; margin thin, entire or lobed; context white to pinkish-buff, up to 2 mm thick at the base; hymenial surface

concolorous with the pileus, pores hexagonal, radially elongated, 1-2 mm wide dissepiments thin, pore tubes cream-brown, decurrent on the stipe, up to 3 mm long.

Hyphal system dimitic. Generative hyphae hyaline, clamped. much branched,thin walled to slightly thick-walled, 3.3 -5.0 um wide. Gloeopleurous hyphae present, up to 8.5 um wide. Binding hyphae hyaline, irregularly wide, sometimes tortuous, thick-walled to solid, mostly unbranched and skeletal-like, but some dichotomously branched, trunk 4-8.5 um wide while tapering branches 1-2 um wide. Basidia 4- sterigmate, narrow clavate, with abundant oil drops in the protoplasm, 17-20 x 4-5 um. Basidiospores ellipsoid- cylindric, hyaline, often apiculate with one to two guttulae, 8.3-12 x 2.5-4 um. Cystidioles present, 15-20 x 3-4 um.

Habit and Habitat: On dead hardwoods.

Collection Site: Jarain and Mawiong.

Distribution: Pantropical, In India reported from Orissa, Uttar Pradesh and West Bengal (Bose 1919-1928; Banerjee, 1947; Roy and De, 1996) and also recorded by Sharma (2000).

Comments: It causes white rot.

40. *Polyporus tuberaster* Jacq.: Fr. Plate 3.54, 3.55

Fries, E.M., 1821, Systema Mycologicum 1: 347

Synonym: *Boletus tuberaster* Jacq. ex Pers. 1801; *Polyporellus tuberaster* (Jacq. ex Pers.) Pilát 1936.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarps annual, centrally to laterally stipitate, simple when growing on wood. Often caespitose when growing on the ground, pileus flesh when fresh, circular to semicircular or even flabelliform in compound basidiocarps, flat to depressed in the centre, up to 15 cm wide and 1.5 cm thick; pileus whitish, ochraceous to pale yellowish brown, covered with a small, tan to dark brown, agglutinated scales especially towards the margin, in pale specimens the scales are not especially distinct, with age becoming more glabrous from the centre as the scales partly are glued to the surface, margin thin, mostly finely ciliate or lacerate, flat in fresh specimens, curved in dried specimens; stipe central to lateral, straight or curved at the base, up to 6 cm long and 1.5 cm thick, with decurrent pores, at the base with white hairs under which there is a thin, resinous cuticle which may extend a short distance above the tomentum, above that the stipe is white to ochraceous; pore surface white to pale tan, pores angular, often somewhat radially elongated, 1-2 mm long and 0.5 -1 mm wide, dissepiments often lacerate or fimbriate, tubes concolorous with the pore surface, up to 5 mm long; context white, up to 1 cm thick, fleshy-tough when fresh, drying rigid and brittle.

Hyphal system dimitic; generative hyphae with clamps, hyaline, thin-walled, 3-9 um wide, dark brown on the stipe and pileus, parallel and forming tufts of hairs that are slightly amyloid in young basidiocarps; skeleto-binding hyphae hyaline, thick-walled to solid, sparingly branched, upto 12 um wide in the main stem; sclerotium mainly with skeleto-binding hyphae, in parts very finely branched and

very thin, in most parts sparingly branched, thick-walled and variable in diameter, 3-10 um wide, in some cases with apical swellings. Basidia clavate, 25-40 x 6-10 um. Basidiospores cylindrical to oblong, ellipsoid, 10-16 x 4.5-7 um.

Habit and Habitat: On hardwoods or on the ground from a blackish sclerotium.

Collection Site: Mawphlang sacred grove.

Distribution: Temperate and subtropical zones in the Northern hemisphere and Australia. Only known from Japan in East Asia. The species occur in warmer areas. Confused often with *P. squamosus*. (Nunez and Ryvarden, 2001).

41. *Pycnoporus sanguineus* (L.ex. Fr.) Murr. Plate 3.51

Murrill, W.A., 1904, Bulletin of the Torrey Botanical Club 31(8): 421

Synonym: *Boletus sanguineus* L. 1763; *Boletus nitens* Batsch 1783; *Trametes sanguinea* (L.) Lloyd 1924; *Trametes cinnabarina* var. sanguinea (L.) Pilát 1940; *Trametes sanguinea* (L.) Imazeki 1943; *Polyporus sanguineus* (L.) Fr. 1821; *Polystictus sanguineus* (L.) Fr. 1851; *Microporus sanguineus* (L.) Kuntze 1898; *Coriolus sanguineus* (L.) G. Cunn. 1949; *Fabisporus sanguineus* (L.) Zmitr. 2001.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basisiocarp annual, sessile or substipitate or effused- reflexed, dimidiate, thin and coriaceous, up to 9.0 x 5.0 x 0.4 cm; upper surface red, smooth, glabrous, often scrupose, zonate; context zonate, tough-fibrous, light red, up to 3 mm thick; hymenial surface dark red, pores circular, 4-6 per mm, pore tubes orange red, up to 2 mm long.

Hyphal systen trimitic. Generative hyphae hyaline, thin-walled, usually unbranched, with occasional branching towards the apex, frequently with deposits of orange granules, 3-6 um wide. Binding hyphae hyaline, thick-walled to solid, much branched, 2.2-3.5 um wide, abundant. Basidia 4-sterigmate, 5-6 um in diameter. Basidiospores thin-walled, hyaline, smooth, short-cylindric, slightly curved, 5-6 x 2-2.5 um. Hyphal pegs frequent.

Habit and Habitat: On standing and fallen trunks of almost every kind of deciduous wood, especially common in open and sunny localities.

Collection Site: Byrnihat

Distribution: Global. Found in India, Indonesia, North America, Thailand, Russia, Vietnam; In India reported from Uttar Pradesh, West Bengal. (Roy and De, 1996, Sharma, 2000)

Comments: It causes white rot. Characterised by producing orange-red basidiocarps, trimitic hyphal system with clamp hyphae and bearing characteristic orange granules on the hyphae (Roy and De, 1996).

42. *Rigidoporus microporus* (Sw.:Fr.) Overeem

Overeem, 1924. Icon. Fung. Malayensum 5:1.

Synonym: Boletus microporus Sw. 1788; Scindalma microporum (Sw.) Kuntze 1898; Polyporus microporus (Sw.) Fr. 1821; Fomes microporus (Sw.) Cooke 1885

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarps annual, more seldom perennial, occasionally resupinate but mostly pileate, often imbricate and gregarious, sessile or broadly attached, dimidiate to flabelliform, up to 10 cm long, 5 cm wide and 1.5 cm thick, consistency hard when dry; pileus first orange-reddish brown and slightly velutinate, later glabrous and fading to wood-colour, concentrically zonate-sulcate, sometimes tuberculate, dull to slightly glossy; margin thin and often deflexed; pore surface first bright orange to reddish brown, fading to pale brown or grey with an orange tint, pores round to angular, 6-9 per mm, dissepiments verythin, tubes single-layered but sometimes stratified and up to 1 cm long, reddish brown; context cream to wood coloured, radially fibrous, up to 1 cm thick.

Hyphal system pseudodimitic; generative hyphae simple-septate, thin to slightly thick-walled, 3-5 um wide; present are also thick-walled hyphae, especially in the context where septa are difficult to observe and which are reminiscent of ordianry skeletal hyphae, up to 8 um wide. Cystidia not present; smooth, thin-walled, mucronate cystidioles present among the basidia, 20-25 x 10-12 um. Basidia 12015 x 7-10 um, with four sterigmata. Basidiospores subglobose, 3.5-5 x 3.5-4 um.

Habit and Habitat: Substrata on numerous genera of hardwoods.

Collection Site: Mawphlang sacred grove

Distribution: Widely distributed in the tropical zone, also in subtropical Eastern North America and Asia where it is known from Nepal to China, Japan, Taiwan, Korea, North Thailand and Vietnam (Nunez and Ryvarden, 2001). In India recorded by (Roy and De, 1996; Leelavathy and Ganesh, 2000; Sharma and Ghosh, 1989; Sharma, 1997 and 2000)

Comments: In fresh condition the imbricate, reddish basidiocarps with minute pores is significant diagnostic. A serious problem in the tropics on crop plants of rubber, cacao, coconut, coffee, tea and bamboo. It causes white rot.

43. *Schizophyllum commune* Fr. 1821 Plate 3.56, 3.57

Fries, E.M., 1821, Systema Mycologicum 1: 330

Synonym: *Daedalea commune* (Fr.) P. Kumm. 1871; *Merulius communis* (Fr.) Spirin and Zmitr. 2004; *Schizonia vulgaris* Pers. 1828.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Agaricales, Family Schizophyllaceae.

Fruit body annual, but durable, thin, small, shell-shaped (1–5cm), dimidiate; usually in groups, leathery-tough; upper surface: greybrown to flesh-colored becoming white with dryness, covered with small hairs, dry, white to grayish or tan; lower surface: appearing as if gilled, hymenium covering fan-like arranged, at the beginning grey, later violet-brown pseudolamellae, which are lengthwise split and outwardly bent; hygroscopic movements of the split lamellae by being hard and rolled up in dry weather and being again flexible and sporulating after years of dryness when again moist; monomitic, tetrapolar (Raper and Miles, 1958).

Spores from 3-4 x 1-1.5 μ up to 5.5-7 x 2-2.5 μ; cylindrical to elliptical; smooth. Cystidia absent.

Habit and habitat: Common on living and dead logs. As wound parasite on living trees after bark fire damage, on stumps, stored stems, frequently on beech as first colonizer; on stored and structural timber outdoors surviving dryness and exposition

to sun by dryness resistance. Found on fallen and dead standing trees of *Pinus kesiya, Artocarpus chaplasha, Eurya acuminata* and *Docynia indica.*

Collection Site: Mawlai, Mawblei, Mawphlang sacred grove, Nongkrem sacred grove.

Distribution: Worlwide, temperate to tropical, very common.

Comments: Edible, eaten by the locals in the region; also eaten in Assam, Congo, Peru and Thailand, and used as chewing gum in Hong Kong, Indonesia and Malaysia (Dirol and Fougerousse, 1981); fructification also in culture. Commonly known as 'Split-Gill', it causes white rot; in the tropics serious wood destroyer, fruit bodies often on imported timber; in vitro only little wood decay (Schmidt and Liese, 1980).

44. *Skeletocutis amorpha* (Fr.) Kotl. and Pouz.

Kotlába, F.; Pouzar, Z., 1958, Ceská Mykologie 12(2): 103

Synonym: *Polyporus amorphus* Fr. 1815; *Bjerkandera amorpha* (Fr.) P. Karst. 1879; *Leptoporus amorphus* (Fr.) Quél. 1886; *Polystictus amorphus* (Fr.) Gillot and Lucand 1890; *Polystictoides amorphus* (Fr.) Lázaro Ibiza 1916; *Tyromyces amorphus* (Fr.) Murrill 1918; *Gloeoporus amorphus* (Fr.) Killerm. 1928; *Polyporus aureolus* Pers. 1825.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, and Family Polyporaceae.

Basidiocarp annual, sessile, effused with reflexed margin or reflexed, imbricate, leathery when fresh, hard and brittle on drying, pileus up to 10 x 6 x 0.5 cm; upper surface white to grey, matted tomentose, concentrically zonate; margin

thin, undulating, incurved when dry; context white of two distinct layers; upper one whitish, very soft and cottony, about 2 mm thick; lower one brown, waxy, dense gelatinous layer, becoming hard on drying, about 1 mm thick; hymenial surface pink to pinkish red, pores waxy, angular, 3-4 per mm, pore tubes up to 1 mm long, gelatinous and soft when fresh and horny when dry.

Hyphal system dimitic, generative hyphae thin to thick-walled, septate, hyaline, clamped, 3-5 um wide, strongly agglutinated in gelatinous layer and also in the trama, some typically encrusted at the ends of dissepiment. Skeletal hyphae hyaline, thick-walled to subsolid, 3-5 um wide, occuring in uppermost layer of the pileus, and a few also in the gelatinous layer. Basidia 4 sterigmate, 10-15 x 3-4 um. Basidiospores hyaline, thin-walled, allantoid, smooth, 4-5 x 1.3-1.8 um. Cystidioles hyaline, fusiform or mucronate.

Habit and Habitat: Found on dead *Pinus kesiya* wood. Has been recorded to occur on *Abies pindrow* Royle, *Cedrus deodara* Loudon, *Picea smithiana* Boiss., *Pinus roxburghii* sargent, *Pinus wallichiana* Jacks (Roy and De, 1996).

Collection Site: Mawphlang sacred grove.

Distribution: Global distribution: Austria, China, India, New Zealand, North America, Portugal, USA, Yugoslavia. In India recorded from Himachal Pradesh and Uttar Pradesh by Roy and De (1996) and Sharma (2000).

Comments: It causes White rot.

45. *Sparassis crispa* (Wulf.) Fr. Plate 3.58

Fries, E.M., 1821, Systema Mycologicum 1: 465

Synonym: *Clavaria crispa* Wulfen 1781; *Masseeola crispa* (Wulfen) Kuntze 1891; *Merisma crispum* (Wulfen) Ehrenb. 1818.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Sparassidaceae.

Fruiting body 20 cm broad, 40 cm tall, sometimes larger, a rounded mass of flattened, wavy, leaf-like branches, white to pale yellow; branch edges discoloring brown in age; arising from a large root-like sterile base, the upper portion appearing chambered when sectioned, solid below; flesh white. Hymenium on the flattened surfaces of the fruiting body. Odor fragrant, somewhat spicy. Spores 5-7 X 3-5 μm elliptical, smooth. Spore deposit white.

Habit and Habitat: Usually solitary at the base of conifers, fruiting from late fall to mid-winter.

Collection locality: Laitkor and Mawlai.

Distribution: Worldwide and common.

Comments: It is edible and delicious when young and fresh. Common name- 'Cauliflower mushroom'. The densely branched fruiting body of *S. crispa* resembles a cauliflower. Initially creamy-buff in color, the long-lived fruiting bodies gradually darken in age, especially along the branch edges. *S. crispa* is believed to be parasitic on conifers. Affected trees produce annual fruitings, sometimes bushel basket in size. The size, color, and flattened branch structure of *S. crispa* distinguish it from other members of the coral group (Burdsall and Miller, 1988).

46. Stereum complicatum (Fr.) Fr. 1838 Plate 3.59

Fries, E., 1838, Epicrisis Systematis Mycologici: 548

Synonym: *Thelephora complicata* Fr. 1828; *Stereum hirsutum* var. complicatum (Fr.) Rick 1940.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Russulales , Family Stereaceae.

Fruit body or sporocarp coriaceous-papery. Reflexed parts narrowly to broadly attached, becoming laterally extended; plicate to complicate; margin thin and lacerate; usually < 1 cm in radius. In section 300-500 μm thick. Upper surface mostly glabrous and shining, or with a thin, transient tomentum with strigose-hirsute patches at the point of attachment; cutis exposed, strongly zonate, with thin, alternating bands of light orange grayish , brownish orange to brown. Hymenial surface pale yellow, brownish orange, grayish brown; usually orange when fresh, sometimes bruising red; sections not diffusing a yellow pigment when mounted in KOH.

Habit and Habitat: Fruiting on dead hardwood stumps and branches, also on wood of *Pinus kesiya.*

Collection site: Mawlai and Mawphlang sacred grove

Distribution : Global.

Comments : It causes white rot.

47. *Stereum hirsutum* (Willdenow: Fries) S.F. Gray Plate 3.60,3.61

Nat. arr. Brit. pl. 1: 653. 1821.

Synonym: *Clavaria crispa* Wulfen 1781; *Masseeola crispa* (Wulfen) Kuntze 1891; *Merisma crispum* (Wulfen) Ehrenb. 1818.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Russulales, Family Stereaceae.

Sporocarp or fruiting body annual or short-live perennial, resupinate when young, forming thin, leathery overlapping shelves at maturity, 1-3.5 cm wide and up to 8 cm long when fused with adjacent shelves; upper surface hairy, undulate, lobed, banded orange-brown to yellow-brown, older tissue grey to greyish-brown; lower fertile surface smooth, orange-buff to pale-buff, if zoned, less conspicuously than the upper surface; flesh 0.5-1.0 mm thick, pliant when young, tough in age; stalk absent; Spores 5.5-7 x 3-3.5 μm, cylindrical, smooth.

Habit and habitat: Fruiting in tiers and overlapping shelves on dead hardwood stumps and branches. Occasionally on wood of *Pinus kesiya.*

Collection Site: Dawki, Mawiong, Mawlai, Mawblei, Mawphlang sacred grove.

Distribution: Worldwide. Recorded from India in several regions (Berkeley, 1856; Hennings, 1901)

Comments: It is commonly also called as 'False Turkey Tail'. Occur as small, wavy, leathery shelves. Fresh fruitings are bright orange-brown to orange-buff, fading in age or dry weather to dull-buff or grey. As the common name suggests, *S. hirsutum* is sometimes confused with *Trametes versicolor*, the so called "true" Turkey Tail. The latter significantly has a pored, not smooth fertile surface (Burt, 1920; Cunningham, 1963; Chamuris, 1985 and 1988; Bougher and Syme, 1998).

48. *Stereum ostrea* (Blume and Nees ex. Fr.) Fr. Plate 3.62, 3.63

Fries, E., 1838, Epicrisis Systematis Mycologici: 547

Synonym: *Thelephora ostrea* Blume and T. Nees 1826

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Russulales , Family Stereaceae.

Fruiting body effused-reflexed to dimidiate or laterally sessile, coriaceous to leathery. Pileus generally up to 5 cm long and 7 cm broad (rarely may be 12 x 9 cm), up to 1 mm thick in section at the base(excluding the tomentum which may be 1.5 mm thick), flabelliform to petalliform, often attached laterally by a narrow base, rarely imbricate; upper surface strongly tomentose, concentrically zonate, zones of erect and appressed tomentum, multicolored, showing a variety of colour shades of yellow and grey in concentric bands, young margin is always some shade of yellow which is followed by deeper shades of brown and grey towards the base; hymenial surface cream yellow to yellow-ochre, smooth; margin acute, paler concolorous. Context subhyaline in section, composed of compactly arranged hyphae, with a thick brown cuticle on the hymenial side. Hyphal system dimitic; skeletal hyphae branched, aseptate, the walls subhyaline, thick, often leaving a narrow lumen; generative hyphae 2-4 um wide, branched, septate clamps absent, the walls subhyaline, thin to moderately thick.

Tomentose hyphae 3-6 um wide, unbranched to rarely branched, distantly septate, usually with retraction septa, clamps absent, the walls subhyaline to tinted brown, thick (up to 2 um) and leaving a narrow lumen. Cystidiate hyphae 6-10 um broad cylindrical to hyphoid being the prolongation of skeletal hyphae which curve

into the hymenium, immersed or projecting slightly out of it., unbranched, aseptate, the walls subhyaline, thick, leaving a capillary lumen except at the top where it broadens gradually. Basidia collapsing after spore discharge, averaging 30 x4.5 um, 4 spored. Basidiospores when present are 5-6 x 2-3 um, ellipsoid, minutely apiculate, the walls hyaline, smooth, thin and amyloid.

Habit and habitat: Growing in clusters , generally found on dead logs.

Collection locality: Byrnihat, Dawki, Laitsohum, Mawphlang sacred grove and Nongkrem sacred grove.

Distribution: In India from Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir and Karnataka (Rehill and Bakshi, 1966; Rattan, 1977; Bagchee and Bakshi, 1954; Swapna *et al.*, 2008).

Comments: It is bigger and more rarely fused than *S. hirsuta.*

49. *Trametes hirsuta* (Wulf. ex Fr.) Pil Plate 3.64, 3.65

Kavina and Pilát, 1939, Atlas Champ. Eur., Polypor., B 3:265.

Synonym: *Boletus hirsutus* Wulfen 1788; *Hansenia hirsuta* (Wulfen) P. Karst. 1879; *Trametes hirsuta* (Wulfen) Lloyd 1924; *Polyporus hirsutus* (Wulfen) Fr. 1821; *Polystictus hirsutus* (Wulfen) Fr. 1851; *Coriolus hirsutus* (Wulfen) Quél. 1886; *Microporus hirsutus* (Wulfen) Kuntze 1898; *Polystictoides hirsutus* (Wulfen) Lázaro Ibiza 1916 ; *Boletus wulfenii* Humb. 1793.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarp usually annual, occasionally reviving in the second season, sessile or effused -reflexed, solitary or imbricate, dimidiate, applanate, sometimes reniform, corky-coriaceous when fresh, rigid on drying, 2-6x 2.5-8 x 0.1-1.0 cm; upper surface white or yellowish, strongly hirsute, often velvety, concentrically zonate; margin thin, even; context white when fresh, becoming woody brown on drying, coriaceous, up to 0.5 cm thick; hymenial surface white to yellowish brown, smooth, pores regular, circular or angular, 2-3 per mm, pore tubes up to 0.5 cm long.

Hyphal system trimitic. Generative hyphae hyaline, thin-walled, clamped, 2-4 um wide. Skeletal hyphae hyaline, tick-walled to solid, straoght or slightly tortuous, rarely branched, with tapering apex, 2.8-5.6 um wide. Binding hyphae hyaline, thick-walled to solid, of two types; (i) with long, tapering branches, 2-4.2 um wide, (ii) with short, much curled branches, giving a coralloid appearance, 1.5-3.0 um wide. Basidia clavate, 4- sterigmate, 12.6 - 16.0 x 4-5.6 um. Basidiospores hyaline, thin-walled, cylindrical, apiculate, 4.5-7.2 x 1.5-3.0 um. Hyphal pegs conical, composing a bundle of thin-walled generative hyphae and projecting 17.5 -24.5 um beyond the hymenial layer.

Habit and Habitat : Host -*Acacia arabica* Willd., *Celtis australis* L., *Prunus persica* (L.) Batsch, *Prunus puddum* Roxb., *Quercus* sp., *Rhododendron campanulatum* Don, *Salmalia malabarica* Schott. and Endl., *Shorea robusta* Gaertn. f., *Toona ciliata* Roem.

Collection Site: Byrnihat, Dawki, Mawphlang sacred grove, Mawblei, Nongkrem sacred grove.

Distribution: Global, recorded from Argentina, Australia, Austria , China, India, New Zealand, North America, Thailand, Vietnam, West Indies, Yugoslavia. In India recorded by several workers (Bose, 1937; Bakshi, 1971; Leelavathy and Ganesh, 1996; Sharma, 2000) and collections recorded from Himachal Pradesh, Madhya Pradesh, Uttar Pradesh and West Bengal (Roy and De, 1996)

Comments: It cause white rot.

50. *Trametes tephroleuca* Berk.

Berkeley, M.J., 1854, Hooker's Journal of Botany and Kew Garden Miscellany 6: 165

Synonym: *Polystictus tephroleucus* (Berk.) Sacc. 1888; *Microporus tephroleucus* (Berk.) Kuntze 1898; *Coriolus tephroleucus* (Berk.) Bondartsev 1953.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarp sessile, dimidiate, coriaceous, 4-5 x 3-3.5 x 1-1.3 cm; uppper surface white cream, coarsely hirsute, lightly zonate; margin thin; context white, fibrous, up to 0.5 cm thick; hymenial surface white to cream brown, pores angular, 1-2 per mm, pore tubes white, up to 0.5 cm long.

Hyphal system trimitic. Generative hyphae hyaline, thin-walled, clamped, 1.5-2.5 um wide. Skeletal hyphae hyaline, thick-walled to solid, unbranched, straight or slightly flexuous, 3-6 um wide. Binding hyphae hyaline, thick-walled, much branched. 2.5-3.2 um wide. Basidia and basidiospores not observed.

Habit and Habitat: On dead logs of hardwood.

Collection locality: Mawphlang sacred grove

Distribution: Global, In India recorded by (Roy and De, 1996; Sharma, 2000) and found in the temperate zones (Roy and De, 1996).

.**Comments:** It causes white rot. Regarded as a form of *T. hirsuta* with larger pores (Roy and De, 1996).

51. *Trametes versicolor* (L.) Lloyd 1920 Plate 3.66, 3.67

Lloyd, C.G., 1921, Mycological Writings 6(65): 1045

Synonym: *Boletus versicolor* L. 1753; *Boletus suberosus* Batsch 1783; *Poria versicolor* (L.) Scop. 1772; *Agaricus versicolor* (L.) Lam. 1783; *Agarico-suber versicolor* (L.) Paulet 1793; *Sistotrema versicolor* (L.) Tratt. 1804; *Polyporus versicolor* (L.) Fr. 1821; *Polystictus versicolor* (L.) Fr. 1851; *Hansenia versicolor* (L.) P. Karst. 1879; *Bjerkandera versicolor* (L.) P. Karst. 1881; Coriolus *versicolor* (L.) Quél. 1886; *Microporus versicolor* (L.) Kuntze 1898;

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Fruit body annual, often reviviscent, hard-leathery, sessile or effused-reflexed, pilei dimidiate-substipitate, convex or imbricate, rarely resupinate, up to 10 cm wide, often in large imbricate clusters, rarely solitary; upper surface: hirsute to tomentose, highly variable in color, with sharply contracted concentric zones of brown, buff, reddish or bluish colors, often green by algae; lower surface: cream-white to ochraceus-yellow, angular to circular pores 4–5 per mm. Pore tubes very short, up to 2.0 mm only.

Hyphal system trimitic. Generative hyphae usually hyaline, thin-walled, branched, clamped, 2.0 - 3.5 um wide, scarcely found, some thick-walled, pale brown, 2.2 - 3.0 um wide and occur in closely compact condition in brown zones on the upper surface of the pileus. Skeletal hyphae hyaline, thick-walled to subsolid, unbranched, straight, aseptate, occasionally with a few septa at the distal ends, 3.5 - 8.0 um wide, abundant. Binding hyphae abundant, 2 - 3 um wide, hyaline, thick-walled to solid, branched, branches of two types (i) long and flexuous, few in number, and (ii) short and coralloid, abundant, occuring above the pore tubes in abundance. basidia 4-sterigmate, narrow clavate, 10.0-15.0 x 3.0 - 4.5 um. Basidiospores hyaline, cylindric, thin-walled, smooth, slightly curved on one side, 5.0- 6.0 x 1.5 - 2.0 um. Hyphal pegs present.

Habit and Habitat: On wounded or dead standing trees, on stored stems, common on 4–6 years old hardwood stumps.

Collection locality: Dawki, Jowai sacred grove, Jarain, Lawbyrtun sacred grove, Lumsymper, Mawiong, Mawphlang sacred grove, Mawblei, Nongkrem sacred grove.

Distribution: Worldwide, very common throughout Europe, dead wood of almost all hardwoods, particularly *Fagus*, also *Betula*, no attack of *Quercus*, *Castanea,* and *Robinia* (Jacquiot, 1981). Some of the records in India has been those from Himachal Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal by (Roy and De(1996), from Kerela by Leelavathy and Ganesh (2000), and Sharma (2000).

Comments: It causes white-rot, often with black demarcation lines. The dimidiate and applanate sporopcarps, white to cream pileus surface with concentric zonations and conspicuous pores are characteristic of this species.

52. *Tremella mesenterica* (Schaeff.) Retz. 1769 Plate 3.72

Retzius, 1769, K. Vet.-Akad. Handl. 30: 249.

Synonyms: *Tremella lutescens* Pers. 1800; *Tremella mesenterica* var. lutescens (Pers.) Pers. 1822; *Tremella quercina* Pollini 1816.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Tremellomycetidae, Order Tremellales, Family Tremellaceae.

Fruiting body gelatinous, pustular to foliaceous, sometimes small and remaining so, often large and conspicuous; bright orange to luteous and brown, occasionally pallid; normally shiny to greasy, not matt.

Hyphae in a gelatinous matrix, all hyphae clamped, haustorial cells seldom seen except in young, conidial specimens. Sterigmata up to 100 μ long, vesicles present, hyphidia sparse, thin-walled and hyaline. Basidia 2-4 septate, ellipsoid to subglobose, not or rarely stalked, average size 15-21 μm wide; septa most frequently diagonal or vertical. Conidiophores densely branched and normally abundant in the hymenium; young specimens may be entirely conidial. Conidia subglobose, ovoid, or ellipsoid, about 2.0-3.0 x 2.0-2.5 μm, often numerous. Spores broadly ellipsoid to oblong, on average 10.0-16.0 x 6.0-9.5 μm from prints of cited specimens; occasionally producing secondary spores; germinating by germ tube or by yeast-like conidia of identical form to the conidia produced on the conidiophores.

Habit and Habitat: Found on the decaying sticks and logs of oaks and other hardwoods, usually when bark is still adnate.

Collection locality: Laitkor, Lawbyrtun sacred grove, Mawphlang sacred grove and Nongkrem sacred grove.

Distribution: Global, In India reported from Karnataka by Swapna *et al.* (2008).

53. *Trichaptum abietinum* (Dicks.: Fries) Ryvarden Plate 3.68, 3.69

Norweg. J. Bot. 19(3–4): 237. 1972.

Synonym: *Hirschioporus abietinus* (Dickson:Fr.) Donk

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Sporocarp or fruiting body annual or short-lived perennial, 1-4 cm broad, up to 0.5 cm thick, flattened to slightly convex, margin wavy, forming tiers of overlapping sessile shelves; surface hairy, zonate, whitish to light-grey, usually pale purple near the margin, in age sometimes greenish from colonizing algae; flesh leathery, thin, pale brown to purplish-brown; hymenophore: tubes single-seried, 1-3 mm long, pale brown; pores 2-4 per mm, circular to angular, at maturity frequently toothlike; purple when young, fading to brownish-purple; spores 4-6.5 x 2.5-3.0 μm, smooth, allantoid (curved cylindrical); spore print off-white; habitat:

Habit and Habitat: In overlapping tiers on dead conifer wood, found year-round, shriveling in dry weather but capable of reviving; fresh fruitings emerging from late fall to mid-winter; inedible, leathery. Cosmopolitan

Collection site: Jowai sacred grove, Mawiong, Mawlai, Mawblei, Mawphlang sacred grove.

Distribution: Common worldwide. Occurrence in India recorded by Roy and De (1996) and Sharma (1997 and 2000).

Comments: It is a small attractive, leathery shelf fungus often dominating on conifer logs in large numbers. It is easily recognizable by the white, hairy, zonate cap, usually with a purplish margin when young, and purple-tinged pores. The pores may breakdown with age to form spines causing possible confusion with species of tooth fungi (Overholts, 1967; Gilbertson and Ryvarden, 1987; Bernicchia, 2005). It is also still referred by many workers to the synonym *Hirschioporus abietinus* (Dickson:Fr.) Donk.

54. *Trichaptum byssogenum* (Jungh.) Ryvarden Plate 3.68, 3.69

Ryvarden, L., 1972. Norweg. J. Bot. 19(3-4): 237. 1972.

Synonym: *Polyporus byssogenus* Jungh. 1838., Verh. Batav. Genootsch. 17:43, 1838 (L:).; *Trametes versatilis* Berk. Hook. Lond. J. Bot. 1:150, 1842 (K:).; *Polyporus venustus* Berk. Hook. Lond. J. Bot. 4:55, 1845 (K:).; *Poria byssogena* (Jungh.) Sacc. 1888.

The species belongs to the Phylum Basidiomycotina, Class Basidiomycetes, Subclass Agaricomycetidae, Order Polyporales, Family Polyporaceae.

Basidiocarps annual, resupinate to effused-reflexed or pileate; pilear surface grey-brownish, finally greyish-tan, hispid, strigose or matted-tomentose with a chestnut brown tomentum which wears away in parts; pore surface purplish when fresh, dull purplish brown on age and drying, pores circular to angular, 1-2 per mm, with thick, entire dissepiments that become thin and lacerate, tubes sharply distinct from the context, pale wood brown, rarely two-layered, up to 1 cm long; context pale wood-brown, soft, spongy and fibrous, up to 3 mm thick.

Hyphal system dimitic; generative hyphae with clamps, thin- to thick-walled in the context, 2-3.5 um wide; skeletal hyphae hyaline, thick-walled, with rare branching, 2-4 um wide. Cystidia abundant, fusoid, thin- tp moderately thick-walled, apically encrusted, 15-25 x 3-6 um. Basidia clavate, 14-17 x 5-6 um. Basidiospores cylindrical, slightly allantoid, 5.5-8 x 2-2.5 um.

Habit and Habitat: Substrata. on conifers and hardwoods.

Collection locality: Byrnihat and Mawiong.

Distribution: Pantropical species, in East Asia extending to subtropical to warm temperate areas in China, Japan, Taiwan, N Thailand, and Vietnam.

Comments: The brown basidiocarps with large pores, and the abundant encrusted cystidia characterize *T. byssogenum* (Nunez and Ryvarden, 2001).

Plate 3.1

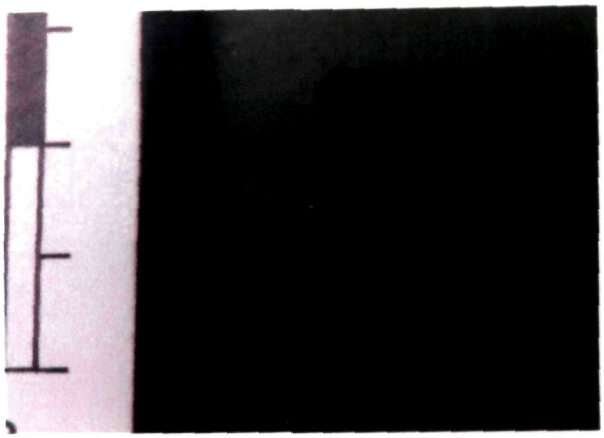


Plate 3.2

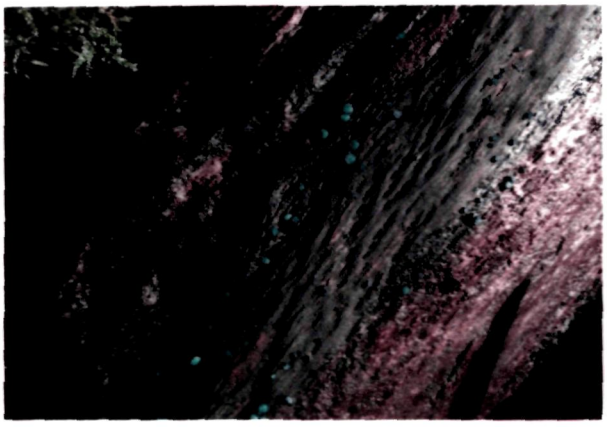


Plate 3.3

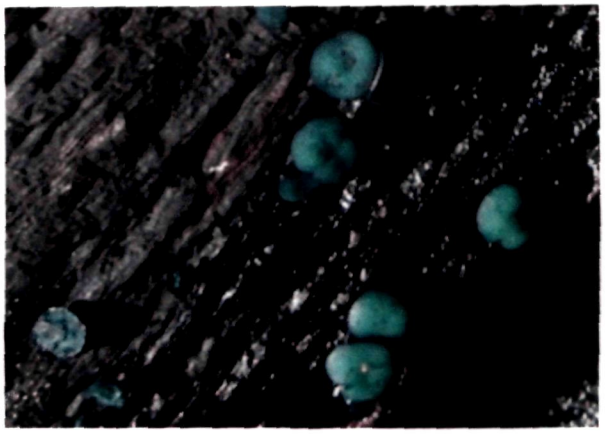


Plate 3.4

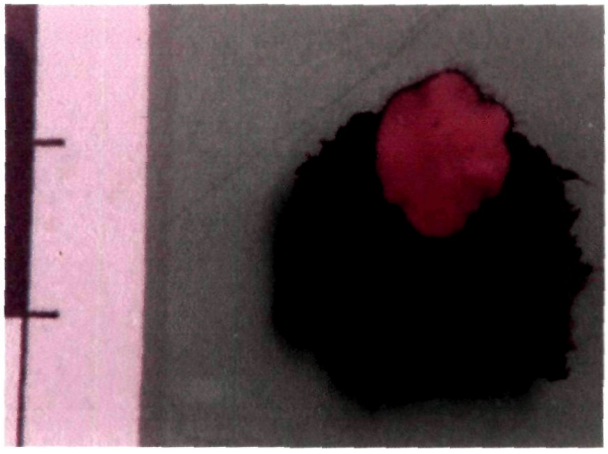


Plate 3.5

Plate 3.6

Plate 3.1. *Bulgaria inquinans* on dead log; Plate 3.2. *Bulgaria inquinans* close-up; Plate 3.3. *Chlorociboria aeruginosa*(on dead logs); Plate 3.4. *Chlorociboria aeruginosa* close-up; Plate 3.5. *Scutellinia scutellata*; Plate 3.6. *Xylaria hypoxylon*

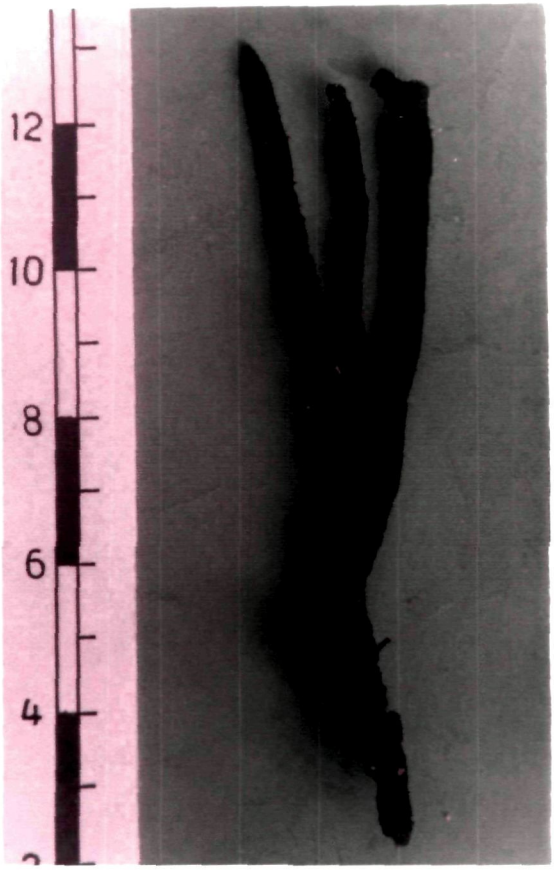


Plate 3.7

Plate 3.8

Plate 3.9

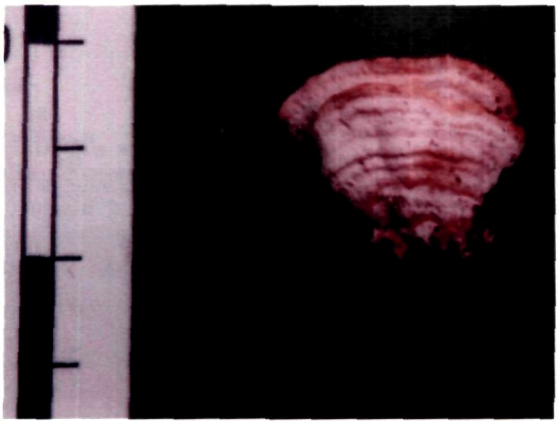


Plate 3.10

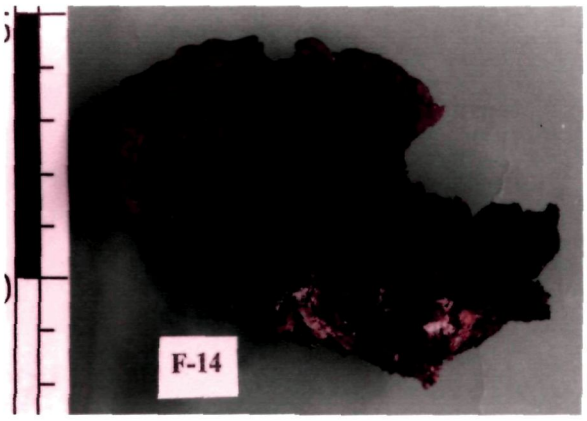


Plate 3.11

Plate 3.7 ***Xylaria polymorpha*****; Plate 3.8** ***Bjerkandera adusta*** **on host branch; Plate 3.9** ***Bjerkandera adusta*** **pore surface; Plate 3.10** ***Coriolopsis telfarii*** **upper surface ; Plate 3.11** ***Cyclomyces tabacinus***

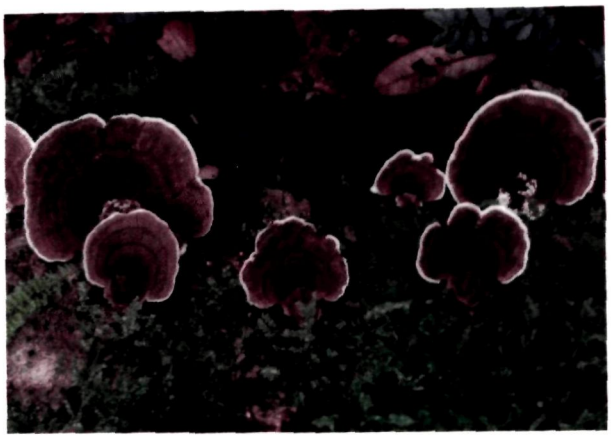


Plate 3.12

Plate 3.13

Plate 3.14

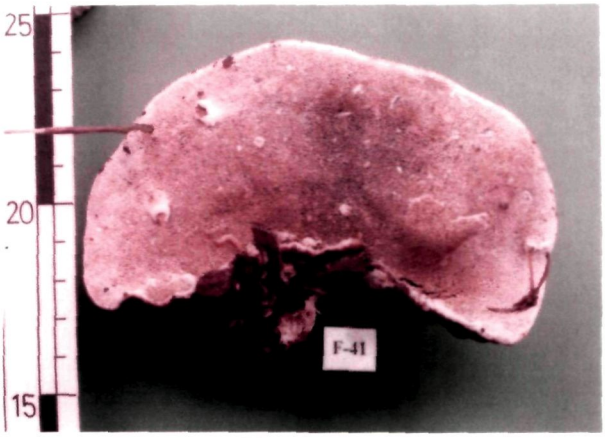
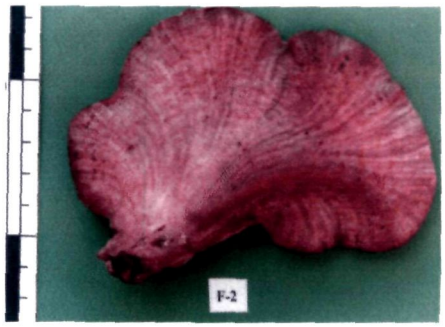


Plate 3.15



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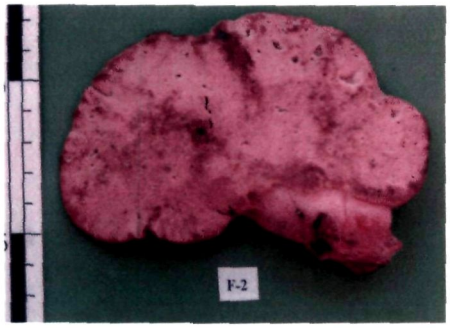


Plate 3.17

Plate 3.18

Plate 3.12 ***Daedalea confragosa*** **on host;**
Plate 3.13 ***D. confragosa*** **undersurface;**
Plate 3.14 ***Earliella scabrosa*** **upper surface;**
Plate 3.15 ***E. scabrosa*** **pore surface; Plate**
Plate 3.16 ***Fistulina hepatica*** **upper surface;**
Plate 3.17 ***F. hepatica*** **pore surface;**
Plate 3.18 ***F. hepatica*** **on host.**

Plate 3.19

Plate 3.20

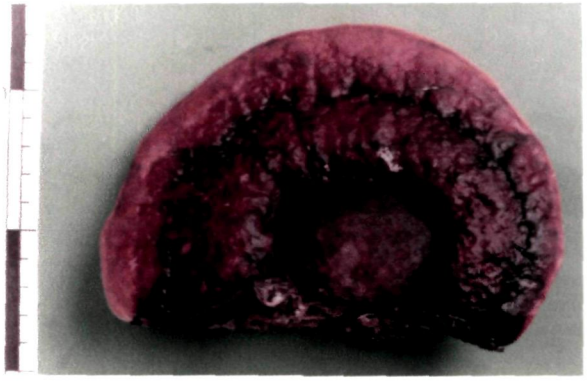


Plate 3.21

Plate 3.22

Plate 3.23

Plate 3.24

Plate 3.25

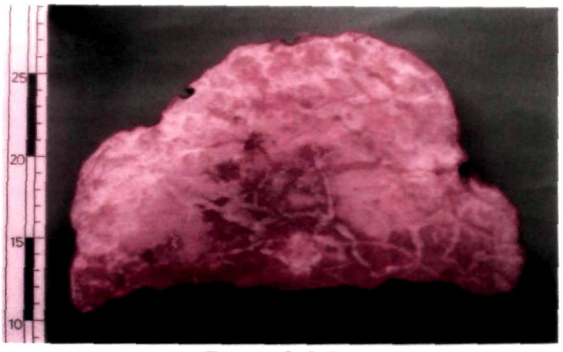
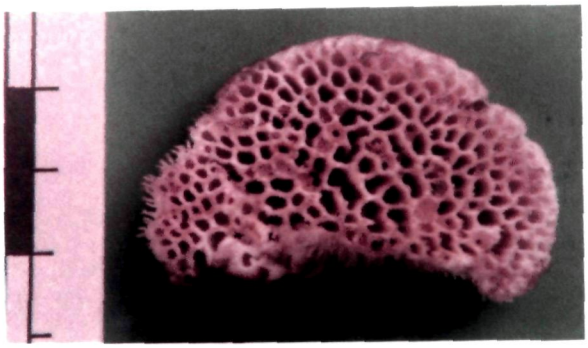


Plate 3.26

Plate 3.19 ***Fomes fomentarius*****; Plate 3.20.** ***Fomitopsis pinicola*** **on** ***Pinus kesiya*****, Plate 3.21** ***F. pinicola*** **upper surface, Plate 3.22** ***F. pinicola*** **pore surface; Plate 3.23** ***Ganoderma applanatum*** **upper surface, Plate 3.24** ***G. applanatum*** **pore surface; Plate 3.25** ***G. australe*** **upper surface, Plate 3.26** ***G. australe*** **Pore surface**

Plate 3.27



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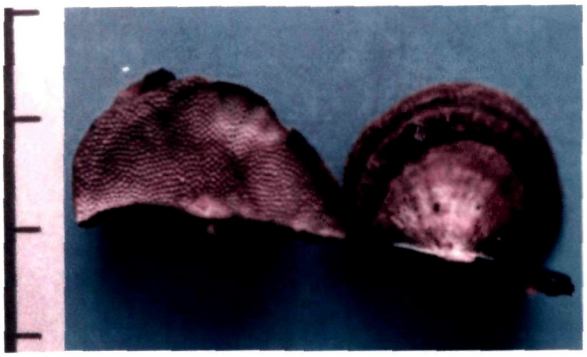
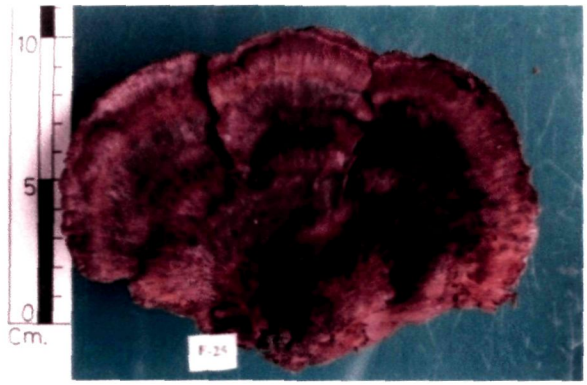


Plate 3.29

Plate 3.30



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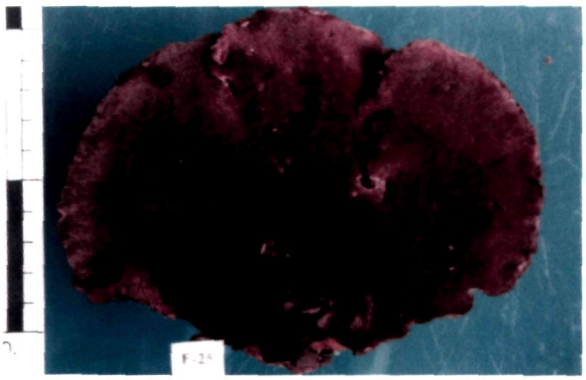

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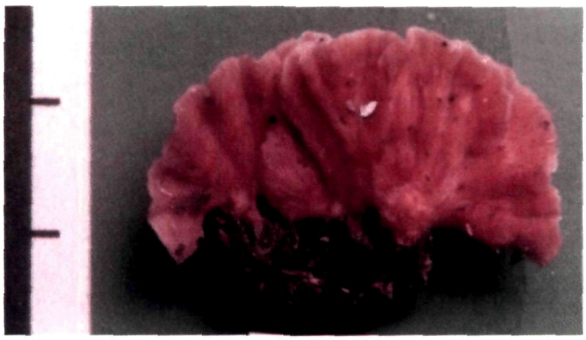

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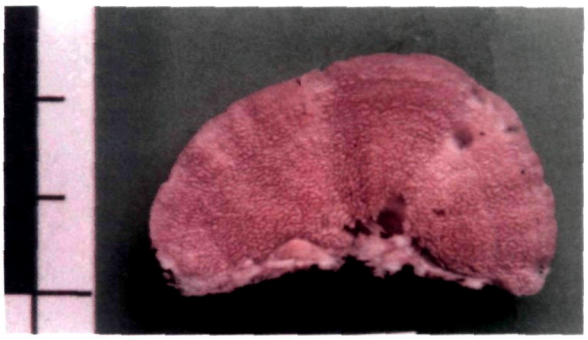


Plate 3.34

Plate 3.27 *Hexagonia apiara* upper surface, Plate 3.28 *H. apiara* pore surface, Plate 3.29 *H. tenuis* both upper and pore surface; Plate 3.30 *Hypholoma fasciculare* on dead branches; Plate 3.31 *Inonotus rheades* upper surface; Plate 3.32 *I. rheades* pore surface; Plate 3.33 *Irpex consors* upper surface; Plate 3.34 *I. consors* under surface

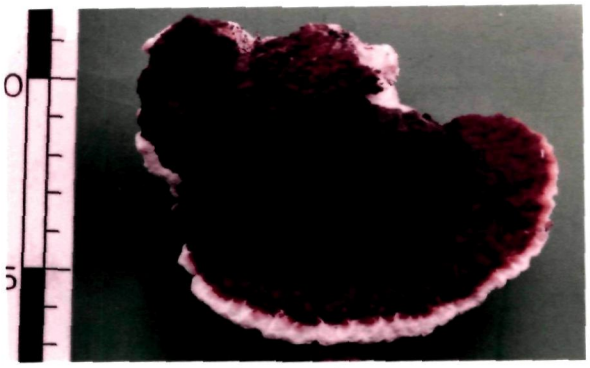


Plate 3.35

Plate 3.36

Plate 3.37

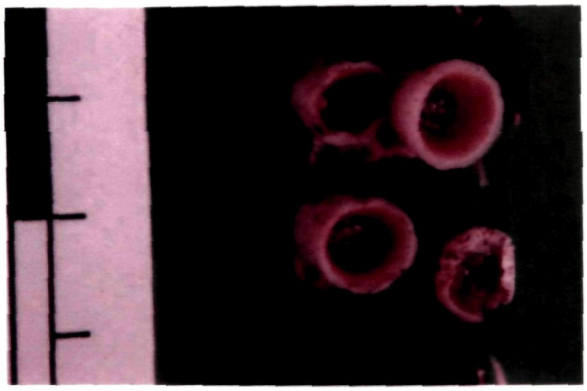


Plate 3.38

Plate 3.39

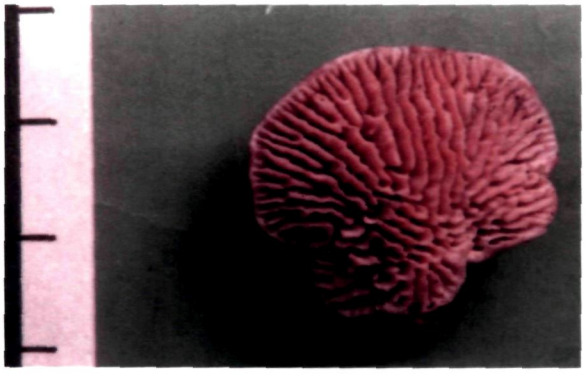


Plate 3.40

Plate 3.41

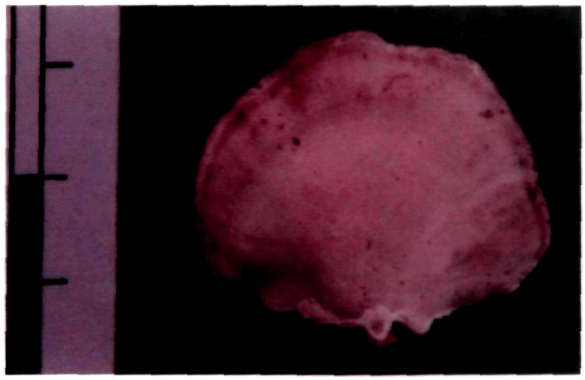


Plate 3.42

Plate 3.35 *Ischnoderma resinosum* upper surface; Plate 3.36 *I. resinosum* pore surface; Plate 3.37 *Laetiporus sulphureus* on dead tree; Plate 3.38 *Nidula niveotomentosa*; Plate 3.39 *Lenzites betulina* upper surface; Plate 3.40 *L. betulina* lower surface; Plate 3.41 *Microporus flabelliformis*; Plate 3.42 *M. flabelliformis* pore surface

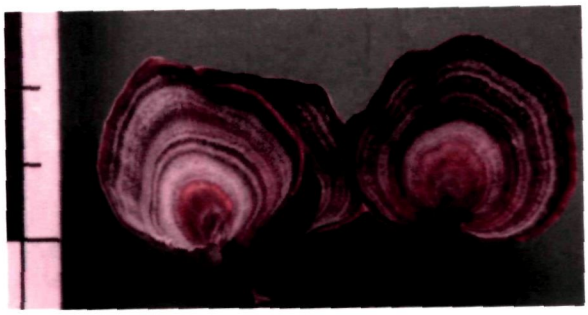


Plate 3.43

Plate 3.44

Plate 3.45

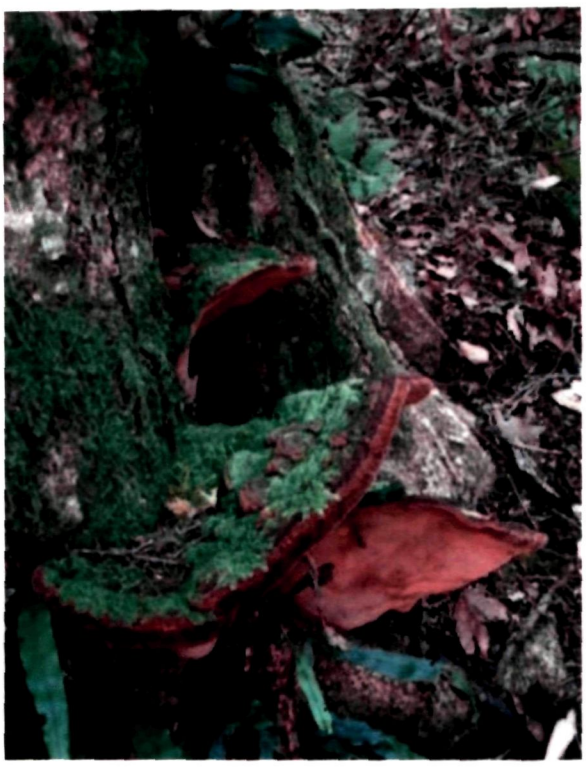


Plate 3.47

Plate 3.46

Plate 3.48

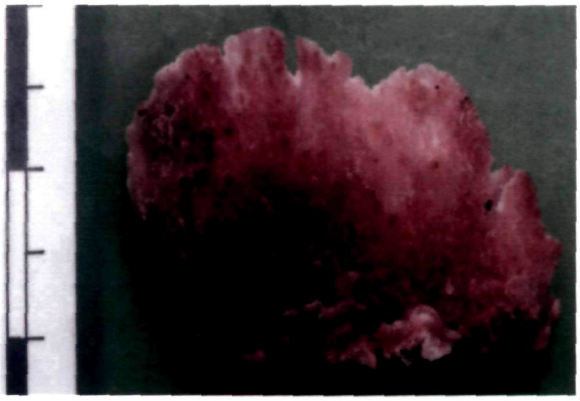
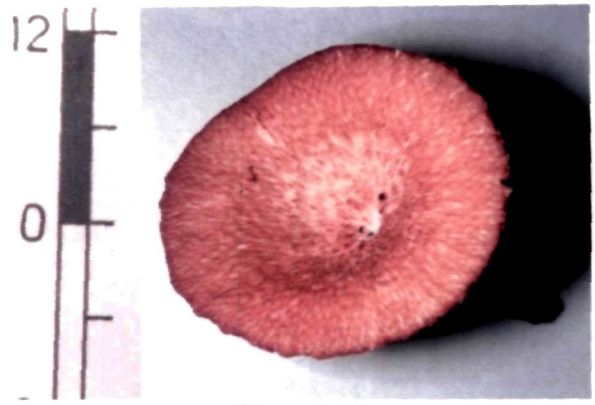


Plate 3.49

Plate 3.43 *Microporus quarrei* upper surface; 3.44 *M. quarrei* pore surface; Plate 3.45 *Microporus xanthopus* on fallen branches; Plate 3.46 *Omphalotus olivascens* hymenial surface; Plate 3.47 *Phellinus wahlbergii* on base of tree; Plate 3.48 *Phlebia tremellosa* on fallen tree; Plate 3.49 *P. tremellosa* upper surface

Plate 3.50

Plate 3.51



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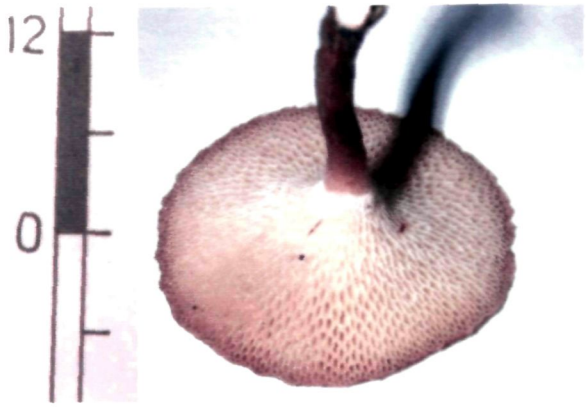


Plate 3.53

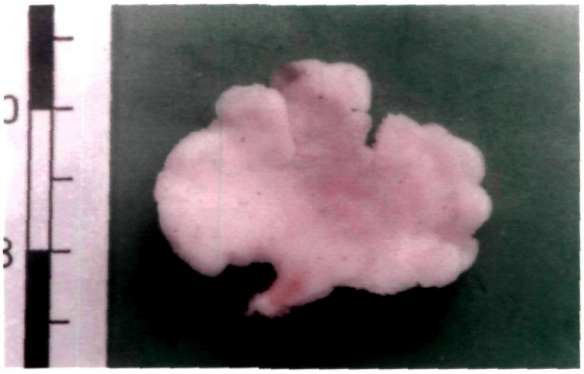


Plate 3.54

Plate 3.55

Plate 3.56

Plate 3.57

Plate 3.50 *Pleurotus ostreatus*; Plate 3.51 *Pycnoporus sanguineus*; Plate 3.52 *Polyporus brumalis* upper surface; Plate 3.53 *P. brumalis* pore surface; Plate 3.54 *Polyporus tuberaster* upper surface; Plate 3.55 *P. tuberaster* pore surface; Plate 3.56 *Schizophyllum commune* upper surface; Plate 3.57 *S. commune* hymenial surface

Plate 3.58

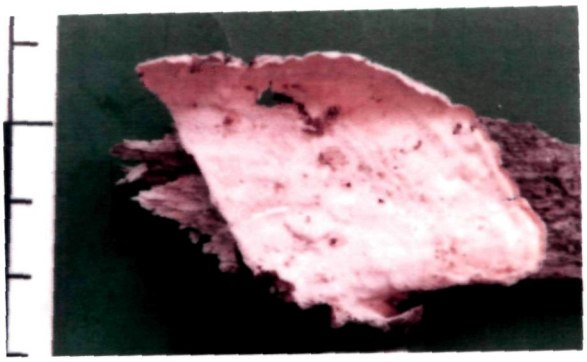


Plate 3.59

Plate 3.60

Plate 3.61

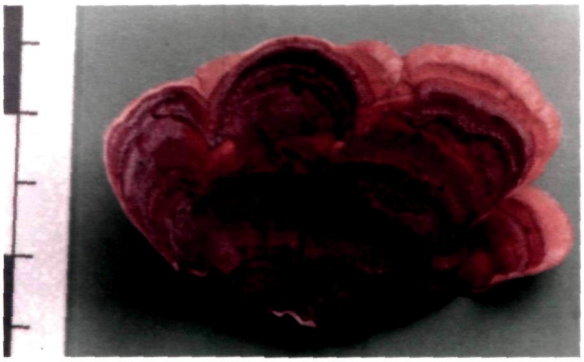
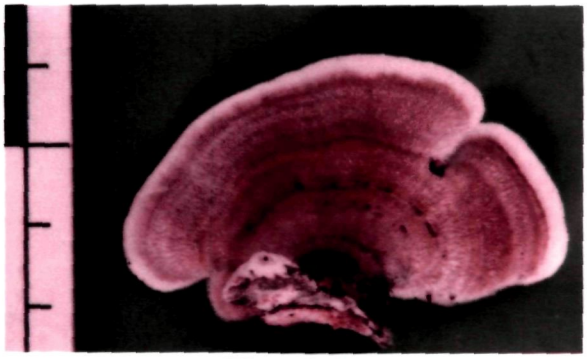


Plate 3.62

Plate 3.63



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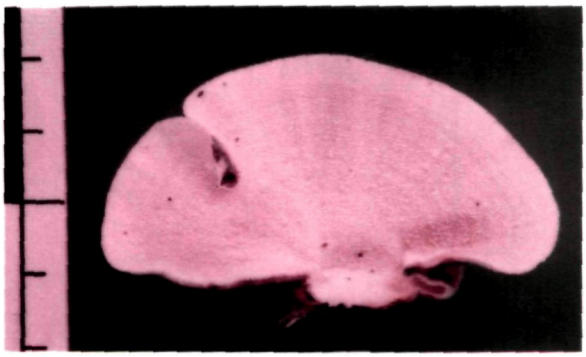

Plate 3.65

Plate 3.58 *Sparassis crispa*; Plate 3.59 *Stereum complicatum*; Plate 3.60 *S. hirsutum* upper surface; Plate 3.61 *S. hirsutum* pore surface; Plate 3.62 *S. ostrea* upper surface; Plate 3.63 *S. ostrea* pore surface; Plate 3.64 *Trametes hirsuta* upper surface; Plate 3.65 *T. hirsuta* pore surface.

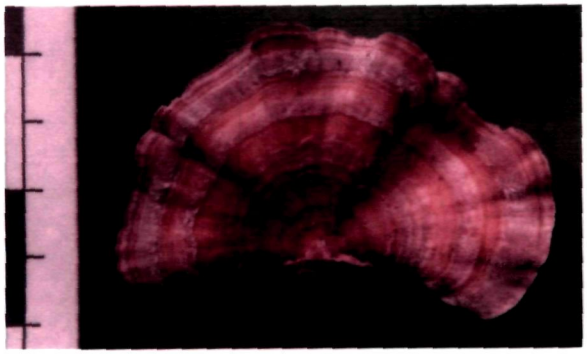

Plate 3.66

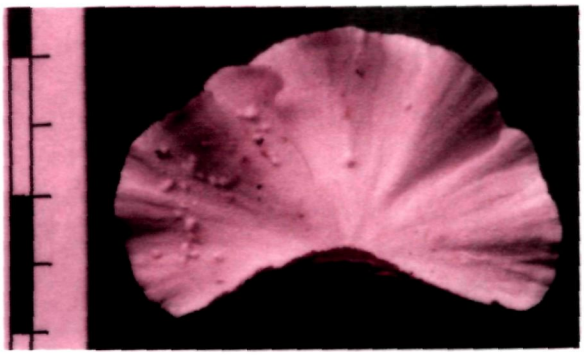

Plate 3.67

Plate 3.68

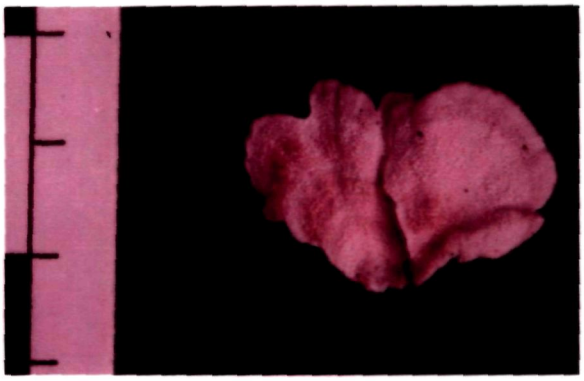

Plate 3.69

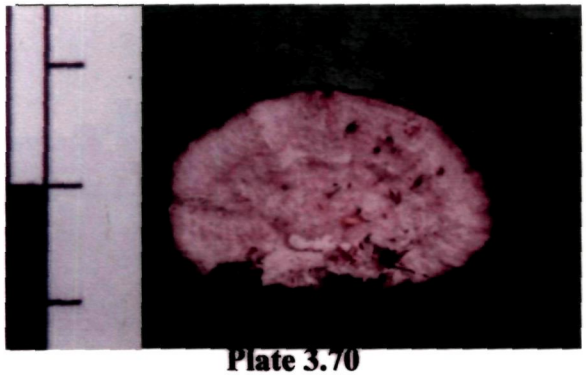

Plate 3.70

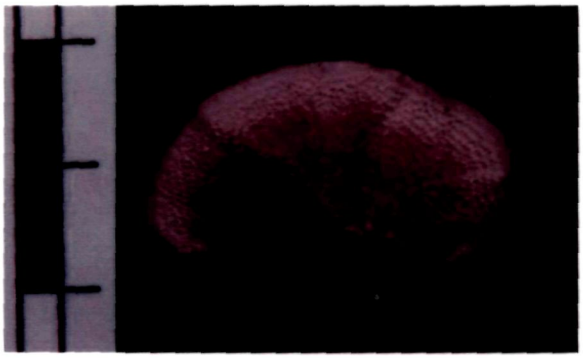

Plate 3.71

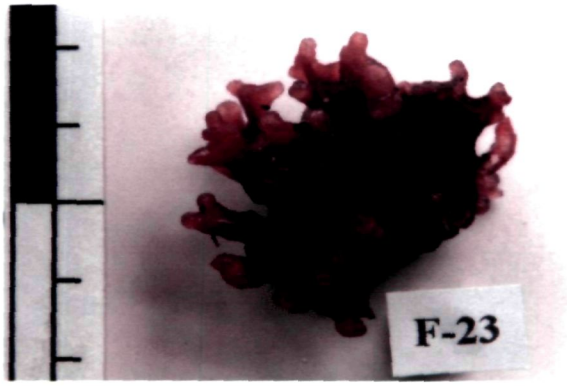

Plate 3.72

Plate 3.73

Plate 3.66 ***Trametes versicolor*** **upper surface; Plate 3.67** ***T. versicolor*** **pore surface; Plate 3.68** ***Trichaptum abietinum*** **upper surface; Plate 3.69** ***T. abietinum*** **pore surface; Plate 3. 70** ***T. byssogenum*** **upper surface; Plate 3. 71** ***T. byssogenum*** **pore surface; Plate 3.72** ***Tremella mesenterica*****; Plate 3.73** ***Auricularia auricula*** **on fallen wood**

Chapter IV

DIVERSITY OF WOOD ROTTING FUNGI IN DISTURBED AND UNDISTURBED SACRED GROVES

IV.1. Introduction

An important measure of an ecosystem's value is its overall biodiversity- that is, the richness of species living within the habitat (Lovejoy 1997; Wilson 1997). It is known that outright destruction of our natural areas is leading to an ever increasing decline in biodiversity worldwide (Kishbaugh and Yocam, 2000), including fungal species (Bunyard *et al.,* 1996). The fungi are essential, yet little understood and often overlooked components of healthy ecosystems. It has been revealed that only 5–10% of the existing fungal biodiversity has been discovered and described (Hawksworth, 1991). A broad diversity of host tree species, of various volumes and diameters, i.e. logs, branches or twigs, and degree of decomposition tend to favour rich fungal communities (Kuffer and Senn-Irlet, 2005).

Sacred groves, although small, are important for fungal conservation because they provide unique types of habitat. Sacred groves are patches of natural forest that have been continuously protected by the religious beliefs of the local people for more than 1000 years (Sinha, 1995; Ramakrishnan, 1996; Chandran and Hughes, 1997; Chandrashekara and Sankar, 1998; Colding and Folke, 2001). It has been documented that there are as many as 79 sacred groves in Meghalaya alone with some more yet unaccounted. These sacred groves called as 'Law Kyntang', 'Law Niam' and 'Law Lyngdoh' in Khasi hills, 'Khloo Blai' in Jaintia hills, and 'Asheng Khosi' in Garo hills are owned by individuals, clans or communities, and are under

direct control of the clan councils or local village Dorbars/ Syiemships/ Dolloiships/ Nokmaships. They show a wide variation in their size and forest canopy cover.

Knowledge about the fungal community of an ecosystem is an important asset, as fungi are considered ecological indicators of perturbation within the environment (Hawksworth, 1991; Hawksworth, 1995; Guzman, 1998). In this chapter, the purpose of this two-year investigation was to inventory species of the wood rotting fungi present within the disturbed sacred grove at Nongkrem and the undisturbed sacred grove at Mawphlang and to evaluate overall diversity between the two sacred groves. Once the species diversity of the wood rotting fungi is assessed, this database can be used as a reference to monitor the overall health of these forest ecosystems in the future.

IV.2. Review of literature

One of the principal reasons for the lack of information on the fungi is the formidable difficulty that fungi present to ecological study (Cannon, 1997). Most species are cryptic, rarely or never forming sporocarps, and most species of tropical fungi are undescribed (Hawksworth, 2001).

It has been suggested that the number of hosts is the main factor that determines fungal species richness (Hawksworth, 1991). It has also been revealed that resource abundance, host diversity and habitat heterogeneity have all been linked to fungal diversity in tropical forests (Lodge, 1997).

The effects of disturbance and forest management on fungal diversity have been reported in a number of studies from northern temperate regions (Vogt *et al.*,

1992; Waters *et al.*,1997; Senn-Irlet and Bieri, 1999) but studies from tropical forests are extremely rare (Lodge and Cantrell, 1994).

Work done in northern Europe suggests that the harvesting of trees at various levels of intensity can affect the diversity of wood-inhabiting fungi (Bader *et al.*, 1995; Hoiland and Bendiksen, 1997; Lindblad, 1998; Ohlson *et al.*,1997; Wasterlund, 1989). In general, most studies on fungal diversity have shown that fungal species richness was lower in disturbed forests than in undisturbed sites (Albrecht, 1991; Hagerman *et al.*, 1999; Byrd *et al.*, 2000). In a study of the relationship between the diversity and structure of assemblages of fungi and their plant hosts in a tropical rain forest, a transect-based study by Gilbert *et al.* (2002) showed that high tree species diversity supports an even higher diversity of polypore fungi. A recent study on the macrofungal diversity in fragmented and disturbed forests of the Western Ghats of India have also shown that sacred groves are important for fungal conservation because they provide unique types of habitat that sustain a distinct fungal assemblage (Brown *et al.*, 2006).

The sacred groves of Meghalaya are in constant threat of disturbances. It has been studied and revealed that the status of 56 sacred groves of Meghalaya showed that 12.5% of them are undisturbed (100% canopy cover), 25% are dense (> 40% canopy cover), 20% are sparse (10-40% canopy cover), while 42.5% of the groves are highly degraded and have even less than 10% canopy cover (Tripathi, 2004). A number of studies on the sacred groves of Meghalaya have been conducted (Khiewtam and Ramakrishnan, 1989 and 1993; Rodgers, 1994; Tiwari *et al.*, 1999)

however, no study has yet been undertaken on the wood rotting fungi and their diversity in the sacred groves.

IV. 3. Materials and Methods

Study Site

A survey of the diversity of the wood rotting fungi from two sacred groves at Nongkrem and Mawphlang in the East Khasi Hills District of Meghalaya was done with the aim to compare the diversity and types of wood rotting fungi found in disturbed and undisturbed sacred groves.

Nongkrem sacred grove or locally called as 'Law Lyngdoh Nongkrem' is a disturbed sacred grove because of continued disturbances and exploitation from the nearby villagers. It covers an area of 6 ha and is about 14 km south west from Shillong and is situated at 91° 54' 40" E latitude and 25° 29' 30" N longitude with an altitude of 1786 msl. Mawphlang sacred grove or locally called the 'Law Lyngdoh', 'Umrisaw', 'Mawkhan', 'Ryngngi', 'Laitsohphoh', etc., is one of the few sacred groves that remains undisturbed. It is about 25 km south-east of Shillong covering an area of 75 ha at an elevation of 1842 msl and lies at 91°56' E latitude and 23°34'N longitude. The two sacred groves were selected because of their similarity in sharing the same climatic condition and geographical setting (Plates 4.0, 4.1 and 4.2).

Climate

The climate in both the study site shares a similar pattern as they lie in close proximity under East Khasi Hills District of Meghalaya. The climate is monsoonic and is directly influenced by the southwest monsoon and the northeast monsoon with distinct warm-wet and cold-dry periods. The maximum temperature in the first year

was 29°C in the month of June-July and in the second year it was 30°C during the month of July. The minimum temperature was 6 °C in the month of January in the first year and 4.5 °C in the month of January in the second year. The rainfall was at a maximum of 684 mm in the month of June and minimum of 5 mm in the month of February in the first year i.e., 2003. In the second year i.e., 2004 the rainfall was at a maximum of 710 mm in the month of June and minimum of 10 mm in the month of February. The relative humidity ranged between 55% -86 % in the morning and 65%-94% in the evening in the first year. In the second year the relative humidity range between 56%-88% in the morning and between 64% -93% in the evening (Fig 4.1).

Sampling

There are no standard methods for accurately estimating the macrofungal species richness of an area based on a sample of the macrofungi (Schmit *et al.*, 1999). The study compared the wood rooting fungi richness based on equal sampling areas (comparable to species density; *sensu* Hurlbert, 1971). Three permanent areas or plots were selected in each of the disturbed and undisturbed forests in which a single 100 m long and 25 m wide transects was laid at random during each visit to record the presence and absence of the wood rotting fungi (Senn-Irlet and Bieri, 1999). Each forest was visited at least more than three times during a period of 6 months from Jan- June and from July to December for 24 months. All sporocarps and clusters of sporocarps of the same species of the wood rotting fungi on a log or tree were counted as one occurrence, independent of number of sporocarps.

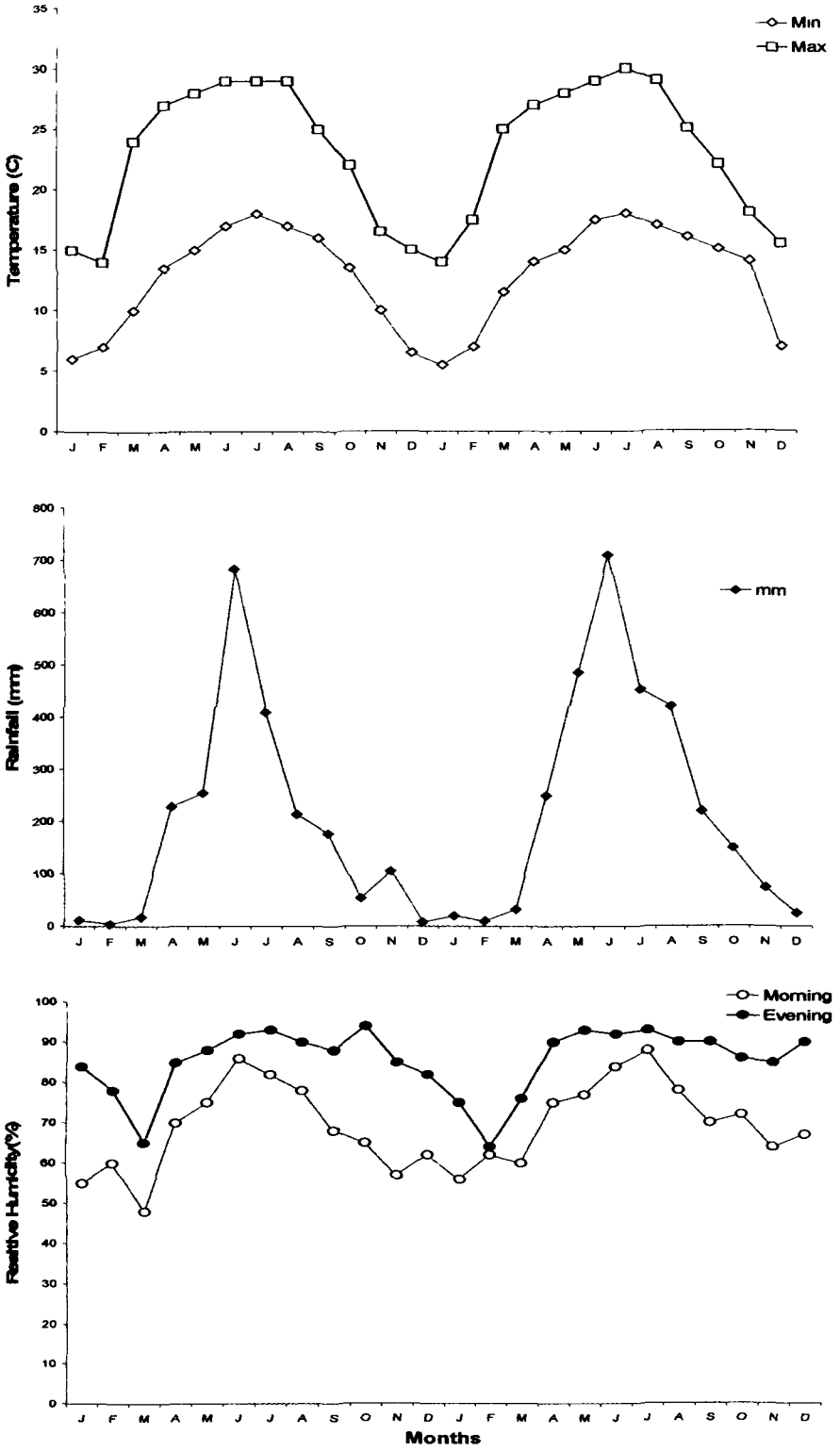

Fig. 4.1. Average temperature , rainfall and relative humidity in East Khasi Hills District during the study period 2003-04

Species Richness

The species accumulated at each sampling was noted and the cumulative species richness of wood rotting fungi in both the sacred groves was calculated at an interval of six months from January to June and from July to December for the two year study periods 2003-2004. The species accumulation graph was then plotted as number of species accumulated within each sampling time of 6 months interval.

Species diversity

Index of species diversity of the wood rotting fungi was calculated using the Shannon and Simpson index of diversity as suggested by Lande (1996) and Magurran (2004)

Shannon index: $H = -\sum(p_i \ln p_i)$

Simpson index: $D = \sum n_i(n_i-1) / N(N-1)$

Where, *ln* is the natural log function and p_i is proportion of the number of i^{th} species to total number of individuals, n_i is the abundance of the i^{th} species, N the total number of all the species.

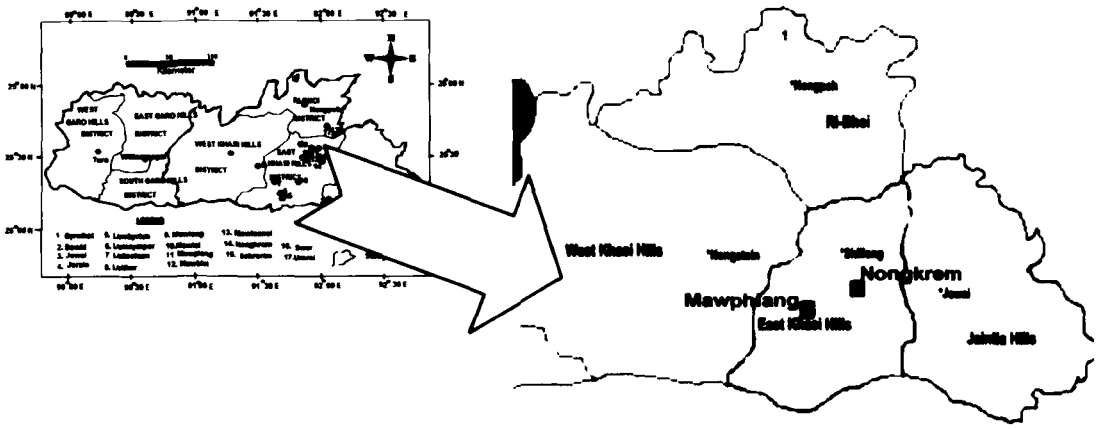

Plate 4.0. Location of Mawphlang and Nongkrem sacred grove in East Khasi Hills District

Plate 4.1. Disturbed sacred grove, Nongkrem

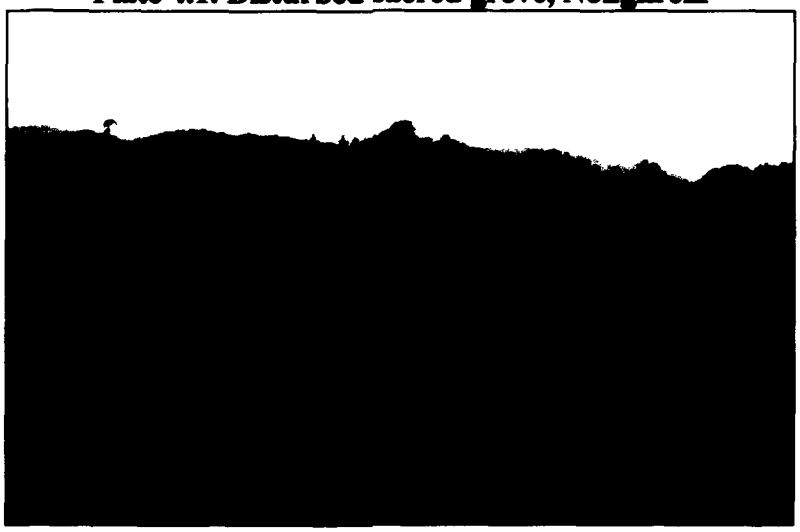

Plate 4.2. Undisturbed sacred grove, Mawphlang

IV.4. Results

Species Richness

A total of 42 wood rotting fungi were identified, of which 19 species were recorded from the disturbed sacred grove and 36 species were recorded from the undisturbed sacred grove. A total of 13 species of the wood rotting fungi were found to be common in both the sacred groves (Table 4.1). It was observed that the species accumulation curves continued to increase with each sampling interval and were not reaching their asymptotes (Fig. 4.1). The number of wood rotting fungi and plant species and species/ha from the two study sites is listed in Table 4.2. The undisturbed sacred grove had a greater species richness with values of 48/ha for the wood rotting fungi and 67/ha for the host trees while the disturbed forest had a value of 25/ha and 47/ha respectively (Table 4.2). The undisturbed sacred grove had a higher species assemblage than the disturbed sacred grove. It was observed that there were 36 wood rotting fungal species and 56 tree species in the undisturbed sacred grove and 19 wood rotting fungal species and 35 tree species in the disturbed sacred grove (Fig. 4.2).

The wood rotting fungi that were common to both the forest were *Earliella scabrosa, Fistulina hepatica, Ganoderma applanatum, G. australe, Hypholoma fasciculare, Inonotus tabacinus, Laetiporus sulphureus, Microporus xanthopus, Phellinus gilvus, Schizophyllum commune, Stereum ostrea, Trametes versicolor* and *Tremella mesenterica* (Table 4.1).

A total of 35 tree species were found in the disturbed sacred grove among which the dominant trees are *Cinnamomum glanduliferum, Elaeocarpus lancifolius,*

Eurya japonica, Eleagnus pyriformis, Lithocarpus dealbatus, Myrica esculenta, Pinus kesiya and Schima wallichi. The undisturbed sacred grove harbored 56 tree species among which the dominant trees were *Eleocarpus lancifolius, Engelhardtia roxburghiana, E. spicata, Exbucklandia populnea, Quercus dealbata, Q. griffithii, Q. glauca, Pyrus pashia, Rhododendron arboreum* and *Symplocos chinensis* (Table 4.3).

Species diversity

Species diversity of the wood rotting fungi was found to be higher in the undisturbed than the disturbed sacred grove. The Shannon's diversity index H was found to be 2.68 and 3.36, and the Simpson's diversity index *D* was 12.87 and 26.23 in both the disturbed and undisturbed sacred groves respectively (Table 4.4).

Table 4.1 List of wood rotting fungi collected from disturbed and undisturbed sacred groves

Sl. No	Fungal Species	Disturbed sacred grove	Undisturbed sacred grove	Species common to both
1.	*Bulgaria inquinans*	+	-	-
2.	*Chlorociboria aeruginosa*	-	+	-
3.	*Cyclomyces tabacinus*	+	+	+
4.	*Daedalea confragosa*	-	+	-
5.	*Earliella scabrosa.*	+	+	+
6.	*Fistulina hepatica*	+	+	+
7.	*Fomes fomentarius*	-	+	-
8.	*Fomes geotropus*	-	+	-
9.	*Fomitopsis pinicola*	+	-	-
10.	*Ganoderma applanatum*	+	+	+
11.	*Ganoderma australe*	+	+	+
12.	*Hexagonia tenuis*	-	+	-
13.	*Hirshioporus abietinus*	+	-	-
14.	*Hypholoma fasciculare*	+	+	+
14.	*Inonotus dryadeus*	-	+	-
16.	*Irpex consors*	-	+	-
17.	*Ischnoderma resinosum*	+	-	-
18.	*Laetiporus sulphureus*	+	+	+
19.	*Lenzites betulina*	-	+	-
20.	*Microporus flabelliformis*	-	+	-
21.	*Nidula niveotomentosa*	-	+	-
22.	*Omphalotus olivascens*	+	-	-
23.	*Phellinus gilvus*	+	+	+
24.	*Phellinus wahlbergii*	-	+	-
24.	*Phlebia tremellosus*	-	+	-
26.	*Pleurotus ostreatus*	-	+	-
27.	*Polyporus tuber-aster*	-	+	-
28.	*Microporus xanthopus*	+	+	+
29.	*Rigidiporus microporus*	-	+	-
30.	*Scleroderma cepa*	-	+	-
31.	*Schizophyllum commune*	+	+	+

Sl. No	Fungal Species	Disturbed sacred grove	Undisturbed sacred grove	Species common to both
32.	*Skeletocutis amorpha*	-	+	-
33.	*Stereum complicatum*	-	+	-
34.	*Stereum hirsutum*	-	+	-
34.	*Stereum ostrea*	+	+	+
36.	*Trametes hirsuta*	-	+	-
37.	*Trametes tephroleucus*	-	+	-
38.	*Trametes versicolor*	+	+	+
39.	*Tremella mesenterica*	+	+	+
40.	*Trichaptum byssogenum*	+	-	-
41.	*Xylaria hypoxylon*	-	+	-
42	*Xylaria polymorpha*	-	+	-
	TOTAL	19	36	13

Table 4.2 Number of wood rotting fungi and host tree species and species per hectare for the two sites

Site	Wood rotting fungi		Host tree	
	Total number of species/ 0.75 ha	number of species/ha	Total number of species/ 0.75 ha	number of species/ha
Nongkrem sacred grove	19	25	35	47
Mawphlang sacred grove	36	48	47	67

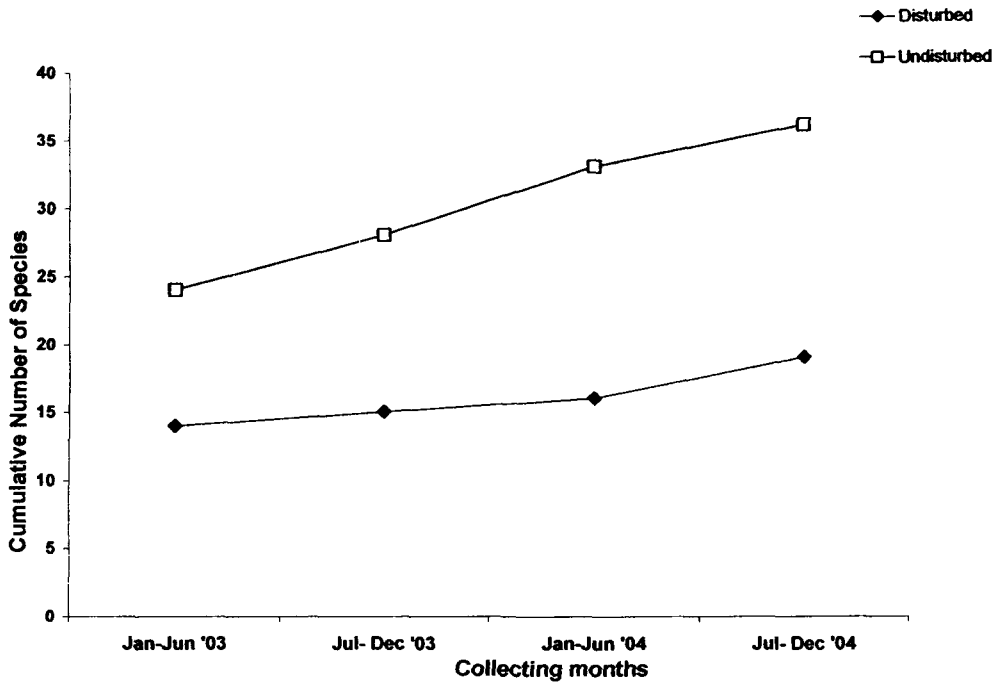

Fig 4.1 Accumulative species richness of wood rotting fungi in the disturbed (Nongkrem) and Undisturbed (Mawphlang) sacred groves of Meghalaya during 2003-04

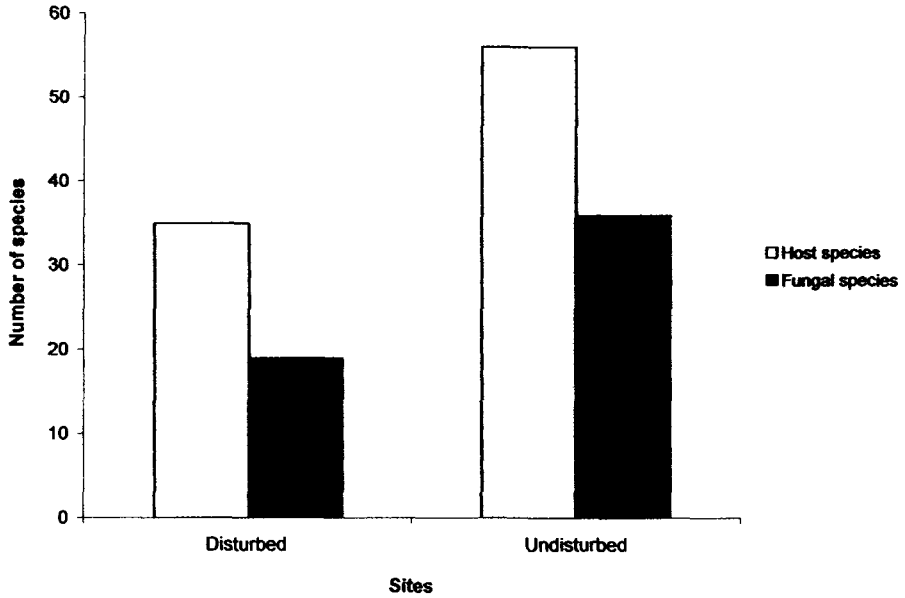

Fig.4.2 Number of species of wood rotting fungi and number of species of plants in the disturbed (Nongkrem) and Undisturbed (Mawphlang) sacred groves of Meghalaya during 2003-04

Table 4.3 Number of host tree species in both the disturbed and undisturbed sacred groves

Disturbed (Nongkrem)	**Total = 35 tree species** **Dominant trees** - *Cinnamomum glanduliferum, Elaeocarpus lancifolius, Eleagnus pyriformis, Eurya japonica, Lithocarpus dealbatus, Myrica esculenta, Pinus kesiya and Schima wallichi.* **Other tree species-** *Docynia indica, Eleocarpus simplex, Engelhardtia spicata, Eurya japonica, Ficus merifolia, Hedera helic, Lindera mebstonaacia, L. nacusua, Litsea elongata, Meliosma wallichi, Mangiitia insignis, Morus australis, Persea duhtiei, Pyrus fastia, Phyllanthus glaucus, Polygala arillata, Prunus cerasoides, Phlocozanthus eubiflorus, Photinia integerrima, Rhus acuminata, Sarcococca pruniformis, Symplocos javanica, S. spicata, S. crataezoides, Tetrastigma serrulutum, Viburnum foetidum.*
Undisturbed (Mawphlang)	**Total = 56 tree species** **Dominant trees-** *Eleocarpus lancifolius, Engelhardtia roxburghiana, E. spicata, Exbucklandia populnea, Pyrus pashia, Quercus dealbata, Q. griffithii, Q. glauca, Rhododendron arboretum,* and *Symplocos chinensis.* **Other tree species –** *Callicarpa psilocalyx, Camellia kissi, Carpinus viminea, Casearia kurzii, Castanopsis kurzii, Cinnamomum glanduliferum, Clerodendron wallichi, Docynia indica, , Eurya acuminata, , Ficus neriifolia, Helicia negrica, Ilex excelsa, Ilex griffithii, Ilex venulosa, Ligustrum lucidum, L. nepalense, L. pulcherrima, Lindera thomsoni, Lithocarpus dealbatus, L. fenestratus, Litsea elongata, Luculia pinceana, Mallotus nepalensis, Manglieta insignis, Medinilla erochrophylla, Morus indica, Myrica esculenta, Olea dentala, Pentapanax subcordatus, Photinia arguta, P. polycarpa, Pinus kesiya, Prunus phaeosticta, P. undulata, Psychotria adnephylla, P. symplocifolia, Pyrularia edulis, Pyrus baccata, P. khasiana, , Rhus chinensis, Saurauia punduana, Schima wallichii, Symplocos theifolia, S. glomerata, S. spicata, Vaccinium sprengelii*

Table 4.4 List of variables between disturbed (Nongkrem)and undisturbed (Mawphlang) sacred groves

Variables	Disturbed	Undisturbed
Species Richness	19	36
Genera	12	26
Family	12	14
Shannon's diversity index H	2.68	3.36
Simpson's diversity index D	12.87	26.23

IV.4. Discussion

Species Richness

A total of 42 species of the wood rotting fungi were identified, wherein the disturbed sacred grove housed 19 species and the undisturbed sacred grove housed 36 species and the two sacred groves shared together 13 species of the wood rotting fungi. The number of species of the wood rotting fungi is not final for the two sacred groves. Many macrofungal species are believed to fruit sporadically, with no consistent pattern of occurrence from year to year (Watling, 1995). Many years of intensive surveys may be required to describe the macrofungal communities of a particular area adequately (Tofts and Orton, 1998).

It was observed that the species accumulation curves continued to increase with each sampling intervals and were not reaching their asymptotes. This in conformation to similar observations in Scandinavia, where even when many logs were surveyed for macrofungi in the species-substrata curve did not reach an

asymptote, indicating that many more species would be discovered if additional logs were sampled (Lindblad, 1998). Similarly, in another study Straatsma *et al.* (2001) monitored a plot area of 1500m^2 in western Switzerland for agarics for over a period of 21-years with sampling frequency of 7 days and recorded 408 species but concluded that the number of species would increase if the survey continued.

The undisturbed sacred grove had a greater species richness with values of 48/ha and 67/ha while the disturbed forest have a value of 25/ha and 47/ha for the wood rotting fungi and host tree respectively. Also, the undisturbed sacred grove had a higher species assemblage than the disturbed sacred grove where the number of species of the wood rotting fungi was 36 and 19 in the undisturbed and disturbed sacred groves, and the number of tree species was 56 and 35 in the undisturbed and disturbed sacred groves respectively. There is evidence that a diverse and healthy plant community will have diverse species of fungi. Villenneuve *et al.* (1989) in their study have determined that the diversity of saprobes was related significantly to vascular plants. Gabel and Gabel (2007) found significant relationship between species diversity of fungi and plants/ha and concluded that the species diversity of all plants and all fungi had a very significant correlation from their study. Hawksworth (1991) has also similarly suggested that the number of wood-inhabiting fungi should be expected to increase with number of tree species. There may be several possible explanations for the lower number of species of the wood rotting fungi in the disturbed sacred grove. Intensive encroachment and disturbances from nearby village may also have an effect. Dead wood and fallen branches are more abundant in undisturbed than disturbed sacred grove. Fallen dead wood is removed away quickly

from the disturbed sacred grove and understorey vegetation is reduced to a large extent. These unchecked disturbances may have reduced the abundance of the wood rotting fungi since many wood rotting fungi depend on dead fallen wood and branches. It has been reported that the *Xylariales* are wood-decomposing saprotrophs and weak parasites with many tropical species (Rogers *et al.,* 1987). Members of this group may live as endophytes within living trees, and initiate wood decay when a branch dies so that decay starts within the canopy (Rayner and Boddy, 1988). They would therefore be expected to be more abundant in trees with dead and damaged branches and in the litter of fallen dead branches and twigs that they shed. Some species are typically found as wood and leaf litter saprotrophs (Alexopoulos *et al.,* 1996). Also most members of the wood rotting fungi are generalist and have a broad range of hosts. Lindblad (2000) found that only 3 of 32 common species of polypore fungi in a Costa Rican dry forest showed host specificity.

There were 13 species of wood rotting fungi that were present in both the forests. Among these, the polyporoid and corticioid fungi are some of the most common and studies have also similarly found that these species account for the majority of fruit bodies found on woody debris (de Vries, 1990). The number of species is not exhaustive because it has been studied that when polypores and corticioid fungi are sampled, often only the largest or most conspicuous species are collected (Bader *et al.,* 1995; Ohlson *et al.,* 1997). In a study conducted in an even-aged *Picea abies* stand in the Netherlands, de Vries (1990) found that 75% of wood-inhabiting species had inconspicuous, tiny, thin or crustose fruit bodies and that such

species made up 44% of overall fungal species richness. Therefore, there may be a positive correlation between quantity of decaying woody and leaf substrata and diversity of the wood rotting fungal species. This is supported by previous studies on other groups of fungi. These studies show that availability and abundance of substrata is an important factor in fungal biodiversity in forest ecosystems (Franklin *et al.,* 1987, Esseen *et al.,* 1992; Bader *et al.,* 1995; Rossman *et al.,* 1998; Norden and Paltto, 2001).

Species diversity

Both the Shannon's and Simpson's diversity index was high for both the two sacred groves. Species diversity of the wood rotting fungi was found to be higher in the undisturbed than the disturbed sacred grove. The higher species diversity in the undisturbed sacred grove may be due to the greater number of potential host tree species. In a study on the macrofungal species diversity in fragmented and disturbed forest stands, Brown *et al.* (2006) have found that habitat requirements are the most important determinant of species composition. They also found no relationship between the size and isolation of sacred groves and their macrofungal richness and the sacred groves had the highest macrofungal morphotype richness per sample area. Rather more important is that the amount of nutrients available to wood-inhabiting fungi is strongly related to the degree of decay of the wood (Edmonds and Eglitis, 1989; Harmon *et al.,* 1986; Maser and Trappe, 1984). The importance of presence of old dying trees and fallen logs for presence of wood rotting fungi is also recognized from studies in temperate areas where it was found that there is a correlation between

the decay of the wood and the species of fungi recorded as sporocarps (Høiland and Bendiksen, 1997; Lindblad, 1998; Renvall, 1994), and total species number is positively correlated with decay stage of the log (Bader *et al.*, 1995).

Although a careful observation of the randomly selected transect at each of the three carefully selected plots with at least more than three visits half yearly was done and the survey of each sacred grove was limited to two years only, it may be likely that only a proportion of the entire wood rotting fungi assemblage was studied. However, from the observations there is no reason to suspect that the proportion of the wood rotting fungi assemblage seen in each site type differed significantly. For this reason, it may be assumed that comparisons that have been made between the two sacred groves are valid.

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Chapter V
WOOD DECAY BY SELECTED SPECIES OF WOOD ROTTING FUNGI

V. 1 Introduction

Fungi are very important agents of biodeterioration as they are active in the breakdown of plant materials, especially cellulose and lignin (Carlile *et al.*, 2001). Wood and wood products in use are often biodegraded by various organisms in many conditions especially if its natural resistance is low. The most important agents of wood biodegradation are fungi, insects and fire.

Wood decaying or wood rotting fungi belong mainly to the group of Basidiomycetes. They invade wood cells and degrade cell wall components resulting in detrimental effects on strength and other wood properties (Rayner and Boddy, 1988; Cartwright and Findlay, 1958). The type and severity of fungal attack depends on the fungi involved and the period of attack. In a freshly felled timber, the earliest fungal colonizers are largely Ascomycetes and Deuteromycetes. When a log is abandoned in the forest for a considerable length of time, the early colonizers are replaced by wood-rotting Ascomycetes and Basidiomycetes (Momo, 1972).

The major structural elements of wood are cellulose, hemicellulose and lignin. Lignin provides strength and rigidity in wood cell walls. Lignin is a water-impermeable aromatic polymer found in all higher plants and serves as a barrier against microbial attack (Dean and Eriksson, 1992). Wood rotting fungi are so far the only organisms capable of degrading lignin. Lignin is degraded by white rot, brown rot and soft rot fungi. White rot fungi are able to degrade both carbohydrates and

lignin, whereas brown rot fungi and soft rot fungi prefer cellulose and hemicellulose as substrates (Tuor *et al.*, 1995).

Of about 1,700 wood-degrading Basidiomycetes in North America, only 120 species (7%) caused brown rot, and of these 79 (65%) were polypores (Eriksson *et al.*, 1990; Ryvarden and Gilbertson, 1993). The white-rot fungi are more distributed among the different Basidiomycetes members with some belonging to the Ascomycetes (Rayner and Boddy, 1988). Most brown-rot fungi affect conifers (Ryvarden and Gilbertson, 1993), while white-rot fungi occur more frequently on hardwood. Brown rot occurs in standing trees, felled and processed wood as well as in sapwood and heartwood.

White rot fungi are the most abundant degraders of wood in nature. Their strategy is to decompose the lignin in wood so that they can gain access to the cellulose and hemicelluloses that are embedded in the lignin matrix. Under optimal conditions, the rates at which white rot fungi mineralize lignin rival their rates of polysaccharide degradation. Basidiomycetes and xylariaceous Ascomycetes that cause white rot are the organisms mainly responsible for wood decay in hardwood forests and in tropical forest ecosystems, and also play a prominent role in temperate coniferous forests (Eriksson *et al.*, 1990; Blanchette, 1991; Dix and Webster, 1995).

The brown rot fungi comprise a relatively small group of Basidiomycetes that decay the cellulose in wood preferentially. They do not degrade the lignin extensively, although they modify it by demethylating it. Brown rot fungi thus stand out as an exception to the usually valid observation that lignocellulose must be delignified first if organisms are to gain access to plant cell wall polysaccharides.

The biochemical system that enables brown rot fungi to circumvent the lignin while degrading the cellulose and hemicelluloses in wood has not been characterized. Although these fungi secrete cellulases and hemicellulases, the enzymes are too large to penetrate the cell wall matrix in wood, and it is evident that other degradative systems must participate as well. Brown rot fungi make a large contribution to wood decay, especially in coniferous forests (Dix and Webster, 1995), and the residual modified lignin they leave behind is an important humus precursor (Hudson, 1986). They deserve much more research attention, but have been difficult to study because they do not exhibit full degradative activity on defined media *in vitro* (Eriksson *et al.*, 1990).

The soft rot fungi are Ascomycetes and Deuteromycetes that decay water saturated (but not totally anaerobic) wood, as well as wood prone to fluctuating moisture regimes. Soft rot fungi are slower and less aggressive decayers than white and brown rot fungi, and are probably less important degraders in a quantitative sense. They attack the polysaccharide component of wood preferentially, but appear to have some ability to decompose lignin (Dix and Webster, 1995). Soft rot fungi have received little research attention, and their degradative mechanisms remain unknown.

The present study was conducted to investigate the decay potential of four commonly occurring wood rotting fungi *Trametes versicolor* (L.: Fries) Pilát, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *Polyporus brumalis* (Pers.) Ex Fries, and *Earliella scabrosa* (Pers.) R.L. Gilbertson and Ryv of the region on woodblocks

of *Pinus kesiya* and *Michelia champaca,* the two most important sources of timber in the region.

V.2 Review of Literature

Lignin is the most abundant aromatic compound on earth, and is second only to cellulose in its contribution to living terrestrial biomass (Crawford, 1981). Lignin is one of the three major polymers in wood cell walls, which provides strength and rigidity, the others being cellulose and hemicellulose (Ullah *et al.*, 2002). Of all naturally produced organic chemicals, lignin is probably the most recalcitrant. This is consistent with its biological functions, which are to give vascular plants the rigidity they need to stand upright and to protect their structural polysaccharides (cellulose and hemicelluloses) from attack by other organisms (Hammel, 1997).

The organisms principally responsible for lignocellulose degradation are aerobic filamentous fungi, and the most rapid degraders in this group are Basidiomycetes (Kirk and Farrell, 1987). Many studies have indicated that fungi proficient in lignin-decomposition belong to the Basidiomycetes, and that the ability to decompose lignin varies considerably among fungal species (Lindeberg, 1947; Mikola, 1955; Tanesaka *et al.,* 1993). The delignification of a solid lignocellulosic substrate is often assessed by the simple procedure of removing its low molecular weight components by extraction, weighing the left over woody residue, degrading the remaining polysaccharide component with strong acid, and then reweighing the leftover insoluble lignin, which is chemically modified and referred to as Klason lignin (Hammel, 1997). Convincing data showing that certain xylariaceous

Ascomycetes delignify wood have been obtained with the Klason procedure (Nilsson *et al.*, 1989)

Fungal activity has been assessed by various methods: O_2 consumption (Carrodus and Triffet, 1975), chitin content (Braid and Line, 1981), CO_2 production (Boddy, 1983), mass loss of substrate, mass increase of fungus, linear growth of hyphae, ergosterol content (Nilsson and Bjurman, 1990), ATP concentration (Bjurmann, 1992), heat production (Xie *et al.*, 1997) or as function of temperature by measurement of heat production rate (Bjurman and Wadso, 2000).

Decay study of woody substrate by fungi using mean percentage weight loss was used by Carranza-Morse and Gilbertson (1989). Weight loss measurement using wood block assay method has been employed to measure the decay potential of wood-decaying fungi by Chow *et al.* (1993 and 1994) and Chee *et al.* (1998).

There are several standards to determine the resistance of untreated wood and wood-based composites against fungi and also to test the efficacy of preservatives. A glass Kolle flask is used according to the European standard (EN 113, 1996) to determine the toxic values of wood preservatives against wood destroying Basidiomycetes cultured on agar medium (Willeitner, 2005). The method can be also used to test the natural durability of timber species etc., (Schmidt, 2006). The technique of sterilization of wood by autoclaving has been used by several workers (Tan *et al.*, 1989; Badham, 1991; Leong *et al.*, 1991 and Fryar *et al.*, 2001).

In terms of optimum growth temperature, several wood rotting fungi have been found to grow well between 26-45°C on agar media and between 20 - 37.5°C,

which are temperatures occurring in buildings, and have their maximum around 45°C (Schmidt and Huckfeldt, 2005)

Wood moisture is the most important factor influencing wood decay by fungi and, consequently, also the most important factor to be taken into consideration in terms of wood protection (Schmidt, 2007). It has been found that the optimum wood moisture content (u, %) for several wood rotting fungi ranged from 34% - 210% (Huckfeldt and Schmidt, 2006). Moisture in wood exists as bound or hygroscopic water within the cell wall due to hydrogen bonding of the hydroxyl groups mainly in the cellulose and hemicelluloses and as free or capillary water in liquid form in the cell lumen as well in other holes in wood tissue. The critical point for wood fungi is the fibre saturation point, which is at about 30% moisture. The classical opinion is that there is no or only minimal fungal activity below the fibre saturation point. However, only that part of water not bound by dissolved substances such as salts and sugars is available to the fungi (Schmidt, 2007).

De Groot (1975) observed that wood moisture content increase considerably with intensity of wood degradation by white-rot fungi in *Pinus radiata*; In a study on the relationship between infection of subalpine spruce and moisture content, Etheridge (1958) have shown that small changes in moisture content have a significant effect on decay. A difference in moisture content of only 3-4% of saturation had a critical effect on the rate of decay by *Coniophora puteana.*

The pH of wood depends to a considerable degree on the presence of volatile acids, the most important of which are acetic and formic acids whose content in living trees may exceed 0.4% per unit of dry weight (Hintikka, 1969). Because of the

presence of free acids the pH of fresh wood is often quite low. In general, the pH of hardwoods varies from 2.8-6.8, whereas it varies from pH 2.7- 8.8 in softwoods (Gray, 1958). Jennison (1952) found the growth optimum of 42 species of decay fungi to vary between 3.5 and 5.5 while Butcher (1968) have found wood inhabiting fungi to have a wide pH range from 4.0-9.0 and a growth optimum between pH 5.0-6.0. The tolerance of acidity has also been found to be greater in wood-inhabiting than in litter-decomposing Basidiomycetes (Hintikka, 1969).

V.3 Materials and Methods

Pure cultures of common dominant wood rotting fungi

The pure cultures of the common wood rotting fungi *Trametes versicolor* (L. Fries) Pilát, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *Polyporus brumalis* (Pers.) Ex Fries and *Earliella scabrosa* (Pers.) R.L. Gilbertson and Ryv were maintained in the laboratory using 2% malt extract agar (MEA) medium (Griffith and Boddy, 1990). Cultures possessing clamp connections or those identified by other features characteristic of basidiomycetes were selected (Nobles 1965). Once the pure cultures are isolated and confirmed to be the fungus they were multiplied in Petriplates and test tubes for further uses and kept in cold storage below 0°C. The pure cultures were then transferred to 250 ml conical flasks under aseptic conditions in a laminar flow chamber and sealed with sterilized cotton wool and aluminium foil. They were then allowed to grow under controlled temperatures of 25±2 °C in a

culture room for 5 days or more, until the medium was well covered with the fungal mycelia.

Composition of Malt Extract Agar medium (MEA; Difco)

Malt Extract	20 g
Agar	15 g
Dextrose	10 g
Peptone	5 g
Distilled Water	1000 ml
Streptomycin	0.5 mg

Wood Block Assay for estimation of decay potential

The method is based on that of Cartwright and Findlay (1958), Chee *et al.*(1998), Fryar *et al.* (2001) and the European standard EN 113 (1996) and modified as necessary.

Wood sampling and treatment of wood

Experimental woodblocks (1.5 x 1.5 x 1.5 cm) were prepared from the outer heartwood (adjacent to sapwood) of matured and carefully selected 25-30 year old *Pinus kesiya* Royle ex Gordon and *Michelia champaca* trees. The wood blocks with knots, visible decay, stains, etc., were rejected. Each wood block was then weighed and serially numbered for easy identification. The wood blocks of *P. kesiya* weighed 1.46 g (± 0.14) and *M. champaca* weighed 1.74 g (± 0.13) respectively. Three replicates were taken for each sample.

The woodblocks were sterilized carefully so as to avoid contamination from any microorganisms present in the wood prior to inoculation by the test fungi. The wood blocks were oven-dried at 110°C for 24 hrs, each wood block was then weighed, marked and then immediately kept inside carefully sealed conical flasks and sterilized in an autoclave for 2 hrs and kept ready to be aseptically transferred to the conical flasks containing the cultured test fungi (Plate 5.1-5.26).

Inoculation of wood with fungi

The sterilized wood blocks were then aseptically transferred to the conical flasks containing pure cultures of fungal mycelium of the wood rotting fungi *Trametes versicolor*, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *Polyporus brumalis* and *Earliella scabrosa* (Pers.) R.L. Gilbertson and Ryv. The control set was also maintained as sterilized woodblocks in MEA medium only. Five woodblocks each was introduced into the Control sets and the conical flasks containing the MEA medium and the test fungi growing on it.

The flasks were incubated at 25±2 ° C for 300 days. Sampling was done at 30-day intervals. On sampling, the woodblocks were taken out from the flasks and superficial fungal mycelium on the woodblocks was carefully scraped off without damaging them.

Weight loss

The initial oven-dried weight (W_1) of each woodblock before inoculation was recorded. After inoculation and incubation, the fungus covering each woodblock was

carefully removed and the block was again oven dried at 110°C for 24 hrs to get the final weight (W_2).

The percentage weight loss was then calculated as follows:

Percentage weight loss = $\mathbf{[(W_1 - W_2)/ W_1] \times 100}$

Where, W_1 = Initial weight

W_2 = Final weight

Lignin content

The decayed wood blocks from treated and control sets were then ground to powder in Wiley Mill Grinder for the estimation of the lignin content as outlined by Peach and Tracy (1955).

0.3 g of the powdered sample was taken from each sample into a 250 ml conical flask. 25 ml of 72% concentrated sulphuric acid (H_2SO_4) was added to each replicate and kept in deep freeze for 24 hrs. It was then filtered in a Whatman No 1 filter paper and the residue left in the filter paper was washed several times with tap water to remove the last traces of sulphuric acid (H_2SO_4). The residue was then washed finally into a watch glass, oven dried and weighed. The amount obtained was recorded as total lignin.

Wood Moisture Content

The proportional wood moisture content **u**, expressed as a percentage is determined gravimetrically by measuring the wood mass before and after drying a wood sample at 103±2°C (Schmidt, 2007):

$$\mathbf{u\ (\%) = [(}W_1 - W_2\mathbf{)/}\ W_2\mathbf{] \times 100}$$

Where, W_1 = *Mass of wet wood*
W_2 = *Mass of dried wood*

Wood pH

The procedure of pH determination was adopted from the cold extraction method for hydrogen ion concentration (pH) of paper extracts, TAPPI (1983) with slight modification. The decayed wood blocks from treated and control sets were grinded to small pieces in a Wiley Mill Grinder for the estimation of the pH. 1g each of the grinded wood pieces was then transferred into a 100-ml beaker and distilled water (pH~ 6.7) was added until the specimens were wet. Distilled water was added again to bring the total volume to 70-ml. The mixture was stirred well and allowed to soak for 1 hour at room temperature. A battery powered pH meter (Fisher Scientific, Accumet 1003) was used for the measurement. The pH meter was calibrated using three standard solutions, pH 4.0, pH 7.0 and pH 10.0. The electrode of the pH meter was submerged into the unfiltered mixture. The pH value was recorded when there was no more drift in the measurement for a period of 30 seconds.

V.4 Results

Estimation of the decay potential

Experiment on the effect of the wood rotting fungi *Trametes versicolor.*, *Hirschioporus abietinus*, *Polyporus brumalis* and *Earliella scabrosa* on the selected two common timber trees of the region *Pinus kesiya* and *Michelia champaca* was done. The assessment of the degree of their effectiveness over a period of 300 days is depicted in the Tables 5.1- 5.4 and in the Figs. 5.1- 5.4.

Weight loss

It was observed that the test fungi have shown a positive effect on the woodblocks of *P. kesiya* and *M. champaca* (Fig.5.1, Table 5.1). The weight loss effected by *T. versicolor* was maximum on both the woodblocks where it was 67.24±0.94% on *P. kesiya* and 34.53±0.67% on *M. champaca* at 300 days.

The other test fungus *E. scabrosa* also showed a similar effect where it was 45.07±1.67% and 24.35±0.46% on the two woodblocks of *P kesiya* and *M. champaca* respectively. The percentage weight loss was, however, lesser in case of woodblocks treated with the other two test fungi where it was 28.08±1.89%, 12.34±0.25% for *P. brumalis* and 13.36±1.79%, 8.57±0.40% for *H. abietinus* on the two test woodblocks of *P. kesiya* and *M. champaca* respectively. The control replicates also indicated minute weight loss with maximum of 8.72±2.19 and 8.22±0.08 on the test woodblocks of *P. kesiya* and *M. champaca* respectively after 300 days of the incubation period.

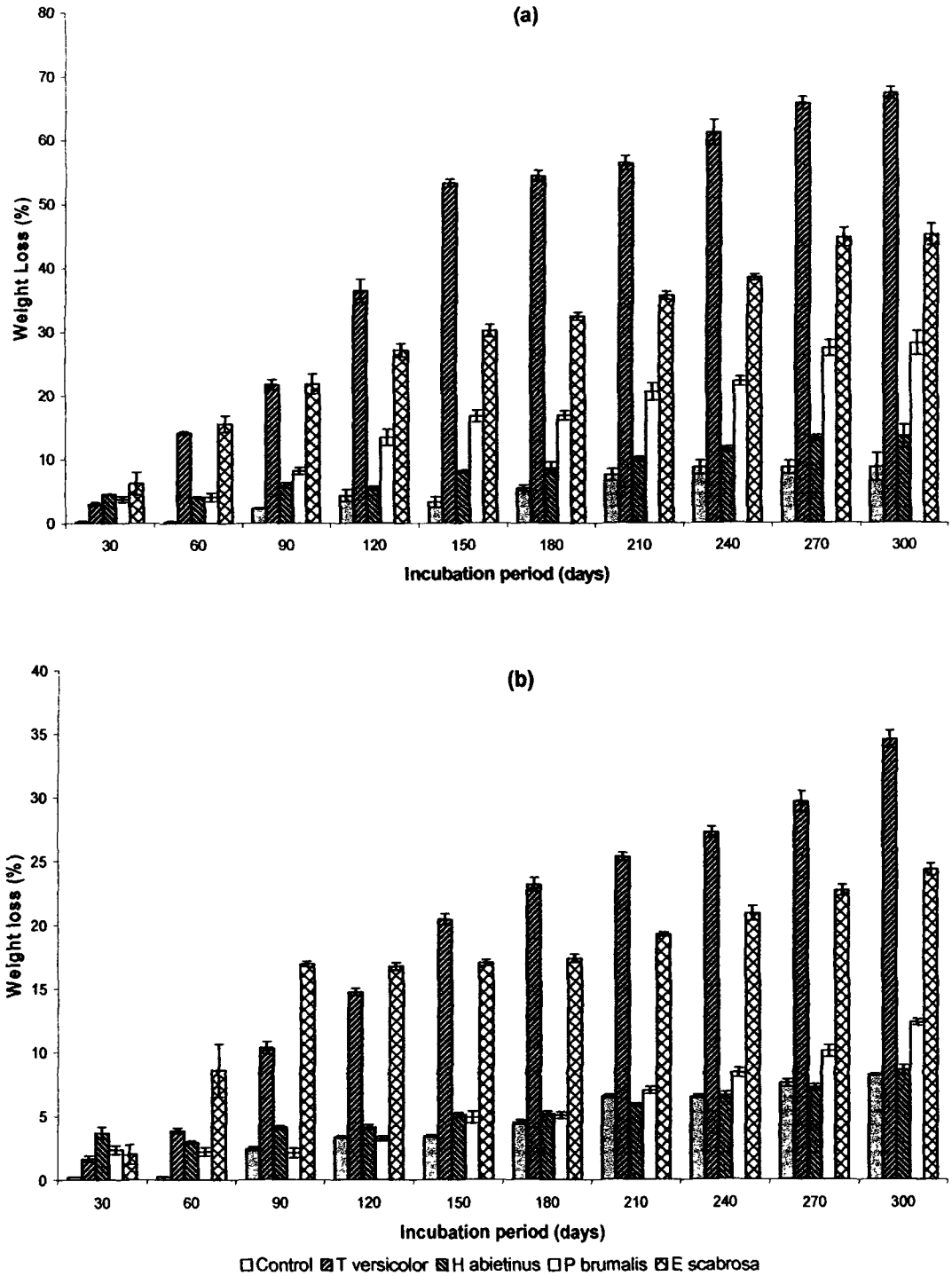


Fig.5.1 Percentage Weight loss affected by different test fungi on (a) *Pinus kesiya* and (b) *Michelia champaca*

Table 5.1 Range of percentage weight loss of woodblocks in treated and control sets. Values in parentheses indicate the mean and standard error.

Wood type	Duration (Days)	Treatment				
		Control	*Trametes versicolor*	*Hirschioporus abietinus*	*Polyporus brumalis*	*Earliella scabrosa*
Pinus kesiya	30	0.08-0.62 (0.27±0.17)	2.63-3.54 (3.04±0.27)	4.53-4.72 (4.60±0.06)	2.95-4.48 (3.8±0.45)	3.15-9.24 (6.26±1.76)
	60	0.12-0.54 (0.26±0.14)	13.75-14.59 (14.22±0.25)	3.94-4.27 (4.06±0.10)	2.91-5.18 (4.1±0.66)	13.14-17.21 (15.63±1.26)
	90	2.16-2.52 (2.33±0.10)	20.45-23.17 (21.69±0.79)	5.51-6.78 (5.99±0.40)	7.16-8.82 (8.24±0.54)	18.76-23.66 (21.83±1.54)
	120	2.35-5.42 (4.22±0.95)	33.52-39.66 (36.43±1.78)	5.15-6.12 (5.50±0.31)	10.93-14.94 (13.45±1.27)	25.21-28.66 (27.14±1.02)
	150	2.84-5.37 (3.76±0.81)	52.29-54.28 (53.27±0.57)	7.84-8.34 (8.14±0.15)	15.24-18.32 (16.78±0.89)	28.82-32.12 (30.18±1.00)
	180	4.56-5.97 (5.45±0.45	53.02-55.94 (54.40±0.85)	6.78-9.55 (8.66±0.94)	15.88-18.21 (16.86±0.70)	31.46-33.56 (32.5±0.61)
	210	5.52-8.49 (7.41±0.95)	55.17-58.94 (56.34±1.07)	9.56-10.58 (10.12±0.30)	17.92-22.44 (20.53±1.35)	34.87-36.84 (35.61±0.62)
	240	6.48-9.87 (8.67±1.10)	57.21-63.65 (61.08±1.97)	10.71-12.05 (11.54±0.42)	21.21-23.55 (22.14±0.72)	37.82-39.31 (38.4±0.46)
	270	6.95-10.53 (8.65±1.04)	64.08-66.52 (65.99±0.98)	12.59-14.11 (13.31±0.44)	24.92-29.22 (27.34±1.27)	42.87-47.56 (44.6±1.49)
	300	4.37-11.38 (8.72±2.19)	66.24-69.12 (67.24±0.94)	10.32-16.52 (13.36±1.79)	26.15-31.85 (28.08±1.89)	42.28-48.07 (45.07±1.67)
Michelia champaca	30	0.19-0.24 (0.22±0.02)	1.41-2.12 (1.65±0.24)	2.784.39 (3.71±0.48)	1.71-2.85 (2.37±0.34)	1.13-3.55 (2±0.78)
	60	0.21-0.31 (0.25±0.03)	3.62-4.28 (3.89±0.20)	2.843.17 (2.95±0.11)	1.81-2.87 (2.22±0.33)	4.48-10.98 (8.6±2.07)
	90	2.27-2.75 (2.44±0.15)	9.6-11.24 (10.35±0.48)	3.974.32 (4.16±0.10)	1.66-2.92 (2.13±0.40)	16.59-17.32 (16.93±0.21)
	120	3.18-3.54 (3.38±0.11)	14.22-15.12 (14.76±0.27)	3.784.45 (4.14±0.20)	2.87-3.56 (3.23±0.20)	16.28-17.29 (16.75±0.29)
	150	3.25-3.57 (3.45±0.10)	19.65-20.62 (20.45±0.42)	4.795.34 (5.13±0.17)	4.02-5.53 (4.92±0.46)	16.56-17.35 (17.02±0.24)
	180	4.14-4.77 (4.52±0.19)	22.13-23.91 (23.2±0.54)	4.915.54 (5.20±0.18)	4.61-5.45 (5.08±0.25)	16.98-18.02 (17.40±0.32)
	210	6.23-6.71 (6.55±0.16)	24.73-25.68 (25.35±0.31)	5.656.14 (5.88±0.14)	6.45-7.38 (7.02±0.29)	18.95-19.56 (19.25±0.18)
	240	6.24-6.72 (6.53±0.15)	26.41-27.91 (27.22±0.44)	6.086.92 (6.61±0.27)	7.66-8.84 (8.38±0.36)	19.83-21.76 (20.9±0.57)
	270	6.98-7.91 (7.56±0.29)	28.55-31.25 (29.64±0.82)	6.957.74 (7.24±0.25)	9.17-10.61 (10.08±0.46)	21.92-23.41 (22.7±0.43)
	300	8.08-8.37 (8.22±0.08)	33.25-35.53 (34.53±0.67)	7.869.23 (8.57±0.40)	11.84-12.65 (12.34±0.25)	23.50-25.08 (24.35±0.46)

Lignin content

Initially the lignin content of the woodblocks was 15.24±0.15% for *P. kesiya* and 12.64±0.09% for *M. champaca.* A decrease in lignin content of the wood was observed with increase in time (Fig.5.2, Table 5.2). The loss in lignin content after 300 days was maximum in the woodblocks treated with *T. versicolor* which showed significant decrease as shown by the remaining lignin content of 6.31±0.48% for *P. kesiya* and 8.21±0.43 % for *M. champaca.* Of the woodblocks treated with the other test fungi, significant decrease in the lignin content of the woodblocks treated with *E. scabrosa* was recorded with mean values of upto 7.26±0.23% and 7.49±0.20% for woodblocks of *P. kesiya* and *M. champaca* respectively. The lignin content in woodblocks of *P. kesiya* and *M. champaca* treated with *P. brumalis* were 9.78±0.24% and 8.51±0.31% respectively and least decrease was observed in those treated with *H. abietinus* where it was 10.86±0.26% in the woodblocks of *P. kesiya* and 8.51±0.31% in the woodblocks *M. champaca.* Control samples remained almost the same with mean values of 15.02±0.25% and 12.16±0.46% for the two test woodblocks *P. kesiya* and *M. champaca* respectively.

Moisture content

The moisture content of the wood showed increasing trend with time (Fig.5.3, Table 5.3). The moisture content after 300 days was maximum for those treated with *T. versicolor* where it was 82.11±1.55% for woodblocks of *P. kesiya* and 75.93±0.66% for woodblocks of *M. champaca. E. scabrosa* was the next species with mean values of 71.08±0.66% and 66.63±0.99% followed by *P. brumalis* with

67.27±0.88% and 48.17±1.19%, *H. abietinus* with 63.81±0.73% and 53.87±0.70% for woodblocks of *P. kesiya* and *M. champaca* respectively. The percentage moisture content for control sets was 57.10±0.56% for woodblocks of *P. kesiya* and 42.68±1.49% for woodblocks of *M. champaca.*

Wood pH

The pH of the wood showed a tendency towards acidity (Fig.5.4, Table 5.4). In case of woodblocks treated with *T. versicolor*, the pH at 300 days was 3.70±0.10 for *P. kesiya* and 4.24±0.23 for *M. champaca.* The pH at 300 days was 3.32±0.12 and 3.92±0.20 for *E. scabrosa,* 4.20±0.20 and 4.53±0.17 for *P. brumalis*, 6.14±0.34 and 6.52±0.29 for *H. abietinus* and 5.9 and 6.2 for the control sets with woodblocks of *P. kesiya* and *M. champaca* respectively.

The correlation coefficient of the physico-chemical characteristics affected by the different wood rotting fungi on the two woodblocks of *P. kesiya and M. champaca* was analyzed. It was observed that in the woodblocks of *P. kesiya,* weight loss was significantly positively correlated with the pH in control sets ($r = 0.90$, $P \leq 0.001$) and *H. abietinus* ($r = 0.62$, $P \leq 0.05$), moisture content in *T. versicolor* ($r = 0.91$, $P \leq 0.001$), *H. abietinus* ($r = 0.78$, $P \leq 0.001$), *P. brumalis* ($r = 0.74$, $P \leq 0.01$), *E. scabrosa* ($r = 0.77$, $P \leq 0.01$). It showed a significant negative correlation with lignin in *T. versicolor* ($r = -0.91$, $P \leq 0.001$), *H. abietinus* ($r = -0.96$, $P \leq 0.001$), *P. brumalis* ($r = -0.83$, $P \leq 0.001$) and *E. scabrosa* ($r = -0.96$, $P \leq 0.001$), and with pH in *P. brumalis* ($r = -0.76$, $P \leq 0.01$) and *E. scabrosa* ($r = -0.95$, $P \leq 0.001$).

Lignin content showed a significant positive correlation with pH in *P. brumalis* (r = -0.68, P≤0.05), *E. scabrosa* (r = -0.89, P≤0.001). It showed a significant negative correlation with moisture in *T. versicolor* (r = -0.82, P≤0.01), *H. abietinus* (r = -0.74, P≤0.01), *P. brumalis* (r = -0.83, P≤0.01) and *E. scabrosa* (r = -0.68, P≤0.05). Moisture content showed a positive correlation with pH in *H. abietinus* (r = 0.61, P≤0.05). It also showed a negative correlation with pH in *T. versicolor* (r = -0.62, P≤0.05) and *E. scabrosa* (r = -0.86, P≤0.001) (Table 5.5).

It was observed that in the woodblocks of *M. champaca*, weight loss was significantly positively correlated with the moisture content in the control sets (r = 0.66, P≤0.05), *T. versicolor* (r = 0.82, P≤0.01), *H. abietinus* (r = 0.80, P≤0.01) and *E. scabrosa* (r = 0.79, P≤0.01), pH in control sets(r =0.65, P≤0.05). It showed a significant negative correlation with lignin in control sets (r = -0.72, P≤0.05), *T. versicolor* (r= -0.90,P≤0.001), *H. abietinus* (r = -0.92, P≤0.001), *P. brumalis* (r = -0.95, P≤0.001), *E. scabrosa* (r = -0.90, P≤0.001), and with pH in *T. versicolor* (r = -0.96, P≤0.001), *P. brumalis* (r = -0.82, P≤0.01), *E. scabrosa* (r = -0.95, P≤0.001). Lignin concentration showed a significant positive correlation with pH in *T. versicolor* (r = 0.89, P≤0.001), *P. brumalis* (r = 0.77, P≤0.01), *E. scabrosa* (r = 0.86, P≤0.001). It also showed a negative correlation with moisture in *T. versicolor* (r = -0.82, P≤0.01), *H. abietinus* (r = -0.72, P≤0.05), *P. brumalis* (r = -0.67, P≤0.05), *E. scabrosa* (r = -0.84, P≤0.001), and with pH in control sets (r = -0.65, P≤0.05). Moisture content showed a positive correlation with pH in *H. abietinus* (r = 0.79,

P≤0.01) and negative correlation with pH in *T. versicolor* (r = -0.79, P≤0.01) and *E. scabrosa* (r = -0.77, P≤0.01) (Table 5.5).

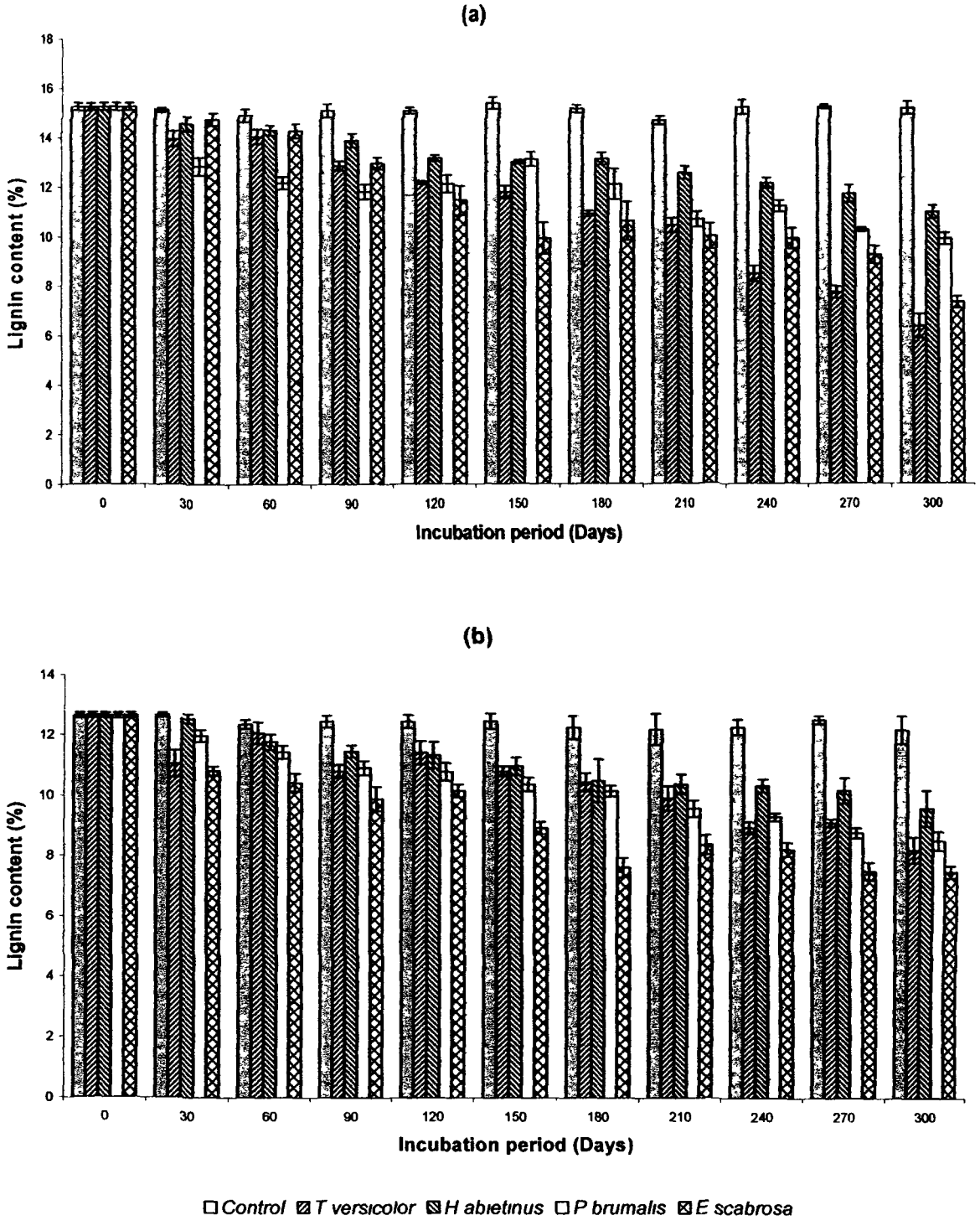


Fig.5.2 Change in lignin content(%) effected by different test fungi on (a) *Pinus kesiya* and (b) *Michelia champaca*

Table 5.2 Range of Lignin content (%) in woodblocks of treated and control sets. Values in parentheses indicate the mean and standard error.

Wood type	Duration (Days)	Treatment				
		Control	*Trametes versicolor*	*Hirschioporus abietinus*	*Polyporus brumalis*	*Earliella scabrosa*
Pinus kesiya	0	14.95-15.45 (15.24±0.15)	14.95-15.45 (15.24±0.15)	14.95-15.45 (15.24±0.15)	14.95-15.45 (15.24±0.15)	14.95-15.45 (15.24±0.15)
	30	14.95-15.24 (15.12±0.09)	13.45-14.55 (13.95±0.32)	14.22-15.12 (14.54±0.29)	12.39-13.56 (12.84±0.36)	14.25-15.08 (14.73±0.25)
	60	14.37-15.16 (14.89±0.26)	13.49-14.51 (14.03±0.30)	14.07-14.69 (14.29±0.20)	11.85-12.65 (12.16±0.25)	13.75-14.74 (14.25±0.29)
	90	14.53-15.35 (15.07±0.27)	12.54-13.18 (12.82±0.19)	13.53-14.42 (13.87±0.28)	11.42-12.37 (11.78±0.30)	12.55-13.38 (12.92±0.24)
	120	14.82-15.25 (15.03±0.12)	12.05-12.28 (12.14±0.07)	12.94-13.37 (13.12±0.13)	11.58-12.75 (12.07±0.35)	10.26-12.23 (12.37±0.59)
	150	14.87-15.71 (15.31±0.24)	11.32-12.23 (11.73±0.27)	12.82-13.11 (12.95±0.09)	12.73-13.63 (13.05±0.29)	9.07-11.12 (9.88±0.63)
	180	14.88-15.38 (15.07±0.16)	10.73-11.08 (10.85±0.11)	12.77-13.55 (13.05±0.25)	11.23-13.24 (12.04±0.61)	9.68-12.08 (10.55±0.77)
	210	14.25-14.75 (14.58±0.17)	9.82-10.79 (10.36±0.29)	12.15-12.98 (12.47±0.26)	10.28-11.23 (10.61±0.31)	9.14-10.86 (9.92±0.50)
	240	14.55-15.49 (15.11±0.28)	8.04-9.05 (8.42±0.32)	11.77-12.46 (12.06±0.21)	10.87-11.58 (11.13±0.23)	9.34-10.64 (9.83±0.41)
	270	14.95-15.26 (15.10±0.09)	8.05-7.72 (7.67±0.24)	11.13-12.28 (11.62±0.34)	10.05-10.33 (10.17±0.08)	8.45-9.56 (9.16±0.36)
	300	14.58-15.45 (15.02±0.25)	5.58-7.21 (6.31±0.48)	10.57-10.63 (10.86±0.26)	9.31-10.08 (9.78±0.24)	6.95-7.72 (7.26±0.23)
Michelia champaca	0	12.47-12.78 (12.64±0.09)	12.47-12.78 (12.64±0.09)	12.47-12.78 (12.64±0.09)	12.47-12.78 (12.64±0.09)	12.47-12.78 (12.64±0.09)
	30	12.52-12.75 (12.66±0.07)	10.25-11.77 (11.06±0.44)	12.25-12.72 (12.54±0.15)	11.68-12.35 (11.98±0.20)	10.54-11.06 (10.82±0.15)
	60	12.15-12.65 (12.36±0.15)	11.65-12.78 (12.07±0.36)	11.36-12.25 (11.78±0.26)	11.13-11.85 (11.44±0.21)	10.11-11.05 (10.44±0.31)
	90	12.25-12.84 (12.45±0.20)	10.54-11.25 (10.82±0.22)	11.21-11.86 (11.47±0.20)	10.56-11.34 (10.92±0.23)	9.12-10.36 (9.91±0.40)
	120	12.11-12.85 (12.44±0.22)	10.87-12.16 (11.42±0.38)	10.55-12.08 (11.33±0.44)	10.47-11.37 (10.79±0.29)	9.85-10.56 (10.17±0.21)
	150	11.95-12.74 (12.45±0.25)	10.52-11.07 (10.81±0.16)	10.38-11.35 (10.96±0.30)	10.14-10.83 (10.38±0.23)	8.55-9.25 (8.93±0.20)
	180	11.48-12.64 (12.24±0.38)	10.11-11.05 (10.44±0.31)	9.34-11.78 (10.49±0.71)	9.84-10.47 (10.16±0.18)	7.12-8.21 (7.62±0.32)
	210	11.15-12.84 (12.17±0.52)	9.12-10.36 (9.91±0.40)	9.83-10.95 (10.38±0.32)	9.25-10.12 (9.57±0.28)	7.87-8.98 (8.37±0.33)
	240	11.95-12.75 (12.25±0.25)	8.55-9.25 (8.93±0.20)	9.94-10.67 (10.34±0.21)	9.13-9.55 (9.30±0.13)	7.88-8.66 (8.22±0.23)
	270	12.22-12.69 (12.48±0.14)	8.87-9.34 (9.11±0.14)	9.42-10.85 (10.18±0.42)	8.57-9.11 (8.77±0.17)	7.12-8.08 (7.51±0.29)
	300	11.25-12.65 (12.16±0.46)	7.44-8.92 (8.21±0.43)	12.47-12.78 (12.64±0.09)	8.16-9.12 (8.51±0 31)	7.27-7.89 (7.49±0.20)

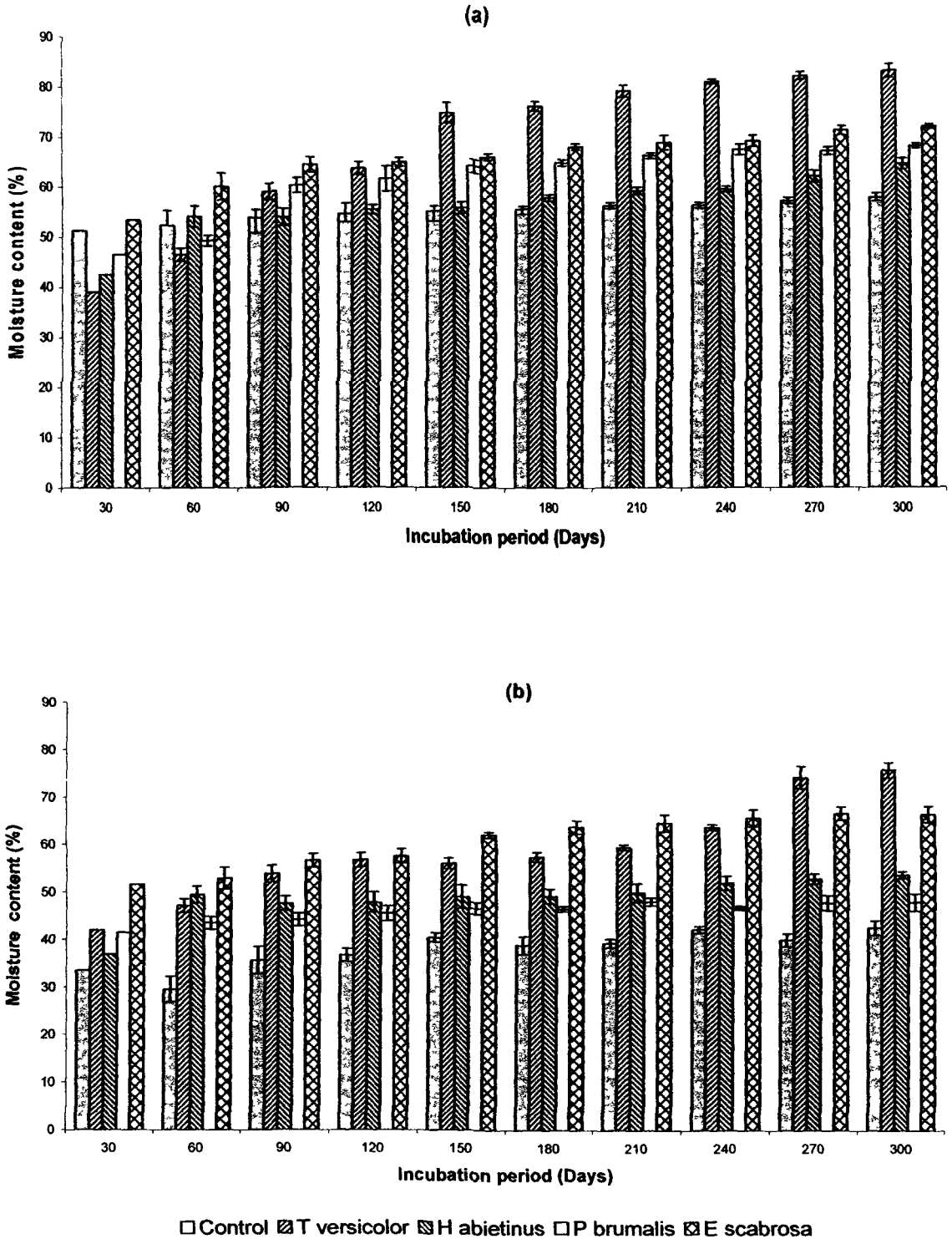


Fig.5.3 Change in moisture content (%) effected by different test fungi on (a) *Pinus kesiya* and (b) *Michelia champaca*

Table 5.3 Range of Moisture Content (%) in woodblocks of treated and control sets. Values in parentheses indicate the mean and standard error.

Wood type	Duration (Days)	Treatments				
		Control	*Trametes versicolor*	*Hirschioporus abietinus*	*Polyporus brumalis*	*Earliella scabrosa*
Pinus kesiya	30	45.32-54.27 (51.24±2.96)	36.92-41.32 (39.02±1.27)	38.56-45.85 (42.44±2.12)	44.58-48.23 (46.45±1.05)	47.86-56.52 (53.29±2.73)
	60	48.85-54.36 (52.19±1.69)	43.26-48.72 (46.42±1.63)	50.52-55.81 (53.94±1.71)	47.1-52.11 (49.15±1.52)	57.18-62.36 (59.89±1.50)
	90	49.55-56.47 (53.59±2.08)	56.78-61.14 (58.82±1.27)	52.51-55.48 (53.71±0.90)	55.05-63.12 (60.02±2.51)	62.36-65.15 (64.15±0.90)
	120	52.36-55.48 (54.35±1.00)	58.65-65.83 (62.32±2.07)	53.12-57.12 (55.16±1.16)	58.7-63.25 (61.25±1.34)	63.22-65.53 (64.56±0.69)
	150	53.82-55.76 (54.81±0.56)	73.21-76.17 (74.31±0.94)	54.23-56.48 (55.43±0.65)	62.58-64.8 (63.74±0.64)	64.75-66.86 (65.63±0.63)
	180	54.35-56.34 (55.18±0.60)	73.45-77.41 (75.66±1.17)	56.17-58.64 (57.37±0.71)	63.66-65.52 (64.38±0.58)	65.21-70.16 (67.53±1.44)
	210	54.84-56.74 (55.76±0.55)	77.64-79.14 (78.54±0.46)	57.82-59.83 (58.71±0.59)	63.66-67.1 (65.72±1.05)	66.35-70.15 (68.25±1.10)
	240	54.54-56.87 (55.78±0.68)	78.95-81.58 (80.22±0.76)	56.85-60.84 (58.94±1.16)	65.86-68.28 (66.81±0.75)	67.28-70.15 (68.44±0.87)
	270	54.87-58.16 (56.52±0.95)	78.68-83.1 (81.23±1.32)	59.18-62.86 (61.39±1.12)	65.68-67.33 (66.38±0.49)	69.64-71.08 (70.41±0.42)
	300	56.28-58.16 (57.10±0.56)	79.24-84.55 (82.11±1.55)	62.66-65.15 (63.81±0.73)	65.7-68.76 (67.27±0.88)	69.93-72.2 (71.08±0.66)
Michelia champaca	30	28.18-36.55 (33.55±2.69)	39.53-44.54 (42.07±1.45)	34.12-40.23 (36.94±1.78)	39.73-44.15 (41.54±1.34)	47.25-55.14 (51.70±2.33)
	60	25.42-35.12 (29.59±2.88)	44.25-50.33 (47.22±1.76)	46.84-52.13 (49.51±1.53)	41.84-46.18 (43.55±1.34)	50.44-55.39 (52.96±1.43)
	90	33.75-38.44 (35.68±1.42)	51.17-56.26 (53.94±1.49)	44.25-51.67 (47.6±2.17)	41.16-46.47 (44.25±1.59)	53.73-58.48 (56.67±1.48)
	120	34.73-37.85 (36.72±1.00)	54.58-58.25 (56.83±1.14)	44.42-52.53 (47.89±2.41)	43.33-47.68 (45.63±1.26)	56.47-58.63 (57.61±0.63)
	150	38.55-44.25 (40.50±1.88)	54.11-57.26 (56.15±1.02)	47.25-52.19 (49.16±1.53)	45.73-47.70 (46.76±0.57)	59.62-64.25 (62.21±1.36)
	180	37.48-40.62 (38.94±0.91)	56.45-58.37 (57.54±0.57)	46.78-53.12 (49.33±1.93)	45.09-47.95 (46.65±0.84)	61.38-67.35 (63.86±1.80)
	210	38.62-40.86 (39.41±0.73)	58.32-60.27 (59.58±0.63)	47.15-52.11 (50.10±1.51)	47.38-48.65 (48.21±0.42)	62.18-68.23 (64.75±1.80)
	240	39.72-44.18 (42.36±1.35)	59.62-67.67 (63.85±2.33)	50.05-53.34 (52.17±1.06)	43.77-48.69 (46.88±1.56)	64.19-68.64 (65.82±1.42)
	270	37.23-42.36 (40.11±1.51)	71.2-76.33 (74.32±1.58)	51.68-54.21 (53.02±0.73)	44.42-50.32 (47.98±1.81)	63.48-69.15 (66.81±1.71)
	300	39.72-44.48 (42.68±1.49)	74.88-77.15 (75.93±0.66)	52.48-54.70 (53.87±0.70)	46.18-50.28 (48.17±1.19)	64.94-68.37 (66.63±0.99)

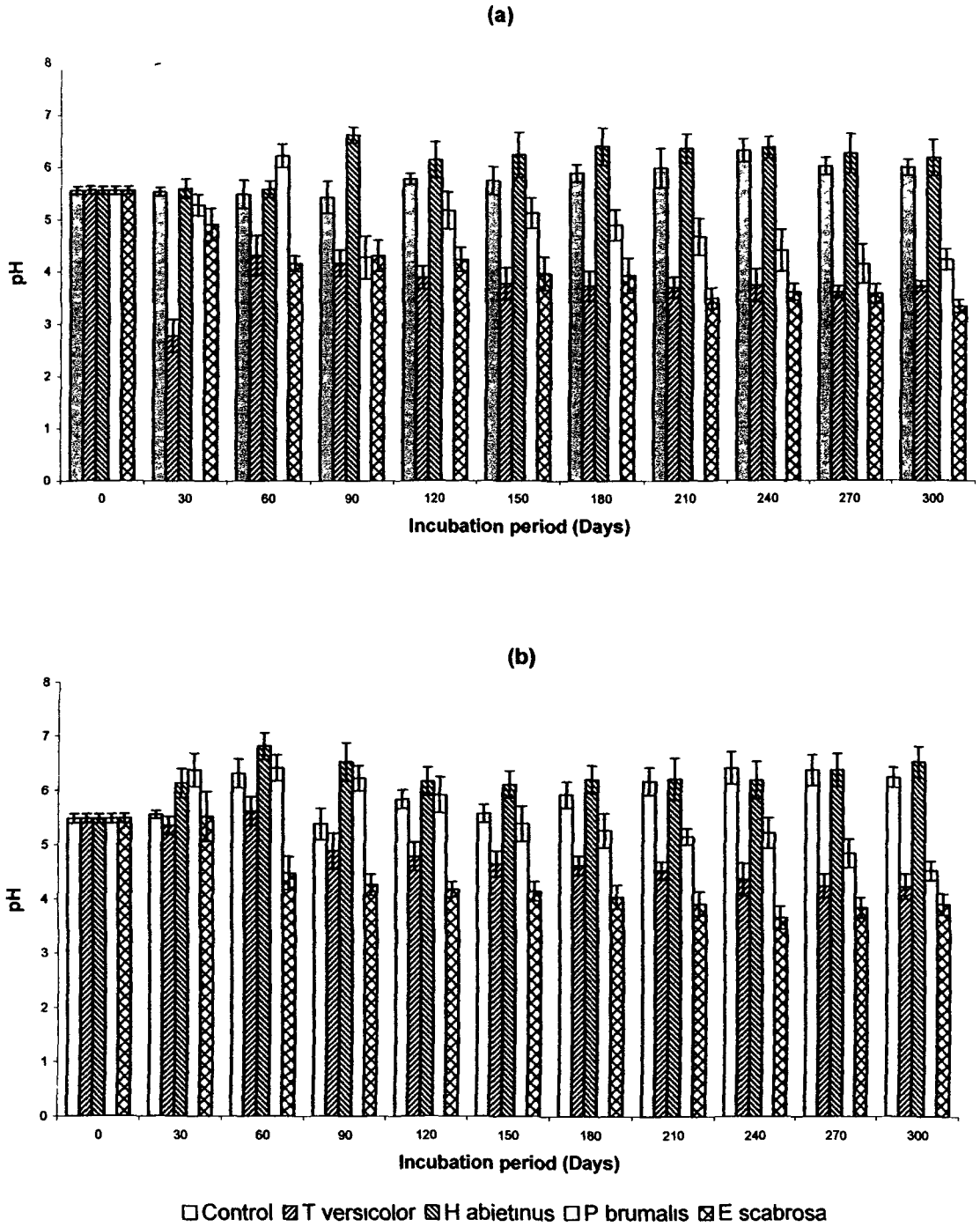


Fig.5.4 Change in pH of woodblocks effected by different test fungi on (a) *Pinus kesiya* and (b) *Michelia champaca*

Table 5.4 Range of pH in woodblocks of treated and control sets. Values in parentheses indicate the mean and standard error.

Wood type	Duration (Days)	Treatments				
		Control	*Trametes versicolor*	*Hirschioporus abietinus*	*Polyporus brumalis*	*Earliella scabrosa*
Pinus kesiya	0	5.48-5.71 (5.56±0.08)	5.48-5.71 (5.56±0.08)	5.48-5.71 (5.56±0.08)	5.48-5.71 (5.56±0.08)	5.48-5.71 (5.56±0.08)
	30	5.39-5.68 (5.53±0.08)	2.47-3.41 (2.78±0.31)	5.35-5.95 (5.59±0.18)	4.88-5.55 (5.28±0.20)	4.48-5.51 (4.91±0.31)
	60	4.95-5.81 (5.48±0.27)	3.56-4.85 (4.31±0.39)	5.37-5.89 (5.58±0.16)	5.78-6.54 (6.21±0.23)	3.92-4.42 (4.15±0.15)
	90	4.81-5.73 (5.42±0.31)	3.65-4.46 (4.15±0.25)	6.31-6.78 (6.61±0.15)	3.65-5.05 (4.27±0.41)	3.85-4.87 (4.30±0.30)
	120	5.56-5.92 (5.76±0.11)	3.60-4.31 (3.88±0.22)	5.56-6.75 (6.12±0.35)	4.56-5.78 (5.16±0.35)	3.86-4.64 (4.22±0.23)
	150	5.23-6.15 (5.72±0.27)	3.19-4.25 (3.76±0.31)	5.39-6.84 (6.22±0.43)	4.80-5.68 (5.11±0.29)	3.62-4.58 (3.95±0.32)
	180	5.56-6.12 (5.87±0.16)	3.15-4.05 (3.71±0.28)	5.67-6.81 (6.38±0.36)	4.52-5.46 (4.88±0.29)	3.32-4.47 (3.91±0.33)
	210	5.21-6.35 (5.96±0.38)	3.28-3.92 (3.68±0.20)	5.77-6.65 (6.33±0.28)	4.23-5.35 (4.65±0.35)	3.15-3.83 (3.47±0.20)
	240	5.84-6.52 (6.28±0.22)	3.20-4.27 (3.72±0.31)	5.93-6.58 (6.34±0.21)	3.83-5.16 (4.38±0.40)	3.35-3.88 (3.58±0.16)
	270	5.76-6.31 (5.98±0.17)	3.35-3.73 (3.58±0.12)	5.48-6.74 (6.22±0.38)	3.65-4.86 (4.12±0.37)	3.27-3.89 (3.55±0.18)
	300	5.7-6.22 (5.95±0.15)	3.51-3.85 (3.70±0.10)	5.56-6.75 (6.14±0.34)	3.91-4.58 (4.20±0.20)	3.18-3.56 (3.32±0.12)
Michelia champaca	0	5.37-5.65 (5.48±0.09)	5.37-5.65 (5.48±0.09)	5.37-5.65 (5.48±0.09)	5.37-5.65 (5.48±0.09)	5.37-5.65 (5.48±0.09)
	30	5.43-5.68 (5.55±0.07)	5.18-5.68 (5.35±0.17)	5.71-6.64 (6.14±0.27)	5.83-6.88 (6.38±0.30)	4.62-6.12 (5.52±0.46)
	60	5.81-6.72 (6.32±0.27)	5.27-6.15 (5.62±0.27)	6.35-7.18 (6.82±0.25)	5.95-6.72 (6.42±0.24)	4.12-5.08 (4.48±0.30)
	90	4.81-5.75 (5.38±0.29)	4.52-5.54 (4.88±0.33)	5.83-6.92 (6.53±0.35)	5.78-6.55 (6.23±0.23)	3.95-4.62 (4.27±0.19)
	120	5.56-6.15 (5.84±0.17)	4.37-5.27 (4.78±0.26)	5.74-6.64 (6.17±0.26)	5.27-6.35 (5.92±0.33)	3.96-4.45 (4.18±0.14)
	150	5.23-5.77 (5.57±0.17)	4.35-5.12 (4.65±0.24)	5.68-6.54 (6.12±0.25)	4.74-5.77 (5.39±0.33)	3.88-4.48 (4.15±0.18)
	180	5.45-6.22 (5.93±0.24)	4.37-4.95 (4.62±0.17)	5.74-6.62 (6.21±0.26)	4.75-5.84 (5.27±0.32)	3.75-4.48 (4.05±0.22)
	210	5.68-6.52 (6.18±0.25)	4.31-4.85 (4.53±0.16)	5.53-6.85 (6.23±0.38)	4.86-5.32 (5.15±0.15)	3.67-4.37 (3.93±0.22)
	240	5.84-6.83 (6.42±0.30)	3.85-4.88 (4.37±0.30)	5.58-6.74 (6.22±0.34)	4.68-5.62 (5.22±0.28)	3.41-4.08 (3.67±0.21)
	270	5.83-6.78 (6.38±0.28)	3.93-4.66 (4.25±0.22)	5.83-6.88 (6.38±0.30)	4.42-5.32 (4.85±0.26)	3.64-4.22 (3.85±0.19)
	300	5.95-6.58 (6.25±0.18)	3.85-4.63 (4.24±0.23)	5.95-6.86 (6.52±0.29)	4.28-4.86 (4.53±0.17)	3.61-4.28 (3.92±0.20)

Table 5.5 Correlation coefficient (r) values among the physical and chemical parameters for the different fungal species and Control with respect to the two types of woodblocks from *Pinus kesiya and Michelia champaca*

Fungal species	Woodblock sources	Physico-chemical properties	Lignin	Moisture	pH
Control	*Pinus Kesiya*	Wt.Loss	NS	NS	0.908***
	Michelia champaca		-0.7125*	0.6653*	0.6507*
	Pinus Kesiya	Lignin	-	NS	NS
	Michelia champaca		-	-	-0.6527*
	Pinus Kesiya	Moisture	-	-	NS
	Michelia champaca		-	-	NS
Trametes versicolor	*Pinus Kesiya*	Wt.Loss	-0.9187***	0.9117***	NS
	Michelia champaca		-0.9089***	0.8214**	-0.9642***
	Pinus Kesiya	Lignin	-	-0.8274**	NS
	Michelia champaca			-0.8222**	0.8935***
	Pinus Kesiya	Moisture	-	-	-0.625*
	Michelia champaca		-	-	-0.7971**
Hirshioprus abietinus	*Pinus Kesiya*	Wt.Loss	-0.9653***	0.7831**	0.6236*
	Michelia champaca		-0.9218***	0.8082**	NS
	Pinus Kesiya	Lignin	-	-0.7422**	NS
	Michelia champaca		-	-0.7211*	NS
	Pinus Kesiya	Moisture	-	-	0.6171*
	Michelia champaca		-	-	0.7938**
Polyporus brumalis	*Pinus Kesiya*	Wt.Loss	-0.8332***	0.7476**	-0.7681**
	Michelia champaca		-0.9595***	NS	-0.8251**
	Pinus Kesiya	Lignin	-	-0.8315**	0.6871*
	Michelia champaca		-	-0.673*	0.7756**
	Pinus Kesiya	Moisture	-	-	NS
	Michelia champaca		-	-	NS
Earliella scabrosa	*Pinus Kesiya*	Wt.Loss	-0.9642***	0.7795**	-0.9524***
	Michelia champaca		-0.9009***	0.792**	-0.9578***
	Pinus Kesiya	Lignin	-	-0.6816*	0.8919***
	Michelia champaca		-	-0.8436***	0.8601***
	Pinus Kesiya	Moisture	-	-	-0.8669***
	Michelia champaca		-	-	-0.7793**

Note: Values marked with * is significant at P≤0.05 , those marked with ** at P≤0.01 and those marked with *** is significant at P≤0.001 respectively. Insigninficant values are marked with 'NS'

V.5. Discussion

Weight loss after 300 days of the incubation period was affected by all the wood rotting fungi. This is in conformity with those of Chee *et al.* (1998) who observed weight loss from twenty isolates of basidiomycetes. It has also been observed that in a very late stage of attack by wood decaying fungi, a wood mass loss of up to 97% was measured (Schmidt, 2006). Maximum weight loss was affected by *T. versicolor* followed by *E. scabrosa*. The weight loss was however lesser in case of woodblocks treated by the other two test fungus *P. brumalis* and *H. abietinus*.

All the wood rooting fungi showed a decrease in the lignin content in both the wood blocks of *P. kesiya* and *M. champaca* for the duration of the test which showed that they have ligninolytic activity. The ligninolytic properties of the wood rotting fungi have been studied by many workers including those of *T. versicolor* (Rogalski *et al.*, 1991; Johansson and Nyman, 1993), *H. abietinus* (Enoki *et al.*, 1988), *P. brumalis* (Lee *et al.*, 2007) and *E. scabrosa* (Guerra *et al.*, 2008). The loss in lignin content was maximum in the woodblocks treated with *T. versicolor* which shows significant decrease. *E. scabrosa* is the other species that showed significant decrease in the lignin content followed by *P. brumalis* and with the least decrease observed in woodblocks treated with *H. abietinus*. There was negative correlation of weight loss with lignin concentration in both the woodblocks of *P. kesiya* and *M. champaca*. It has been observed that the ability to cause weight loss in intact wood is a safe indication of the ability of test organisms to degrade lignin (Kirk, 1984).

The percentage moisture content of the woodblocks showed an increase as the days of incubation increases. The increase in moisture content was higher in the woodblocks of *P. kesiya* as compared to those of *M. champaca*. Although they were absolutely dried when introduced, the control woodblocks placed on the MEA medium containing no fungal mycelium soon soaked up moisture from the medium. The control samples of both *P. kesiya* and *M. champaca* woodblocks at 30 days of incubation showed an increase in moisture content. Similarly, when the woodblocks are inoculated on the test fungi growing on the growth medium, some of the water is soaked up by the wood from the medium with the help of the fungal mycelium.

The minimum wood moisture content for wood colonization was for some fungi around 20% u. (Huckfeldt and Schmidt, 2006). Wood moisture is the most important factor influencing wood decay by fungi (Schmidt, 2007). It has been found that the optimum wood moisture content (u, %) for several wood rotting fungi ranged from 34% - 210% (Huckfeldt and Schmidt, 2006). The moisture content after 300 days was found to be maximum for *T. versicolor* for both the woodblocks of *P. kesiya* and *M. champaca*. The next species is *E. scabrosa* followed by *P. brumalis*, *H. abietinus* and control sets for the woodblocks of *P. kesiya* and *M. champaca* respectively.

Moisture in wood exists as bound or hygroscopic water within the cell wall due to hydrogen bonding of the hydroxyl groups mainly in the cellulose and hemicelluloses and as free or capillary water in liquid form in the cell lumen as well in other holes in wood tissue. The critical point for wood fungi is the fibre saturation

point, which is at about 30% moisture. The classical opinion is that there is no or only minimal fungal activity below the fibre saturation point. However, only that part of water not bound by dissolved substances such as salts and sugars is available to the fungi (Schmidt, 2007). The Moisture content was positively correlated with weight loss in the wood blocks of both *P. kesiya* and *M. champaca*. The increase in moisture content may be influenced to a considerable extent by the test fungi because of changes in the structure of the woodblocks. De Groot (1975) has observed that wood moisture content increased considerably with intensity of wood degradation by white-rot fungi in *Pinus radiata*. It has also been studied that small changes in moisture content have a significant effect on decay. A difference in moisture content of only 3-4% of saturation had a critical effect on the rate of decay by *Coniophora puteana* (Etheridge, 1958).

The pH of the wood showed a tendency towards acidity for all the wood rotting fungi on the two types of wood blocks tested. The pH of wood depends to a considerable degree on the presence of volatile acids, the most important of which are acetic and formic acids whose content in living trees may exceed 0.4% per unit of dry weight (Hintikka, 1969). Because of the presence of free acids, the pH of fresh wood is often quite low. In general, the pH of hardwoods varies between 2.8-6.8, while it varies between pH 2.7- 8.8 in softwoods (Gray, 1958). Jennison (1952) found the growth optimum of 42 species of decay fungi to vary between 3.5 and 5.5 while Butcher (1968) has found wood inhabiting fungi to have a wide pH range from 4.0-9.0 and a growth optimum between pH 5.0-6.0. The tolerance of acidity has also

been found to be greater in wood-inhabiting than in litter-decomposing Basidiomycetes (Hintikka, 1969).

There was a positive correlation of weight loss with only the control sets whereas a negative correlation was observed for weight loss with pH in all the test fungi. Fungi have been known to alter their microenvironment to meet their requirements. It has been observed that some indoor wood-decay fungi causing brown-rot decay accumulate oxalic acid (oxalate) in rather large quantities and acidify their microenvironment (Rypáček, 1966). It has also been revealed that a reduction in the pH of their microenvironment by the ligninolytic fungi is thought to favour the activity of non-enzymatic systems and cellulolytic enzyme activity (Goodell *et al.,* 2003). The deviation in pH in both the inoculated woodblocks of *P. kesiya* and *M. champaca* from those of the control samples may be attributed to such reasons.

The results of this study also bear well with studies where other researchers have found that correlation between cultural studies and field studies with wood decay fungi have been found to be naturally good (Asthana and Shearer, 1990; Miller *et al.,* 1985; Pearce, 1990). This may be due to the relative bulk, durability and relatively stable micro-environmental conditions of woody resources (Rayner and Boddy, 1998).

In conclusion, the laboratory test for estimation of decay potential by the wood block assay method on the commonly occurring wood rotting fungi of the region is positive on the two common timber trees.

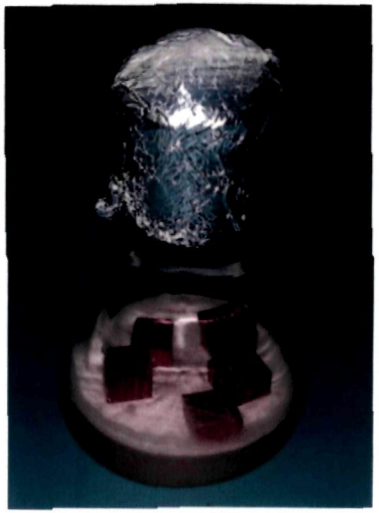


Plate -5.1

Plate -5.2

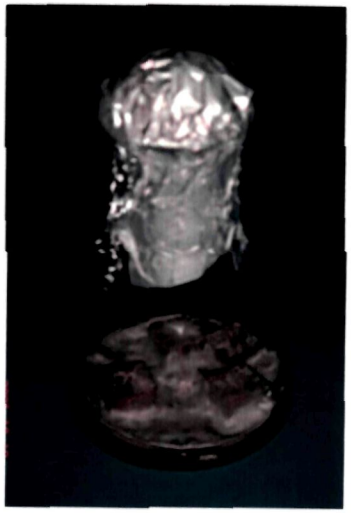


Plate -5.3

Plate 5.1-5.3: Treatment of *Pinus kesiya* woodblocks by fungal culture of *Hirschioporus abietinus.* Plate 5.1 (Day 1) , Plate 5.2 (Day 60) and Plate 5.3 (Day 300)

Plate -5.4

Plate -5.5

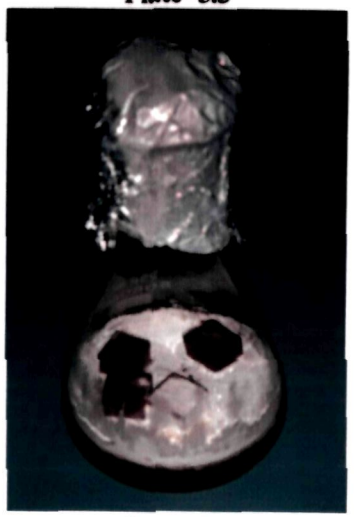
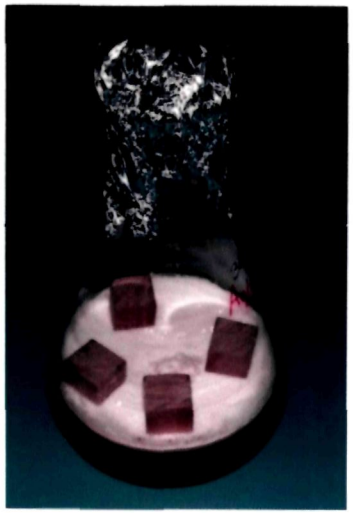


Plate -5.6

Plate 5.4 -5.6: Treatment of *Michelia champaca* woodblocks by fungal culture of *Hirschioporus abietinus.* Plate 5.4 (Day 1) , Plate 5.5 (Day 60) and Plate 5.6 (Day 300)



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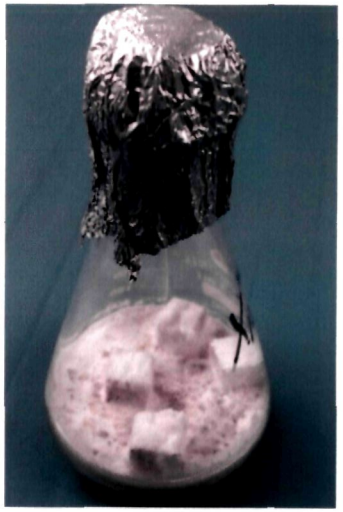
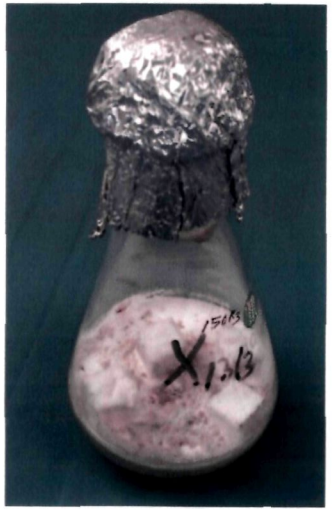


Plate -5.8

Plate -5.9

Plate 5.7- 5.9: Treatment of *Pinus kesiya* woodblocks by fungal culture of *Trametes versicolor*. Plate 5.7 (Day 1) , Plate 5.8 (Day 60) and Plate 5.9 (Day 300)

Plate -5.10



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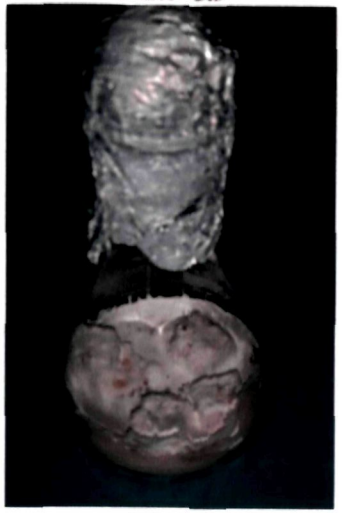
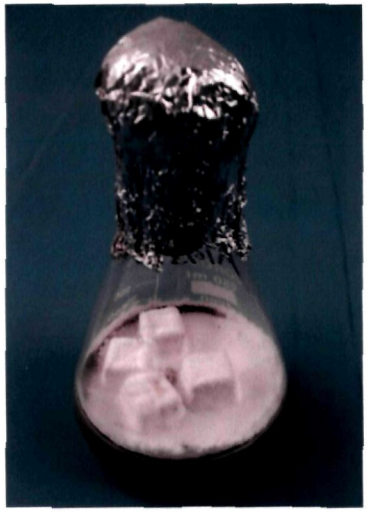


Plate -5.12

Plate 5.10-5.12: Treatment of *Michelia champaca* woodblocks by fungal culture of *Trametes versicolor*. Plate 5.10 (Day 1) , Plate 5.11 (Day 60) and Plate 5.12 (Day 300)

Plate -5.13



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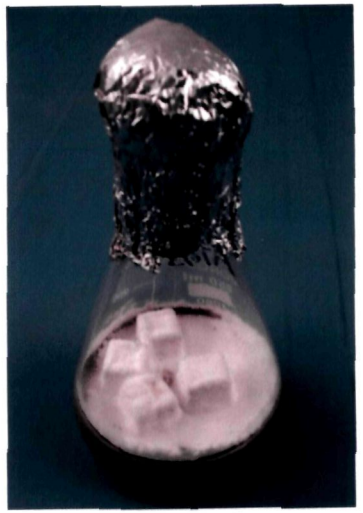


Plate -5.15

Plate 5.13-5.15: Treatment of *Pinus kesiya* woodblocks by fungal culture of *Polyporus brumalis.* Plate 5.13 (Day 1) , Plate 5.14 (Day 60) and Plate 5.15 (Day 300)

Plate -5.16

Plate – 5.17

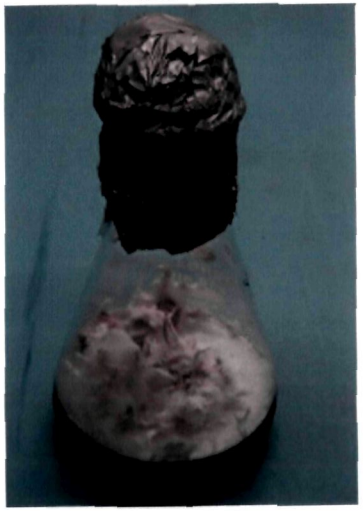
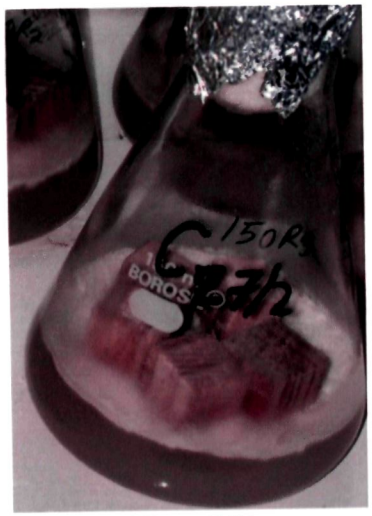


Plate – 5.18

Plate 5.16 - 5.18: Treatment of *Michelia champaca* woodblocks by fungal culture of *Polyporus brumalis.* Plate 5.16 1(Day) , Plate 5.17 (Day 60) and Plate 5.18 (Day 300)



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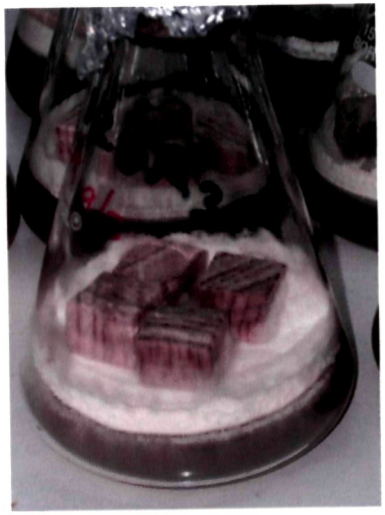

Plate -5.20

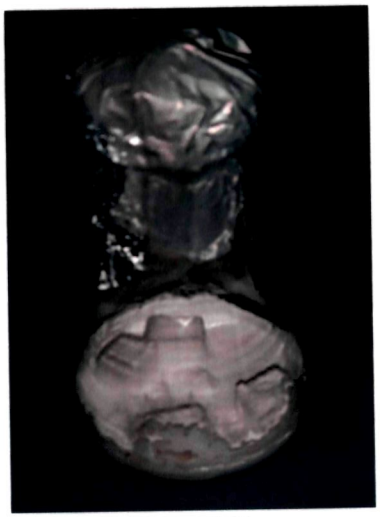

Plate -5.21

Plate 5.19-5.21: Treatment of *Pinus kesiya* woodblocks by fungal culture of *Earliella scabrosa.* Plate 5.19 (Day 1) , Plate 5.20 (Day 60) and Plate 5.21 (Day 300)

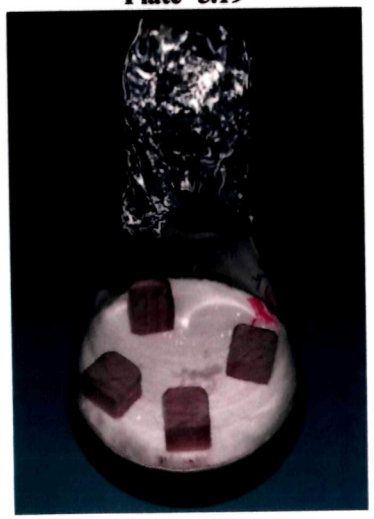

Plate -5.22

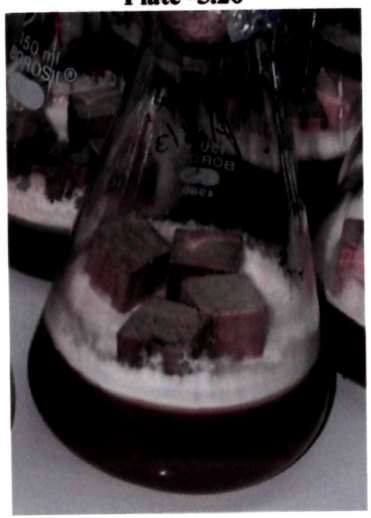

Plate -5.23

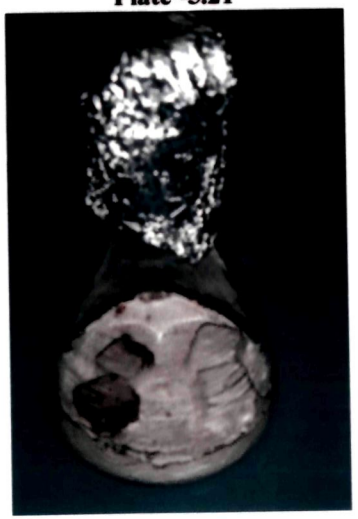

Plate -5.24

Plate 5.22-5.24: Treatment of *Michelia champaca* woodblocks by fungal culture of *Earliella scabrosa.* Plate 5.22 (Day 1) , Plate 5.23 (Day 60) and Plate 5.24 (Day 300)

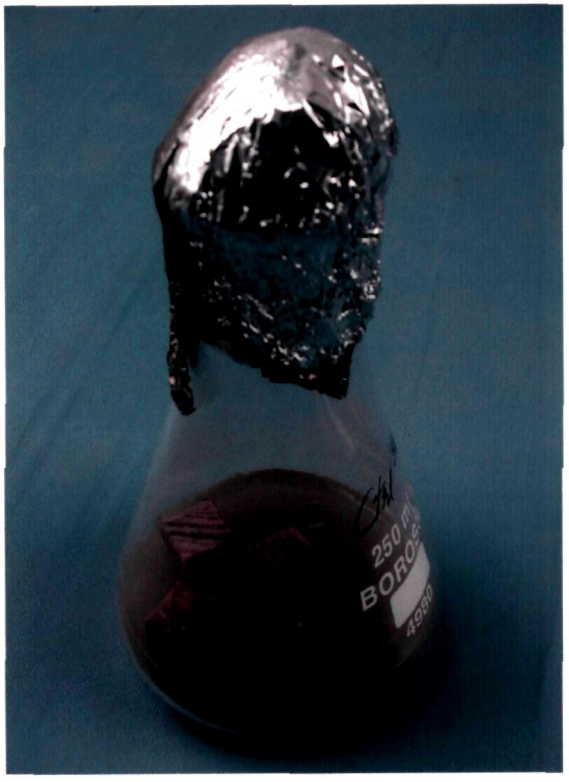

Plate 5.25. Control woodblocks of *Pinus kesiya*

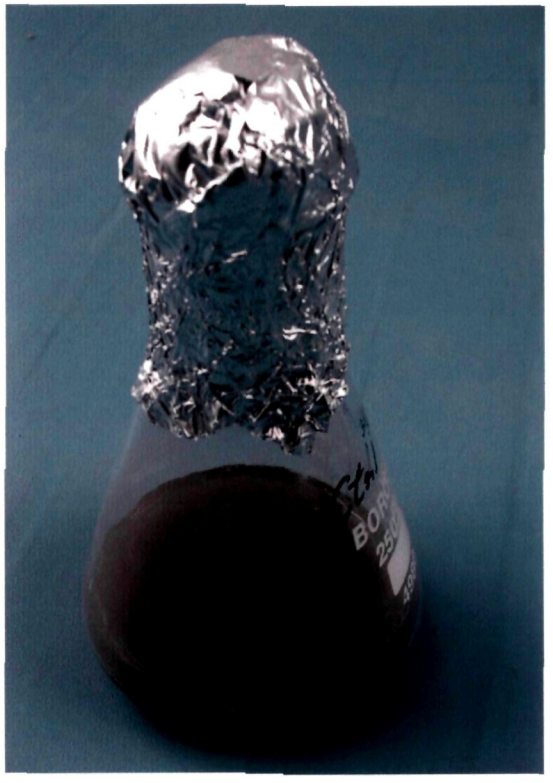

Plate 5.26. Control woodblocks of *Michelia champaca*

SUMMARY

The present study was carried out in the eastern part of Meghalaya covering various forests within the districts of East Khasi Hills, West Khasi Hills, Jaintia Hills and Ri Bhoi. The study was conducted in the state of Meghalaya which lies between 25°02' and 26°07'N latitude and 89°49' and 92°50' E longitude with a geographical area of 22,429 sq. km, situated in northeast India . The elevation ranges from 60 to 1,950 msl.

The wood rotting fungi were collected from the different sites which were located within the area with geographical position in between the latitude 25 °N - 26 ° N and longitude 91° 40' E - 92° 30"E, with altitudinal range from 604 – 1945 msl in the region.

The present work was undertaken with the aim to generate a baseline data on the general distribution and diversity of the wood rotting fungi in Meghalaya. The study will also include the taxonomical study of the collected specimens and the decomposition of two common woods by selected species of the wood rotting fungi. The present work was carried out under the following heads:

1. Distribution and Diversity of the wood rotting fungi in the eastern districts of Meghalaya
2. Taxonomy of the wood rotting fungi in Meghalaya
3. Diversity of the wood rotting fungi in disturbed and undisturbed sacred groves
4. Wood decay by selected species of wood rotting fungi

A broad based collection of the fungal fruiting bodies was done from different forests stands in the districts of Ri-Bhoi, Jaintia Hills, East Khasi Hills and

West Khasi Hills of Meghalaya during the period June 2002 – December 2004 involving three wet seasons. The collections were made from Byrnihat, Dawki, Jarain, Lawbyrtun, Lumsymper, Laitsohum, Laitkor, Mawiong, Mawlai, Mawblei, Mawlasnai, Umroi, Swer sacred grove, Sohrarim sacred grove, Nongkrem sacred grove, Mawphlang sacred grove, and Jowai sacred grove. The study did not include small or inconspicuous sporocarps. The wood rotting fungi were collected from the different collecting sites with altitudinal ranging from 604 – 1945 msl in the region.

The herbarium specimens were maintained with plastic bags kept in paper bags and the bottled specimens were intact with the collection number, date and details of the habitat and site of collection. This will form a part of the collection of herbarium specimen at the Department of Botany, NEHU and will be used for future reference.

During the period altogether 54 specimens could be identified according to standard macroscopic and microscopic characteristics from the collection sites. Out of the 54 specimens or morphotypes, 5 species belonging to 4 genera and 4 families from the Ascomycetes and 49 species belonging to 34 genera and 17 families from the Basidiomycetes could be identified. The family Polyporaceae with 24 species was found to be the most dominant, followed by the Hymenochaetaceae (6 species), Ganodermataceae (3 species), Stereaceae (3 species) Hapalopilaceae (2 species) and the Xylariaceae (2 species). One species each from the families Auriculariaceae, Bulgariaceae, Fistulinaceae, Fomitopsidaceae, Gloeophyllaceae, Helotiaceae,

Strophariaceae, Nidulariaceae, Tricholomataceae, Meruliaceae, Pleurotaceae, Pyrenemataceae, Schizophyllaceae, Sparassidaceae and Tremellaceae were also obtained. The genus with highest number of species represented are the polypore members- *Microporus, Polyporus, Trametes,* the Ganodermataceae member- *Ganoderma*, the Hymenochaete member- *Phellinus* and the Stereaceae member- *Stereum* with 3 species respectively.

The frequency of occurrence in the collection sites were calculated for the duration of the collection period and was observed to be 41.17% for *Earliella scabrosa, Hirshioporus abietinus, Schizophyllum commune* and *Trametes versicolor,* 35.29% for *Fomitopsis pinicola* and *Polyporus xanthopus*, 29.41% for *Fistulina hepatica, Nidula niveotomentosa, Stereum hirsutum, S, ostrea* and *Trametes hirsuta,* and 23.52% for *Ganoderma applanatum, Cyclomyces tabacinus* and *Pleurotus ostreatus* respectively. These species were observed to be the most abundantly distributed in comparison to the other species in all of the collection sites.

The habitats of the wood rotting fungi vary from living to dead fallen minute twigs, small and large branches to the most massive of tree trunks. The identification of the host tree in case of several year old fallen trees was extremely difficult. The majority of the hosts were mainly of angiospermic wood and few species from coniferous wood. Gymnospermic wood of *Pinus kesiya* and angiospermic wood such as those of *Alnus nepalensis, Alstonia scholaris, Ardisia flouribunda, Artocarpus chaplasha, Betula alnoides, Carpinus viminea, C. semiserrata, Cassia fistula, Castanopsis tribuloides, C. indica, Cinnamomum*

pauciflorum, C. parthenoxylon, Corylopsis himalayana, Elaeocarpus lancifolius, Erythroxylon kuntiana, Eurya accuminata, Exbucklandia populnea, Ficus clavata, F. elastica, F. trachycarpa, Grevillea robusta, Ligustrum rubustrum, Manglieta insignis, Myrica esculenta, Prunus cerasoides, Pyrus pasha, Quercus dealbata, Q. fenestrata, Q. serrata, Q. griffithi, Rhododenron arboretum, Schima wallichi, Shorea robusta, Syzigium tetiagons, Vaccinium griffithianum, Viburnum colebrookianum, and *V. foetides* were some of the main host trees that were encountered during the study.

For the taxonomical study, collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literatures (Overholts, 1953; Ryvarden and Johansen, 1980; Gilbertson and Ryvarden, 1986; Bakshi 1971; Rattan, 1977; Roy and De, 1996; Sharma, 2000; Leelavathy and Ganesh, 2000; Ainsworth & Bisby, 2001). Nomenclature, taxonomic position and author names followed the databases: Index Fungorum- IFS (http://www.indexfungorum.org), the International Plant Names Index – IPNI (http://www.ipni.org) and MycoBank (http://www.mycobank.com). The genera and species are listed alphabetically and compiled based on an intensive search of literature records. Comparison was also done with some of the materials at the Mycology Herbarium and National type collection of Forest Research Institute (FRI), Dehra Dun. The host trees were identified with the help of experts. Voucher specimens are housed at the Microbial Ecology Laboratory, Department of Botany.

The species that was studied along with their family are as below:

Ascomycetes: Bulgariaceae – *Bulgaria inquinans*, Helotiaceae – *Chlorociboria aeruginosa*, Xylariaceae – *Xylaria hypoxylon, X. polymorpha*, Pyrenemataceae – *Scutellinia scutellata.*

Basidiomycetes : Auriculariaceae – *Auricularia auricula*, Hapalopilaceae– *Bjerkandera adusta, Ischnoderma resinosum*, Polyporaceae –*Coriolopsis telfarii , Daedalea confragosa, Earliella scabrosa, Fomes fomentarius F. geotropus, Hexagonia apiara, H. tenuis, Hirshioporus abietinus, Irpex consors, Laetiporus sulphureus, Lenzites betulina, Microporus flabelliformis, M. quarrei, M. xanthopus, Polyporus brumalis, P. tenuiculus, P. tuber-aster, Rigidiporus microporus, Skeletocutis amorpha, Pycnoporus sanguineus, Trametes hirsuta, T. tephroleucus, T.versicolor, Trichaptum byssogenum*, Fistulinaceae- *Fistulina hepatica*, Fomitopsidaceae-*Fomitopsis pinicola*, Ganodermataceae-*Ganoderma applanatum, G. australe, G. lucidum*, Gloeophyllaceae - *Gloeophyllum striatum*, Strophariaceae –*Hypholoma fasciculare*, Hymenochaetaceae-*Cyclomyces tabacinus, Inonotus dryadeus, I. rheades Phellinus adamantinus, P. gilvus, P. wahlbergii*, Nidulariaceae-*Nidula niveotomentosa*, Tricholomataceae- *Omphalotus olivascens*, Meruliaceae- *Phlebia tremellosus*, Pleurotaceae- *Pleurotus ostreatus*, Schizophyllaceae- *Schizophyllum commune*, Sparassidaceae- *Sparassis crispa*, Stereaceae- *Stereum complicatum, S. hirsutum, S. ostrea*, Tremellaceae- *Tremella mesenterica.* The habitats range from live and dead trees.

For the Diversity of wood rotting fungi in disturbed and undisturbed sacred groves two sacred forests were Nongkrem sacred grove or locally called as 'Law

Lyngdoh Nongkrem' is a disturbed sacred grove and covers an area of 6 ha. It is about 14 km south west from Shillong an altitude of 1786 msl. and is situated at 91° 54' 40" E latitude and 25° 29' 30" N longitude. Mawphlang sacred grove or locally called the 'Law Lyngdoh', 'Umrisaw', 'Mawkhan', 'Ryngngi', 'Laitsohphoh', etc., is one of the few sacred groves that remains undisturbed. It is about 25 km south-east of Shillong covering an area of 75 ha at an elevation of 1842 msl and lies at 91°56' E latitude and 23°34'N longitude.

The study compared the wood rooting fungi richness based on equal sampling areas (comparable to species density; *sensu* Hurlbert, 1971). Three permanent areas or plots were selected in each of the disturbed and undisturbed forest in which a single 100 m long and 25 m wide transects was laid at random during each visit to record the presence and absence of the wood rotting fungi (Senn-Irlet and Bieri, 1999). Each forest was visited at least more than three times during a period of 6 months from Jan- June and from July to December for 24 months. All sporocarps and clusters of sporocarps of the same species of the wood rotting fungi on a log or tree were counted as one occurrence, independent of number of sporocarps.

Species Richness

The species accumulated at each sampling was noted and the cumulative species richness of wood rotting fungi in both the sacred groves was calculated at an interval of six months from January to June and from July to December for the two year study periods 2003-2004. The species accumulation graph was then plotted as number of species accumulated within each sampling time of 6 months interval.

Species diversity

Index of species diversity of the wood rotting fungi was calculated using the Shannon and Simpson index of diversity as suggested by Lande (1996) and Magurran (2004).

Shannon index: $H = -\sum(p_i \ln p_i)$

Simpson index: $D = \sum n_i(n_i-1) / N(N-1)$

Where, *ln* is the natural log function and p_i is proportion of the number of i^{th} species to total number of individuals, n_i is the abundance of the i^{th} species, N the total number of all the species.

A total of 42 number of the wood rotting fungi were identified, wherein the disturbed sacred grove housed 19 species and the undisturbed sacred grove housed 36 species and the two sacred groves share together 13 number of the wood rotting fungi (Table 4.1). It was observed that the species accumulation curves continued to increase with each sampling intervals and were not reaching their asymptotes (Fig. 4.1). The number of wood rotting fungi and plant species and species/ha from the two study sites is listed in Table 4.2. The undisturbed sacred grove had a greater species richness with values of 48/ha for the wood rotting fungi and 67/ha for the host trees while the disturbed forest had a value of 25/ha and 47/ha respectively (Table 4.2). The graph (Fig. 4.2) also shows that the undisturbed sacred grove had a higher species assemblage than the disturbed sacred grove for both the wood rotting fungi (36 and 19) and tree species (56 and 35).

The wood rotting fungi that were common to both the forest were *Earliella scabrosa, Fistulina hepatica, Ganoderma applanatum, G. australe, Hypholoma*

fasciculare, Inonotus tabacinus, Laetiporus sulphureus, Microporus xanthopus, Phellinus gilvus, Schizophyllum commune, Stereum ostrea, Trametes versicolor and *Tremella mesenterica* (Table 4.1). About 35 tree species were found in the disturbed sacred grove among which the dominant trees are *Cinnamomum glanduliferum, Elaeocarpus lancifolius, Eurya japonica, Eleagnus pyriformis, Lithocarpus dealbatus, Myrica esculenta, Pinus kesiya and Schima wallichi.* The undisturbed sacred grove was found to house about 56 tree species among which the dominant trees were *Eleocarpus lancifolius, Engelhardtia roxburghiana, E. spicata, Exbucklandia populnea, Quercus dealbata, Q. griffithii, Q. glauca, Pyrus pashia, Rhododendron arboreum* and *Symplocos chinensis* (Table 4.3).

Species diversity

Species diversity of the wood rotting fungi was found to be higher in the undisturbed than the disturbed sacred grove. The Shannon's diversity index H was found to be 2.68 and 3.36, and the Simpson's diversity index *D* was 12.87 and 26.23 in both the disturbed and undisturbed sacred groves respectively (Table 4.4).

A study was conducted to investigate the decay potential of four commonly occurring wood rotting fungi *Trametes versicolor* (L.: Fries) Pilát, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *Polyporus brumalis* (Pers.) Ex Fries and *Earliella scabrosa* (Pers.) R.L. Gilbertson and Ryv of the region on woodblocks of *Pinus kesiya* and *Michelia champaca,* the two most important sources of timber in the region.

The pure cultures of the common wood rotting fungi *Trametes versicolor* (L. Fries) Pilát, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *Polyporus brumalis*

(Pers.) Ex Fries and *Earliella scabrosa* (Pers.) R.L. Gilbertson and Ryv were maintained in the laboratory using 2% malt extract agar (MEA) medium (Griffith and Boddy, 1990).

Wood Block Assay for estimation of decay potential

The method is based on that of Cartwright and Findlay (1958), Chee *et al.*(1998), Fryar *et al.* (2001) and the European standard EN 113 (1996) and modified as necessary

Experimental woodblocks (1.5 x 1.5 x 1.5 cm) were prepared from the outer heartwood (adjacent to sapwood) of matured and carefully selected 25-30 year old *Pinus kesiya* Royle ex Gordon and *Michelia champaca* trees. The wood blocks with knots, visible decay, stains, etc., were rejected. Each wood block was then weighed and serially numbered for easy identification. The wood blocks of *P. kesiya* weighed 1.46 g (± 0.14) and *M. champaca* weighed 1.74 (± 0.13) respectively. Three replicates were taken for each sample.

The woodblocks were sterilized carefully so as to avoid contamination from any microorganisms present in the wood prior to inoculation by the test fungi. The wood blocks were oven-dried at 110°C for 24 hrs, each wood block was then weighed, marked and then immediately kept inside carefully sealed conical flasks and sterilized in an autoclave for 2 hrs and kept ready to be aseptically transferred to the conical flasks containing the cultured test fungi (Plate 5.1-5.26).

The following parameters were taken into consideration for the study – Weigth loss, Lignin content, Moisture content and pH.

Estimation of the decay potential

Experiment on the effect of the wood rotting fungi *Trametes versicolor.*, *Hirschioporus abietinus*, *Polyporus brumalis* and *Earliella scabrosa* on the selected two common timber trees of the region *Pinus kesiya* and *Michelia champaca* was done. The assessment of the degree of their effectiveness over a period of 300 days is depicted in the Tables 5.1- 5.4 and in the Figs. 5.1- 5.4.

Weight loss

It was observed that the test fungi have shown a positive effect on the woodblocks of P. *kesiya* and *M. champaca* (Fig.5.1, Table 5.1). The weight loss effected by *T. versicolor* was maximum on both woodblocks where it was 67.24±0.94% on *P. kesiya* and 34.53±0.67% on *M. champaca* at 300 days.

Similarly the other test fungus *E. scabrosa* also showed a similar effect where it was 45.07±1.67% and 24.35±0.46% respectively on the two test woodblocks of *P kesiya* and *M. champaca.* The percentage weight loss was however lesser in case of woodblocks treated by the other two test fungus where it was 28.08±1.89%, 12.34±0.25% for *P. brumalis* and 13.36±1.79%, 8.57±0.40% for *H. abietinus* on the two test woodblocks of *P. kesiya* and *M. champaca* respectively. The control replicates also indicated minute weight loss with maximum of 8.72±2.19 and 8.22±0.08 on the test woodblocks of *P. kesiya* and *M. champaca* respectively after 300 days of the incubation period

Lignin content

There was also a decrease in lignin content of the wood with increase in time (Fig.5.2, Table 5.2). The loss in lignin content after 300 days was maximum in the

woodblocks treated with *T. versicolor* which showed significant decrease as shown by the remaining lignin content of 6.31±0.48% and 8.21±0.43 % for *P. kesiya* and *M. champaca* respectively. Similarly, as shown by the weight loss the other test fungi *E. scabrosa* is the other species that showed significant decrease in the lignin content with mean values of upto 7.26±0.23% and 7.49±0.20% for woodblocks of *P. kesiya* and *M. champaca* respectively. The remaining lignin content in woodblocks of *P. kesiya* and *M. champaca* treated with *P. brumalis* were 9.78±0.24% and 8.51±0.31% respectively and least decrease was observed in those treated with *H. abietinus* where it was 10.86±0.26% and 8.51±0.31% respectively in the two test woodblocks. Control samples remained almost the same with values of 15.02±0.25% and. 12.16±0.46% respectively for the two test woodblocks *P. kesiya* and *M. champaca*.

Moisture content

The moisture content of the wood showed increasing trend with time (Fig.5.3, Table 5.3). As the wood is inoculated on the test fungi growing on the growth medium, some of the water is soaked up by the wood from the medium and also with the help of the fungal mycelium. This is indicated by comparison with control samples. The moisture content after 300 days is maximum for those treated with *T. versicolor* where it was 82.11±1.55% and 75.93±0.66% for woodblocks of *P. kesiya* and *M. champaca* respectively. *E. scabrosa* is the next species with mean values of 71.08±0.66% and 66.63±0.99% followed by *P. brumalis* with 67.27±0.88% and 48.17±1.19%, *H. abietinus* with 63.81±0.73% and 53.87±0.70% and control samples

with 57.10±0.56% and 42.68±1.49% for woodblocks of *P. kesiya* and *M. champaca* respectively.

Wood pH

The pH of the wood showed a tendency towards acidity (Fig.5.4, Table 5.4). The pH at 300 days was 3.70±0.10 and 4.24±0.23 for *T. versicolor,* 3.32±0.12 and 3.92±0.20 for *E. scabrosa,* 4.20±0.20and 4.53±0.17for *P. brumalis*, 6.14±0.34 and 6.52±0.29 for *H. abietinus* and 5.9 and 6.2 for the control samples with woodblocks of *P. kesiya* and *M. champaca* respectively.

The correlation coefficient of the physico-chemical characteristics affected by the different wood rotting fungi on the two woodblocks of *P. kesiya and M. champaca* was analyzed. It was observed that in the woodblocks of *P. kesiya,* weight loss was positively correlated with the pH in control sets($r = 0.90$, $P \leq 0.001$) and *H. abietinus* ($r = 0.62$, $P \leq 0.05$), moisture content in *T. versicolor* ($r = 0.91$, $P \leq 0.001$), *H. abietinus* ($r = 0.78$, $P \leq 0.001$), *P. brumalis* ($r = 0.74$, $P \leq 0.01$), *E. scabrosa* ($r = 0.77$, $P \leq 0.01$). It showed a negative correlation with lignin in *T. versicolor* ($r = -0.91$, $P \leq 0.001$), *H. abietinus* ($r = -0.96$, $P \leq 0.001$), *P. brumalis* ($r = -0.83$, $P \leq 0.001$) and *E. scabrosa* ($r = -0.96$, $P \leq 0.001$), and with pH in *P. brumalis* ($r = -0.76$, $P \leq 0.01$) and *E. scabrosa* ($r = -0.95$, $P \leq 0.001$). Lignin concentration showed a positive correlation with pH in *P. brumalis* ($r = -0.68$, $P \leq 0.05$), *E. scabrosa* ($r = -0.89$, $P \leq 0.001$). It showed a negative correlation with moisture in *T. versicolor* ($r = -0.82$, $P \leq 0.01$), *H. abietinus* ($r = -0.74$, $P \leq 0.01$), *P. brumalis* ($r = -0.83$, $P \leq 0.01$) and *E. scabrosa* ($r = -0.68$, $P \leq 0.05$). Moisture content showed a positive correlation with pH

in *H. abietinus* (r = 0.61, P≤0.05). It also showed a negative correlation with pH in *T. versicolor* (r = -0.62, P≤0.05) and *E. scabrosa* (r = -0.86, P≤0.001) (Table 5.5).

It was observed that in the woodblocks of *M. champaca*, weight loss was positively correlated with the moisture content in the control sets (r = 0.66, P≤0.05), *T. versicolor* (r = 0.82, P≤0.01), *H. abietinus* (r = 0.80, P≤0.01) and *E. scabrosa* (r = 0.79, P≤0.01), pH in control sets(r =0.65, P≤0.05). It showed a negative correlation with lignin in control sets (r = -0.72, P≤0.05), *T. versicolor* (r= -0.90,P≤0.001), *H. abietinus* (r = -0.92, P≤0.001), *P. brumalis* (r = -0.95, P≤0.001), *E. scabrosa* (r = -0.90, P≤0.001), and with pH in *T. versicolor* (r = -0.96, P≤0.001), *P. brumalis* (r = -0.82, P≤0.01), *E. scabrosa* (r = -0.95, P≤0.001). Lignin concentration showed a positive correlation with pH in *T. versicolor* (r = 0.89, P≤0.001), *P. brumalis* (r = 0.77, P≤0.01), *E. scabrosa* (r = 0.86, P≤0.001). It also showed a negative correlation with moisture in *T. versicolor* (r = -0.82, P≤0.01), *H. abietinus* (r = -0.72, P≤0.05), *P. brumalis* (r = -0.67, P≤0.05), *E. scabrosa* (r = -0.84, P≤0.001), and with pH in control sets (r = -0.65, P≤0.05). Moisture content showed a positive correlation with pH in *H. abietinus* (r = 0.79, P≤0.01) and negative correlation with pH in *T. versicolor* (r = -0.79, P≤0.01) and *E. scabrosa* (r = -0.77, P≤0.01) (Table 5.5).

CONCLUSION

The present work on the wood rotting fungi of Meghalaya is only a preliminary work on the species of the region. Evidently such coverage is by no means complete for the entire area, or even the eastern part of Meghalaya and many forests still remain almost completely unexplored. However, an effort was made on the general diversity and distribution of the wood rotting fungi for the eastern part of the state.

The distribution of the wood rotting fungi was not entirely defined by the altitude or the geographic location. It was also observed that the wood rotting fungi had a wide range of host preferences and only a few species are host specific. The diversity is mainly affected by the nature and presence of suitable host substratum. The study on species diversity of wood rotting fungi in two sacred groves showed more species diversity in the undisturbed sacred grove than that in disturbed sacred grove indicating the importance of sacred groves in maintaining diversity of the wood rotting fungi. It also clearly showed the importance of the abundance of suitable host substrata for the distribution and diversity of the wood rotting fungi. The members of the Polyporaceae family belonging to the Basidiomycetes were the most dominant wood rotting fungi with a few representations from the Ascomycetes.

It is imperative that a long term survey of selected forests including the sacred groves be undertaken to catalogue the diversity of the wood rotting fungi for the whole of Meghalaya. It would be valuable to continue and maintain a long term

monitoring of the wood rotting fungi in the two sacred groves to understand the nature of diversity and succession of the wood rotting fungi in disturbed and undisturbed sacred groves in the region. The importance of sacred groves as an important treasure house and conservation tool for the wood rotting fungi need to be elaborated to the public and the native inhabitants.

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2.	Atomic Energy & Societal Development in India	Department of Atomic Energy, Mumbai	Shillong	18th Sept. 2002	Participant
3.	72nd Annual Session of NASI and Symposium.	The National Academy of Sciences, India	Shillong	25th-27th Oct, 2002	Participant
4.	National Roving Seminar on Patenting in Biotechnology.	Department of Biotechnology, Ministry of Science & Technology, New Delhi	Shillong	26th Oct., 2002	Participant

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8	Recent Trends in Plant Ecology and Biodiversity Research	Department of Botany, North Eastern Hill University	Shillong	20th-22nd May, 2004	Participated
6.	Statistical Methods in Medical & Health Sciences	Department of Statistics, North Eastern Hill University, Shillong	Shillong	19th-21st Feb, 2009	Participated
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8. List of research publications:

1. Sailo, J.Z., Dkhar, M.S. and Kayang, H.K. 2010. A preliminary report on the Wood rotting fungi of Meghalaya (communicated).

2. Sailo, J.Z., Dkhar, M.S. and Kayang, H.K. 2010. The diversity of wood rotting fungi in the sacred groves of Meghalaya (communicated).

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