DIVERSITY OF WOOD ROTTING FUNGI FROM DISTURBED AND UNDISTURBED FORESTS OF MEGHALAYA, INDIA

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Abstract : This study has been undertaken to investigate the diversity of the wood rotting fungi from a disturbed and undisturbed forest of Meghalaya using the traditional sacred grove forests that are present in the state. A two year study was conducted in which a total of 42 species wood rotting fungi were identified. 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 forests. Species diversity indices of the wood rotting fungi also showed that the diversity was higher in the undisturbed than the disturbed sacred grove.

Keywords **– wood rotting fungi, sacred grove, disturbed, species, diversity**

I. 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, 2004).

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). 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) but no significant study has yet been undertaken on the wood rotting fungi and their diversity in the sacred groves. 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.

II. RESEARCH METHODOLOGY

II.1. Study Site

The study site are two sacred groves at Nongkrem and Mawphlang in the East Khasi Hills District of Meghalaya. 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 23º34'N longitude. The two sacred groves were selected because of their similarity in sharing the same climatic condition and geographical setting (Fig1.0, 1.1 and 1.2).

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 was 29ºC in the month of June-July and minimum temperature was 6ºC in the month of January. The rainfall was at a maximum of 710 mm in the month of June and minimum of 5 mm in the month of February. The relative humidity ranged between 55% - 86 % during the study.

Fig. 1.0 Location of Study Site Mawphlang and Nongkrem, East Khasi Hills District, Meghalaya, India

Fig 1.1. Disturbed Forest of Nongkrem sacred grove

Fig 1.2. Undisturbed Forest of Mawphlang sacred grove

II.2. 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 (Hurlbert, 1971). Three permanent areas or plots were selected in each of the disturbed and an 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.

II.3. 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 period. The species accumulation graph was then plotted as number of species accumulated within each sampling time of 6 months interval.

II.4. Species diversity

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

$$\textbf{Shannon index: } H_S = -\sum(p_i \ln p_i)$$

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

III. Results and Discussion

III.1. Species Richness

The undisturbed sacred grove had a higher species assemblage than the disturbed sacred grove. 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-1). It was observed that the species accumulation curves continued to increase with each sampling interval and were not reaching their asymptotes (Fig. 1.3). 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-1).

It was also observed that there 56 tree species in the undisturbed sacred grove and 35 tree species in the disturbed sacred grove (Table-2). The dominant trees found in the disturbed sacred grove are *Cinnamomum glanduliferum, Elaeocarpus lancifolius, Eurya japonica, Eleagnus pyriformis, Lithocarpus dealbatus, Myrica esculenta, Pinus kesiya and Schima wallichi.* The dominant trees found in the undisturbed sacred grove were *Eleocarpus lancifolius, Engelhardtia roxburghiana, E. spicata, Exbucklandia populnea, Quercus dealbata, Q. griffithii, Q. glauca, Pyrus pashia, Rhododendron arboreum* and *Symplocos chinensis* (Table-2).

Table-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 austral*	+	+	+
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*	+	+	+
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

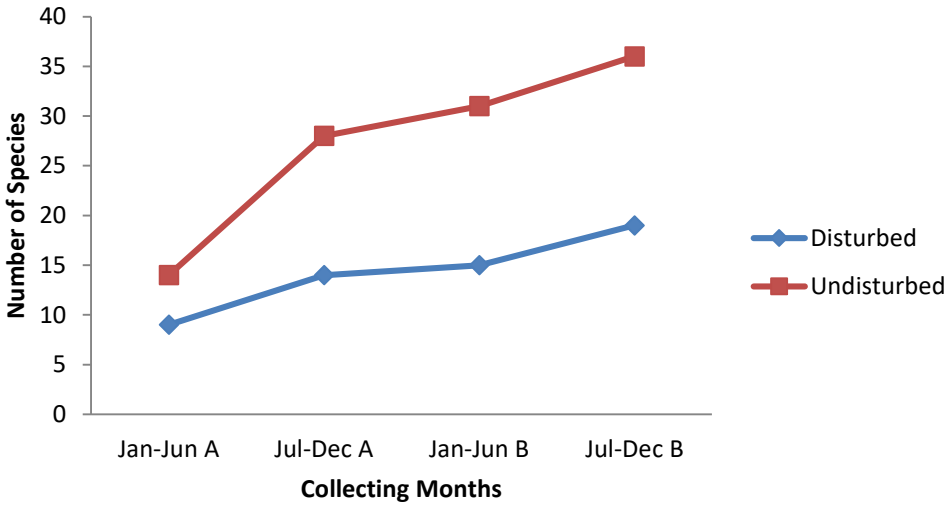

Fig 1.3 Cumulative species richness of wood rotting fungi in the disturbed (Nongkrem) and Undisturbed (Mawphlang) forests/sacred groves of Meghalaya during the two year study period.

Table-2. Number of host tree species in both the disturbed and undisturbed forests

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*

III.2.Species diversity

The 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 in the disturbed and undisturbed sacred groves respectively (Table-3). The table also shows the number of host trees present in the two study sites.

Table-3 Number of wood rotting fungi, host tree species and Shannons Diversity Index (H_S) for the two sites

Site	Wood Rotting Fungi	Host Tree	Shannons Diversity Index- H_S of the Fungi
Disturbed Site (Nongkrem sacred grove)	19	35	2.68
Undisturbed Site (Mawphlang sacred grove)	36	56	3.36

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. It has been observed that many macrofungal species are known 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 is 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 36 and 56 while the disturbed forest have a value of 19 and 35 for the wood rotting fungi and host tree 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.

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. A number of studies have shown 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).

The Shannon's diversity index was higher in the undisturbed forest site, i.e. Mawphlang 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).

IV. Conclusion

From the observations it may be concluded that the proportion of the wood rotting fungi assemblage seen in each site type differ significantly and there is more species diversity in the undisturbed site i.e. Mawphlang. It may also be concluded that the undisturbed sacred groves in Meghalaya are a rich natural storehouse of the wood rotting fungi.

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