Biology diversity of fungi, especially in the tropics is under threat (Wilson, 1988). The same can be said about temperate fungi also. Especially for country like India which is under immense population pressure and population living nearby forests is largely dependent on forests for their daily need. Therefore it is important that the range of species present in these habitats be recorded rapidly as destruction of habitats is so rapid that species may be either locally or may be globally extinct before they can be recorded as some species are rare and confined to a particular habitat or region. Many of them contain medicinally important chemicals vital for humanity (Wilson, 1988). Records of species in different geographical areas are essential for environmental decision making (Hyde, 2003) as fungi are the indicators of forest health.

2.1 How many fungi are there?

Magnitude of fungal diversity was estimated to be 1.5 million (Hawksworth, 1991) but this figure was considered ‘conservative’ by many (May, 1991; Smith & Waller, 1992; Hawksworth and Rossman, 1997) because the estimate was based on extrapolation from several data sets and numerous potential fungal habitats and localities were remained to be understudied (Hawksworth, 2001). Pascoe (1990) suggested that there were at least ten times as many fungi as vascular plants and gave an estimated total of 2.7 M fungi world-wide. Smith and Waller (1992) too considered 1.5 M low, estimating that there were probably 1 M undescribed fungi on tropical plants alone. Cannon (1997) gave an estimate of whopping 9.9 M. The other estimates are somewhat close or similar to that of Hawksworth’s estimate (Hammond, 1992; Smith & Waller, 1992; Rossman, 1994; Hammond, 1995; May, 2000; Arnold et al., 2000). A more recent estimate of the total number of fungi to 7,20,256 (Schmit and Mueller, 2007) is also low compared to present estimates that include environmental samples.

Despite above mentioned deviations, the 1.5 M figure is still the most accepted model of estimated fungal species and cited as accepted working hypothesis by many. The number of accepted fungal species known by 2007 is nearly 97,330 (98,000) in Dictionary of the Fungi (Kirk et al., 2008). The addition of 1300 microsporidians brings the total of all described fungi to about 99,000 species. The current recorded number of fungi has crossed 100,000 mark (Tedersoo et al., 2014). Each year nearly 800–1000
species are recorded. The present record is the work of approximately 250 years. The speed at which the new species are recorded could take another 1000–1500 years or even more to get a complete picture. The use of molecular methods had not yet been considered as a means of species discovery. The main factors behind the low number of fungi are due to difficulty of isolation and failure to apply molecular methods as this may contribute to lower numbers of species in certain groups (Blackwell, 2011). For example, analysis of environmental DNA (eDNA) samples from a soil community revealed a high rate of new species accumulation at the site, and these data supported an estimate of 3.5 to 5.1 million species (O’Brien et al., 2005). Hawksworth (2012) last estimated the new number to be between 1.5 – 3 millions.

2.2 Fungal-Plant Ratio

Hawksworth (1991) compared the numbers of fungi and plants in a range of areas and sites in Britain. The fungus: plant ratio at Slapton was found to be 5:1 and was supposed to be rising rather than previously estimated 3:1 in 1990. Finally, fungus to plant ratio of 6:1 was accepted as a reasonable working hypothesis for 1.5 M species. The 6:1 factor emerged from the analysis of the numbers of fungi (including lichens) occurring on all substrata in a given area and not just the fungi present on plants (Hawksworth, 2001). An extrapolation of that ratio to a world scale using the same estimate of 270,000 vascular plant species gave an estimate of 2.27 M for the number of fungi on Earth. Shivas & Hyde (1997) on reviewing data on plant pathogen diversity in the tropics, concluded that each plant genus could be expected to support around 50 fungi of which half would be host specific and few would have wide host ranges. This contributes to all fungal forms (both Ascomycetes and Basidiomycetes). Blanco et al. (1997) on studying macromycetes in pine-oak forests in Mexico found 1300 species in an area with 450 plants, giving a macromycete: plant ratio of about 3.5:1. On assuming a conservative 270 K plants, that implies almost 1 M macromycete species alone worldwide. In general macromycetes are less host-specific than microfungi, but the numbers in a particular area compared to plants are pertinent to overall extrapolations (Hawksworth, 2001). If present higher estimates of land plant numbers of somewhat under 400,000 species (Paton et al., 2008; Joppa et al., 2010) are applied, the fungal species numbers will be expected to outnumber land plants by as much as 10.6 : 1 (O’Brien et al., 2005).

2.3 Current status
Hawksworth (1993) noted that about half the newly described fungal species were from the tropics, individual countries those generating most new species were not exclusively tropical and then included the USA, France and Japan as well as India and Brazil. A comparable study of the data for 1990-99 revealed a shift with 60% discovered in tropical countries vs 40% in others. India was generating most species (913 approx.), followed by the USA (819 approx.), Australia (813 approx.), China (795 approx.) and France (565 approx.) (Hawksworth, 2001) but according to Hyde (2003) up to 1989 there were only 7 researchers in India with 30 publications but situation became worse till 1994 as there were no longer any publishing researchers in India (Hyde 2003). India was previously productive, but with a rapid decline in both publications and active taxonomic mycologists after 1989. However, the trend has changed a bit but with meagre efforts. Most of earlier workers are either deceased, retired or moved to some different fields. Current status too is not very satisfactory as replacement of mycologist is not happening and their number is declining rapidly. There are some active mycologists in the field of macrofungi, especially that of fleshy fungi but wood inhabiting fungi are often overlooked and ignored.

There are nearly 14,883 fungal species (Singh & Dash, 2014) in comparison to 18,667 vascular plant species (Singh & Dash, 2014). So, we have only managed to discover nearly 13% of the total estimate if we take fungal plant ratio of 6:1 or if we take recent ratio of 10.6:1 (O’Brien et al., 2005), the percentage reduces to around 7%. It is disturbing to note that about 90% fungi are not reported from India. Evaluation of fungal diversity is nearly stunted as for the last many years we have not reassessed the areas previously studied. We do not know whether the reported fungi still in existence or not. Approximate number given by Singh & Dash (2014) is based on previously reported species. For the past few decades deforestation has been a common practice as population increased in nearby area. So there is need to revisit the areas. Modern taxonomy is dominated by molecular methods of identification and India lags far behind in this due to unavailability of adequate funds as well as taxonomic expertise. It is not possible to isolate DNA from individual fruiting body. So, taxonomic expertise is must to carry out diversity studies as primary study is done by most of the times by amateurs and if we lack touch of traditional taxonomy it will be difficult to describe new species.

2.4 Number of ‘Aphyllophorales’
The term ‘Aphyllophorales’ constitutes all forms of wood decaying fungi (mainly Polyporoid and Corticioid fungi). It is an obsolete order which is not used in current literature (Kirk et al. 2008), yet it has usefulness as collective term because wood inhabiting fungi has now been diversified in many clade. Study of Aphyllophorales is one of the oldest form of classical taxonomy. Rossman (1994) published a list where he gave estimated number of known Aphyllophorales to be 20,000 and up to 2008 known number of Aphyllophorales was approximately 3200 species (Kirk et al., 2008) including all forms which were earlier part of polyporoid clade but later on diversified. Various species are found in polyporoid clade during the surveys as the polypores, especially those involved in wood decay, tend to be rather widely distributed and show limited host-specificity. No up to date list is available for Aphyllophoroid species from India or we can say we do not have any idea that how many Aphyllophorales are there but number could be nearly 500-600 species. Bakshi (1971) has described 246 species of Polypores from India, Rattan (1977) 198 resupinate Aphyllophorales from North Western Himalaya, Sharma (2013) gave a number of nearly 650 Aphyllophorales from North Western Himalaya. On viewing the vast climatic conditions and diverse vegetation India has, the expected number could reach to as low as 1,000 species of Aphyllophorales.

2.5 Previous studies in study area

Wood inhabiting fungi are not extensively studied in India. Wood inhabiting fungi were subjected to research in early 19th century to late 80’s but later on a stagnant or slow phase has come as number of research article in the field of taxonomy of wood inhabiting fungi has reduced much. Most of the research done on wood decaying fungi is of before 1990.

Chakrata is a temperate region with ample rain that provides fair chances of wood inhabiting fungi to grow. On reviewing the literature it was found that first report of wood decaying fungi from Chakrata started in 1950 by Bagchee and Bakshi where they gave an account of wound parasites of Indian trees from Dehradun and foothills of Himalayas (Kalsi) and described six wood inhabiting fungi. But actual representation from the hills of Chakrata came when they described and illustrated wood decaying fungi collected on oaks (Bakshi and Bagchee, 1950) from various parts of Western Himalaya including Chakrata. Later some more fungi were added from Oaks and other hardwoods (Bagchee et al., 1954). Wood inhabiting fungi of conifers were later studied (Bakshi
1955; Bakshi et al., 1955). Not only Polypores but corticioides were also studied. Thelephoraceae was described and illustrated in great detail from Western Himalaya by Bakshi and co-workers (Bagchee & Bakshi, 1954; Rehill & Bakshi, 1965a; Rehill & Bakshi, 1965b). There were some new records too from India; Lentinus lepideus, Poria ferruginosa (Bakshi et al., 1955); Coniophora cerebella (Bakshi et al., 1957); Polyporus leucospongia (Bakshi et al., 1958) Trametes sepium (Bakshi et al., 1958), Polyporus amorphus, P. biformis, P. fumosus, P. semipileatus (Bakshi & Singh, 1961), Fomes connatus, F. scutellatus (Singh & Bakshi, 1961), Fomes allardii, F. lineus (Bakshi & Singh, 1965). However, most of the reported fungi were new record from India but only few of them were published as new. There are 122 records of the fungi reported from Chakrata (Source: Forest Pathology Herbarium Records). Bakshi (1971) gave detailed account of wood decaying fungi on trees and timber, where he included most of the fungi recorded from Chakrata.

2.6 Systematic approaches in studying the diversity of wood decaying fungi

Wood decaying, wood inhabiting or wood loving fungi are the important component of the forest ecosystem which have their role in degradation of lignin, the stabilising element of wood, regulating the plant diversity and function as ecological niches. Wood inhabiting fungi are a morphological group of basidiomycetes, including more than 3200 species world-wide (Kirk et al., 2008).

2.6.1 Systematic sampling

Numerous standardized surveys have been conducted on terrestrial macro-fungi and only few have been conducted on wood inhabiting fungi. There is yet no permanent method for sampling wood inhabiting fungi. Mueller et al. (2004) has given in great detail about the sampling of macrofungi. Basically, there are two recommended protocols for sampling macrofungi: Opportunistic, which means carefully walking through a study site and collecting sporocarps of selected taxa. Mycologists traditionally have sampled sites by this method. However, it does not allow for rigorous comparisons of different sites, which requires that sampling intensity be standardized at each site. Fixed plot method, where data of different sites are compared that have same area, same fruiting season, other parameters can also be taken into consideration if plots are very distantly related like vegetation type, rain precipitation, slope elevation etc. Collection of all fungi within a series of plots or transects ensures that all taxa fruiting at the time are
scrutinized and reduces the likelihood that cryptic (morphologically similar) species will be overlooked. Often with such an approach many specimens are identifiable initially only to genus. If the same plots or transects are sampled repeatedly for several years, most taxa eventually will be identified (O’Dell et al., 2004). To maximize the documentation of macrofungal diversity of a site, combination of opportunistic and plot-based sampling should be employed (Mueller et al., 2004).

Currently, plot frequency is the best measure of species abundance i.e. the number of subplots in which a taxon occurs because it represents the minimum area covered by that species in the study site. A sporocarp may be present in several sampling units or subplots may have originated from one large or several small mycelia (Dahlberg and Stenlid, 1994). However, plot frequency provides only a rough estimate of abundance and importance (Schmit et al., 1999). Consequently, size, shape, and spacing of sampling units (plots, transects) are important aspects of sampling design.

To discover morphologically similar fungi sub-plotting is best way as it intensify sampling, through this fungi fruiting on large diameter wood are easily under sampled as there will be low density of large pieces of wood in those subplots and few of those large pieces will be in the right stage of decay to support fungal fruiting (Lodge et al., 2004). Permanent plots provide a good estimate of diversity for a defined area, as well as information on annual variation in fruiting phenology. They also are easy to relocate and measure (O’Dell et al., 2004). Permanent plots have the advantage of being monitored easily over time. Because of the clumped distribution of sporocarps of many fruiting macrofungi. Subplots adjacent to one another are more likely to contain the same species than those at a distance (Murakami 1987).

The number of species of fungi on wood increases with the size of the area sampled, or more specifically, the amount of substratum sampled (Lodge et al., 2004). The distribution and amount of substratum present therefore will dictate the size of the area to be sampled at a particular site. Small-size woody debris generally is encountered much more frequently than large-diameter wood. Thus, the area that must be searched to obtain an adequate sample of wood inhabiting fungi will depend on the distribution and frequency of the different diameter classes of downed wood, as well as the frequency of the fungi under study (Lodge et al., 2004). However, using as many as logs for wood inhabiting fungi did not reach to asymptote (Lindblad 1998).

Small to medium sized woody debris (1.0–15.0-cm diameter) for macrofungi can be surveyed in randomly or regularly spaced subplots of 10 m in diameter, although...
larger plots may be needed if fallen branches are rare as diameter of the plots depends on the density of fallen wood in the diameter classes of interest and the type of fungi under study. The practical upper limit for the diameter of a circular plots is between 10 m and 20 m or 78.5–314 m² (Huhnndorf et al., 2004). Only A few forests have been surveyed and gridded in such a way that grid cells may be selected as sample plots. Most of them are present in North America or Europe (Lodge et al., 2004).

If plots or subplots for sampling fungi on small debris are set up along transect lines, sample units can be selected and density of large fallen or standing-dead trees in the area estimated using the point quarter method (Cottam and Curtis, 1956). In that technique, points are identified along the transect line at distances selected using a random numbers table. Then, the distance from each point to the base of the nearest fallen log or dead tree in the northwest, northeast, southeast, and southwest quarters is measured. Those distances are used to calculate density of standing or fallen trees. Recording the diameters and heights or lengths of the trees and logs and the compass orientation on which they fell is useful for relocating them. Alternatively, if the forest is gridded, or if parallel transect lines are established at regular intervals, then the locations of large woody debris, tree falls, and snags can be mapped. If the sampling area is large, global positioning systems (GPS) can be used to identify the locations of logs and dead trees, and locations can be mapped using latitude and longitude in a geographic information system (GIS). Logs to be sampled are selected from the mapped ones (Huhnndorf et al., 2004).

Studies in which terrestrial macrofungi are surveyed usually use arbitrary sampling units, or plots. Plots range in size from 1 m² to 1000 m² and can be square, rectangular, or circular. The same plots often are scrutinized for several years. When studies involve removal of most sporocarps (e.g., to determine sporocarp productivity), however, some investigators move plots on each sampling occasion to avoid effects of disturbance (Luoma, 1991; O’Dell et al., 1999). Applying species-effort techniques to macrofungi has demonstrated the need to sample an area larger than that required for plants (Mueller et al., 2004). Arnolds (1992) recommended plots of 1000 m² in forest or 500 m² in grasslands, with a minimum of five plots per community type being sampled. Total area sampled per site should be 0.1 hectares along the transect line defined. A 0.1-hectare area contains 250 4m² subplots but only 200 5m² subplots. Mueller et al., (2004) recommended the use of 5-m² circular subplots.
2.6.2 Methods used in sampling

Lindner-Czederpiltz et al., (1999) while studying of polyporoid and corticioid fungi used 100x60 m quadrats which were divided into three contiguous 20x100 m subplots which ran east-west. To perform destructive sampling i.e. all the logs were turned up and down to check if there is any sporophore. They were further divided into 10x100m strip and 5x100 m strip. They again deployed the same method during study of effects of forest management on fungal diversity (Lindner et al., 2006). Kuffer et al., (2004) used 50 m² plot for corticioid fungi and 250 m² for others in Ukranian beach Forest. McMullan-Fisher et al. (2002) studied 14 study sites in the Eastern Central Highlands, Victoria, Australia. At each site, ten 10 m² (1 x 10 m) strip plots were established at random positions and orientation within a 2 ha area. Strip plots were used to prevent disturbance due to the surveying (e.g. trampling) and to ensure that fruit bodies were not overlooked in the dense undergrowth. Packham et al. (2002) established eight 50 m x 10 m sites in the Hermons Road–Esperance area near Geeveston in southern Tasmania. Sites were interspersed, with no two sites more than 5.5 km apart, and four sites were in each of mature mixed forest. At each site, two parallel 50mx1m transects were established, 8m apart. Macrofungi were recorded within transects which were divided into five 10 m x 1m subplots for the purposes of recording macrofungal abundance. To record vascular plants and a number of variables associated with microhabitat, each site was also divided into five contiguous 10mx10 m quadrats. Norden et al., (2004) chosen 25 sites in Southern Sweden to survey coarse woody debris (CWD) in four 10 x 100m transect (4000 m²). Transect were separated by 10m. Fine Woody Debris (FWD) were surveyed in 2 x 2.5 m squares placed randomly. Fungi were inventoried along three of the four transects, each 2 x100 m thus covering area of 600 m² or 1200 m² per site. 

Gibertoni (2008) while studying Polyporoid fungi in Estação Científica Ferreira Penna, an area of pristine Amazonia forest in the State of Pará in Brazil used 20 m x 1000 m of transects. This is somewhat different of Hattori (2005) where he used line transect method by walking in a random direction at 25 m/minute for 30 minute in random direction. Transect by Gibertoni (2008) is a form of belt transect which gives information on abundance as well as presence or absence of species. Gilbertoni et al., (2015) again used belt transect of 500x10 m in Atlantic Rain Forest of North East Brazil.

O’Hanlon and Harrington (2011, 2012) proposed 100 m² plot in 27 sites of Ireland for surveying macrofungi. Rectangular permanent plot of 2x50 m within the 100 m² were established. However, there were other studies where definite length of plot was
not used but study area was divided into plots (Yamashita et al., 2010; Kuffer and Senn-Irlet 2005; Schmit 2005; Sippola et al., 2005). King (2010) ran a transect for macrofungi, along the length of the plot, from the NE to NW, discounting 20 m to avoid edge effect at the University of Michigan Biological Station in Pellston, MI, USA. He used meter sticks to define an area of 2m on either side, and walked along the length of the transects noting the type and quantity of mushrooms at each. For the first sample he ran the transect exactly 20m in from the edge, and following transects were run at 5m intervals (25m, 30m, 35m and 40m westward). The resulting plot sizes were 4m in width, and approximately 75m in length, depending on the dimensions of the specific burn plot. Gates (2011) used a 20 m transect at four plots in native, tall, wet Eucalyptus obliqua forest in southern Tasmania. Ylläsjärvi et al., (2011) studied Picea-dominated forests type in the Ylläs-Aakenus region. A polypore inventory route in the form of a line transects 20x100 m was placed on the map so that it crossed several forest stands within a particular area. Gomez-Hernandez and Williams-Linera (2011) used 10 permanent 10m x 10m plots to measure all trees ≥ 5 cm diameter at breast height. Ten 5m x 5m plots within the 10m x 10m plots for woody plants. Bassler et al., (2012) set up 88 sampling plots of 0.1 ha along transects in three management category sites at logged forest site (Mt. Lackenberg) and the disturbed forest site (Mt. Rachel) in Germany, Bavarian Forest National Park and the old-growth forest site (Mt. Trojmezna and Mt. Plechy) is in the Czech Republic (Sumava National Park). Distance between plots kept 100m. Zotti et al., (2013) established 11 permanent plots located in two different areas of Liguria (NW Italy) dominated by oak (Quercus petraea) and 11 permanent non-continuous plots among Ligurian pine plantations, with a size of about 1000 m² (approximately of 32 m × 32 m). Blaser et al., (2013) assessed dead wood fungal diversity using a sample area of 20x20 m in three research regions of Germany. Andrew et al., (2013) carried out sampling of macrofungi in transect of thirty 500 × 10 m which were separated by a distance 50 m along transects and 100 m between transects. The transects were established at low and high altitudes of Mount Cameroon Region and these cut across food crop fields, bush fallow, farmers’ trails, cocoa and oil palm plantations, secondary and primary forests. Karun and Sridhar (2014) carried out survey for macrofungi in random quadrats (25 × 25 m) at a distance of about 100 m in the arboretum and plantations in Southwest coast of Karnataka, India. Sporocarps on soil, leaf litter, twigs, bark, wood, standing dead or live trees (bark or branches) in each quadrat were considered for sampling and enumeration. Yamashita et al., (2014) used
200x100 m plot to estimate the wood inhabiting fungal diversity at Pasoh Malaysia which were further divided into 200 10x10m plots.

2.7 Diversity studies

Macrofungi have longest history of diversity studies of any mycota. Sufficient data are available from Europe, America and East Asian countries and for the past few decades dramatic increase has been observed from South Asian countries like Thailand, Malaysia and Singapore. But contribution from Indian subcontinent has decreased many folds (Hyde, 2003). Decrease in number of Mycologists and taxonomic studies from Indian subcontinent is a matter of concern. So, knowledge of macrofungal diversity is also at stake. Taxonomic obstacles and the absence of long-term studies prevent us from conclusively answering even basic questions about the number of species at a specific location or whether diversity is greater in one type of forest than in another (Hyde, 2003).

The evaluation of fungal diversity is always a daunting task. Still there is no clear inventory for macrofungi as discussed above. A detailed account of how to study the fungal diversity and their pattern is given by Mueller et al., (2004). There are different measures to assess the fungal diversity. Small quadrates are used for mushrooms while a larger quadrat is needed for Polypores. Again corticioid fungi also assessed by small quadrates (Mueller, 2004). Various studies has been done to assess the diversity of fungi in different regions. Initially more stress was given on taxonomy of the fungi but later on need of pattern distribution and ecological study to assess the diversity developed.

Numerous surveys have been conducted on terrestrial macro-fungi and only few have been conducted on wood inhabiting fungi. Examples of surveys of wood-inhabiting fungi include the altitudinal studies of wood decaying fungi from Kumaun Hills (Mehrotra et al., 1983), Resupinate Aphylllophorales of Smoky Mountain (Jung, 1985), Scandinavian pyrenomycetes (Mathiassen, 1993); wood rotting basidiomycetes (Renvall, 1995); Wood decay basidiomycetes from fallen Eucalyptus of native Australian vegetation (Frayer et al., 1999), basidiomycetes, ascomycetes, and slime molds (Heilmann-Claussen, 2001). Ryvarden and Núñez (1992), Bisht & Harsh (1997) recorded fungal diversity from Kumaun Himalayas, Bisht & Harsh (2000) studied Macrofungal diversity in North East Himalaya, Lindblad (2001) studied polypores in the tropics; Packham et al. (2002) studied biodiversity of macrofungi in mature and young regrowth Tasmanian wet Eucalypt forests where they found that variation in the
macrofungal communities was correlated with a different set of the measured environmental variables rather than variation in the vascular plant communities. Mature and young regrowth forests possessed distinctly different macrofungal floras, with approximately 40% of the taxa in each forest type being restricted to that type of site. McMullan-Fisher et al., (2002) studied changes in the occurrence of macrofungi with time following forestry activities and fire in Mountain Ash (Eucalyptus regnans) dominated forests, in the Eastern Central Highlands, Victoria, Australia. Forests of 0-57 years after fire were used to compare macrofungal communities. Pattern analysis through classification and ordination showed that there was a distinct change in the macrofungal community over time since disturbance. The change in the suite of macrofungi closely reflected the changes in macro fungal substrates in the forests of different ages. Macrofungi found to be specific to certain stages of regeneration after fire will provide a subset of indicator taxa suitable for use in further surveys. Norden et al., (2004) studied CWD in Southern Sweden; and investigated the relative importance of coarse (diameter >10 cm) and fine woody debris (1-10 cm) for fungi in broadleaf forests in southern Sweden. According to them coarse woody debris (CWD) was more species rich than fine woody debris (FWD) for a given number of basidiomycete records. Küffer et al., (2004) Diversity of wood inhabiting fungi in beech forests in Transcapathia, (Ukrain); Küffer and Senn-Irlet (2005) studied indirect ecological effects such as altitude, inclination and exposition in five main biogeographical regions of Switzerland. These regions had different pattern of fungal species richness: while the Plateau at lower altitudes was found to be rather rich, the regions with the highest forests cover, yielded less species; Hattori (2005) studied diversity of wood decaying fungi in different vegetation types of Japan. In his study polypore communities revealed a correlation between forest vegetation types and the species composition of polypores occurring in the forests. Diversity of polypores was found to be high in beech forests compared with secondary forests and conifer plantations. There were several specific species to beech, Castanopsis, and secondary pine forests, respectively; Schmit (2005) studied hurricane recovery plot for macrofungi in Puerto Rico; Sippola et al., (2005) compared species diversity of polypores between woodland key habitats (WKHs) and old-growth forest controls in boreal forests in eastern Finland. WKHs, which were set aside for their rich vascular plant flora, turned out not to be hot spots for the species richness of polypores, nor did their species composition represent the overall species richness of the area. Only a fraction of the overall polypore diversity was represented in the small-size WKHs (<0.5 ha), and the protection of red-listed and
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indicator polypores in WKHs was random; (Lindner, 2006) studied effects of forest management on fungal diversity. Mean species richness and diversity index values did not vary significantly by management class, although mean richness on large diameter wood (≥15 cm diam) varied with moderate significance. Richness values on small diameter debris varied significantly by year, indicating that a large part of year-to-year variability in total species richness is due to small diameter debris. Regression analyses indicated that substrate quality (diameter and species), quantity and management history of the stand were important in predicting the number of occurrences of the five most-abundant species; Kotiranta et al., (2007) studied Polypore diversity in central Ural Russia as no up to date information was available for this region; Junninen (2007) studied conservation of polypore diversity in managed forests of boreal Fennoscandia; Adamčík et al., (2007) gave a list of macrofungi from the Poloniny National Park in Slovakia; Gilbertoni (2008) Polyporoid fungi in Estação Científica Ferreira Penna, an area of pristine Amazonia forest in the State of Pará in Brazil. Results showed that despite the high number of species, the cumulative species curve was not stabilised; Gilbert (2008) evaluated the host and habitat preferences among the Aphyllororales, a guild of wood-decay basidiomycete fungi was considered to be host generalists. Fungal patterns of host association in three well-defined, floristically distinct, tropical wetlands were studied. Their result showed that the host preferences may be important in shaping the assemblages of wood-decay fungi, and that the effect of environment on the distribution of susceptible plant species, rather on the fungi themselves, may ultimately drive the apparent habitat specificity of many fungi; Yamashita et al., (2010) studied species richness and host utilization patterns of wood-inhabiting aphylloraceous fungi in an old-growth beech and oak forest in a cool, temperate area of Japan, their results suggest that tree genus and tree part are important factors determining fungal community structure because these were selected as complementary predictor variables. Both oak and beech appear to be the most important tree genera for maintaining wood-inhabiting fungal species richness because the fungal flora formed on oak CWD is nearly complementary to those on chestnut, with low fungal species richness; King (2010) conducted a study examine the relationship between forest age and the abundance and diversity of fungi within. This study showed that longer, more in-depth studies of forests undergoing controlled burns might show, to a statistically significant degree, the greatest fungi abundance and diversity in intermediately aged plots, in accordance with the Intermediate Disturbance Hypothesis. Gates (2011) studied diversity and ecology of wood-inhabiting macrofungal species
assemblages in a regenerating tall, wet, native *Eucalyptus obliqua* forest in southeast Tasmania. The area was surveyed after 43 years for natural and anthropogenic disturbances. Study provided evidence that forest maintains a core of common wood-inhabiting macrofungal species irrespective of type of disturbance. The species most frequently observed in older forests can also occur in younger managed forests if biological legacies such as large diameter wood, well-decayed wood, large living trees and a diversity of tree species remain after silvicultural treatment. Ylläsjärvi (2011) analyzed the relationships between 86 polypore species richness and 35 habitat variables in 81 northern boreal old-growth forest stands in Finland. Species richness and the number of red-listed species were analyzed separately using generalized linear models. Most species were infrequent in the studied landscape and no species was encountered in all stands. The species richness increased with the volume of CWD and the basal area of living trees. The number of red-listed species increased along the same gradients, but the effect of basal area was not significant. Polypore species richness was significantly lower on western slopes than on flat topography. Species richness was higher on northern and eastern slopes than on western and southern slopes. The results suggest that a combination of habitat variables used as indicators may be useful in selecting forest stands to be set aside for polypore species conservation. O’Hanlon and Harrington (2011) found low diversity of Agaricomycetes than previously reported. Diversity and distribution of species in the Republic of Ireland were also found to be low than other European countries; Dai et al., (2011) surveyed wood-rotting fungi in Hainan Province; Gomez-Hernandez and Williams-Linera (2011) examined whether macromycete alpha and beta diversity were associated with woody plant diversity, forest structure, or microclimate, in four tropical montane cloud forests (TMCFs) at lower (1240–1440 m) and higher altitudes (1790–1900 m) in Veracruz, Mexico. Macromycete richness was negatively correlated with overstorey tree richness, understorey vegetation structure, and air temperature, but was positively correlated with air humidity and soil water content and altitude. Ordinations separated lower from higher altitude forest sites. Changes in composition and abundance of macromycete species with altitude were explained by precipitation, temperature, and understorey vegetation structure, while soil water content effect changes within a growing season. Results imply that understorey vegetation structure is a more important aspect for macrofungal diversity management than for woody plant diversity. O’Hanlon and Harrington (2012) examined macrofungal communities of Irish native tree species (ash and oak) and exotic tree species (Scots pine
and Sitka spruce). Both native and exotic tree species had same macrofungal diversity; Bolhassan et al., (2012) Polyporales diversity in Peninsular Malaysia. Bassler (2012) studied the community characteristics of wood decaying fungi in a high montane Norway Spruce forest with three different management types. Species accumulation curves for the disturbed forest were more similar to those of the logged forest than to those of the old-growth forest; Markkanen & Halme (2012) studied polypore communities in broad leaved boreal forests in Finland; Zotii et al., (2013) assessed mycodiversity under Pinus nigra plantations at Liguria (NW Italy) and checked possible correlations between fungal diversity/abundance and ecological parameters. The mycodiversity was found to be low the reason for low diversity could be Pinus nigra plantation and serpentine soil. They found Significant correlations exist between the mycodiversity and the pH, the altitude, and the grass cover percentage, Carlos et al., (2013) studied effect of slash and burn agriculture on fungal biodiversity from some selected Colombian Amazon forests in relationship to plant biodiversity and successional stages. Suitable substrates, especially dead wood that occurred as a result of recent slash and burn agriculture, resulted in the formation of many sporocarps of wood-inhabiting species. Andrew et al., (2013) carried out study to document the diversity and distribution of macrofungi in the Mount Cameroon Region. These were assessed at low and high altitudinal ranges in the four flanks of the mountain during the rainy and early dry seasons. Karun and Sridhar (2014) done a preliminary diversity survey of macrofungi in an arboretum and three plantations (Acacia, Areca and cashew) of the southwest coast of India. The macrofungal species richness was higher in arboretum compared to plantations. Gibertoni et al., (2015) studied poroid fungi in the Atlantic Rain Forest in Northeast Brazil. The results indicate the importance of the constant inventories and also of revisions of material deposited in herbaria as tools to improve the knowledge about the Brazilian mycota. Yamashita et al., (2014) estimated the diversity of wood-decaying polypores in tropical lowland rain forests in Malaysia. In their study they evaluated the effect of sampling and suggested that if potential sampling effort is limited, surveying a larger area on fewer occasions is a reasonable compromise to ensure coverage of the majority of polypore species. Abergo and Salcedo (2015) studied the beech forests of Navarre (northern Spain) to detect and characterize the understudied wood-inhabiting fungal groups in the beech forests. In their opinion field-mycologists tend to focus on certain fungal groups, and in general rare species are less frequently encountered. Particularly, species with corticioid fruit body type have been especially
overlooked in that territory. Gibertoni et al., (2015) studied distribution of poroid fungi (Basidiomycota) in the Atlantic Rain Forest in Northeast Brazil. In their study they found that fungal communities did not form distinct groups in relation to the forest type or season, but the areas were different from each other and the variation can be partially explained by the distance among them when using linear regression. The poroid fungi were more frequently recorded in logs of decay stage 1 and 2 and their size had little, if none, effect on polypore occurrence.

2.8 Checklist of Polypore fungi around the world


2.9 Morphological or Molecular method of identification?

Morphology was the main tool used until the latter part of the last century to characterize fungi and to develop the taxonomy and putative phylogeny of different groups (Rajchenberg, 2011). Macroscopic and microscopic features of culture for each

Molecular phylogenetics has certainly been the main research focus for the past two decades, and little effort has been invested in understanding other basic features of their life cycles. Critical factors, such as the nuclear behaviour of the mycelium plus other “minor” features such as the number of nuclei in basidiospores and the germination rate of the latter, have remained neglected aspects of the biology of these fungi. Correspondingly key features such as the mating system and cultural features have been given progressively less and less importance, leaving a holistic picture of the taxa incomplete (Rajchenberg, 2011).

Many fungi are cryptic sporocarp producers, and, when they are found, are difficult to identify morphologically. For this and other reasons, molecular tools have been particularly valuable in fungal ecology/diversity studies that strive to document or analyze fungal communities (Aime & Brearley, 2012). Molecular methods have helped to clarify limits of closely related species and to establish host ranges (e.g., Crous et al., 2008).

In the past two decade great advancement has been observed in phyllogenetic study of aphyllophoraceous fungi. Molecular tool has been proven useful to complement, and sometimes overrule, morphological evidences in order to re-classify the fungi (Hibbett et al., 2007) but yet, the evolutionary backbone of the fungi has not been resolved with confidence. This is because of limited gene sampling (James et al., 2006) bearing the possibility of a biased view on evolutionary relationships (Rokas et al., 2003). Especially, the widely used rDNA and its spacers are problematic (Alvarez & Wendel 2003; since their complex mode of evolution is not sufficiently taken into account by the current models. Alternatively, a larger set of genes had been used, but the analyses then were confined to few taxa with sequenced genomes. This substantially increased branch support values, however it was to the cost of bearing the risk of
misleading conclusions on phylogenetic relationships due to insufficient taxon sampling (Miettinen, 2011).

New orders in Polypore are generated on the basis of DNA based phylogenies (Binder et al., 2010). Still we do not know much about the classification and evolutionary relationship of Polypores and there is much to do in this field. To study the relationship between species DNA based phylogenies are quite useful and as we move higher in order our dependency on DNA based phylogenies increase.

Nuclear ribosomal DNA (nrDNA) internal transcribed spacer region (ITS) and neighbouring large subunit coding region (LSU or 28S) has been used as basic gene region in all phylogenetic studies conducted. The ITS region has two regions of non-coding DNA, ITS1 and ITS2, with a coding, conservative 5.8S region between them. ITS is a quickly evolving region used for species-level taxonomy; its conservative parts when used together with (partial) LSU provide suitable sequences for constructing phylogenies between genera and orders (Miettinen, 2011).

2.10 Prospect of Morphology

Polypores are currently scattered in approximately in 12 recognized order, which are intermixed with other fruit body types, sharing common features. With increase of phylogenetic studies, polypore genera has diversified in many clades. This makes difficult to recognize genera of specimen. Taxonomists are already facing this problem and even having available DNA, this could be a hard task. According to Miettinen (2011) “there are two good reasons to stick with morphology as far as possible when creating natural classification for fungi. First, for some time to come species identification in field studies and by amateurs will have to be done with morphological means. Secondly, we will never be able to produce DNA sequences of all species, possibly not even all newly described species. A number of species exist in the eyes of science only as old, degraded specimens in herbaria. If we loose the touch to morphology, those species could not be related to fungal tree of life. No doubt at some point easy and cheap sequencing methods will emerge for identification of single specimens of polypores and corticioid fungi. These methods may replace morphological identification in many ecological studies altogether. However, environmental sampling and identification of sequences require well-referenced databases, and building those databases will require morphological expertise.”
The importance of morphology (macro and microscopic) studies cannot be undermined. Morphological studies should be supported by molecular studies. It would be curious if someone knows the DNA sequence but does not know the fungus how it looks, grows and its life history.

2.11 Ecological role

Wood-decaying fungi are excellent ecosystem engineers, because they directly modulate the availability of resources other than themselves for several other functional groups (Harley 1971; Jones et al., 1994; Krajick 2001; Moore et al., 2004). Fungi regulate diversity of vegetation in forest by making dominant species victims of their own success. Fungi spread quickly between closely packed plants of the same species, preventing them from dominating and enabling a wider range of species to flourish.

Standing and fallen decaying trees support a high species rich environment and plays important role in formation of ecological niches (Odling-Smee et al., 2003). Course woody debries (CWD) is an essential component of mammal, bird, amphibian, arthropod and microbial habitats (Harmon et al., 1986; Bull et al., 1997, Burris & Hanly, 2005, Crow et al., 2002). They provide a food source for a wide range of invertebrates including Collembola, mites and nematodes (Shaw, 1992), and gain nutrition in turn from living or dead animals as well as plants.

Some of the examples studies recognizing deadwood as main source of resources of living organisms include: small mammals (Maser et al., 1978), Forest-floor vertebrates (Butts and McComb, 2000), Soil macro-arthropods (Jabin et al., 2004), Insects in polypores (Jonsell and Nordlander, 2002), Coleoptera (Kappes and Topp, 2004), Gastropods (Kappes, 2005) etc.

2.12 Conservation

Conservation cannot be easily attained. Practical conservation of biodiversity depends upon the reliable information of what type, how much and where the diversity is. In most of the cases the basic level of biodiversity information is observation on species occurrence over time and space in an area. Biodiversity information database and platform have seen considerable progress in recent years. They have a high potential in conservation science in general, but may be even more revolutionary in relation to poorly known species such as fungi, whose practical conservation work has been jeopardised by scattered and poorly controlled information and this may seriously undermine conservation priorities and scientific conclusions (Molina et al., 2011; Jetz et al., 2012).
Accurate recording of the species occurrence over large geographical areas is time consuming and therefore costly. There is need to put emphasis on the importance of information on collection effort, including the use of GPS based tracking data, along with observations. In practice, funding for surveying species is very unfairly distributed, and targeted towards organism groups that are generally considered spectacular, attractive or intelligent. Fungal communities are notoriously difficult to characterise for ecological and biodiversity studies as well as for conservation purpose (Ahad et al., 2014). Minter (2013) refers to fungi as “Orphans of Rio” as they do not find place with other organisms in International Biological Diversity scheme.

Though wood inhabiting fungi support a web of organisms, they themselves are part of biodiversity too. Number of fungi increases as the number of substrate increases (Sippola and Renvall 1999; Humphrey et al., 2000). So reduction in dead wood can result in reduction of wood inhabiting fungi too. According to Siitonen (2001) 90% reduction in dead wood can result in 50% loss of wood inhabiting fungi. This can also be understood as a large number of course woody debris (CWD) may allow more room for large fungal individuals to develop. Many wood inhabiting fungi required certain size of wood for fruiting. Relationships between CWD size and the number of fungal species might to some extent be dependent on the age of the part of the tree concerned, as size is partly related to age. Age involves factors such as the presence of heartwood and the initiation of heart rot while the wood was still standing (Lonsdale, 2007). Size of the CWD is also related to the moisture as larger logs can retain more moisture thus allow more time for colonization of various species with different requirement (Odor et al., 2006). So, for forest ecological point of view, wide range of CWD (both low and high turnover of CWD) is needed in order to conserve species of varying requirements (Lonsdale 2007).

The loss of species diversity alters ecosystem function, stability and the ability to provide goods and services to society (Loreau et al., 2001; Hooper et al., 2005; Wertz et al., 2006; Cardinale et al., 2012). Fungal diversity is related to plant diversity and therefore, loss of the plant diversity is likely to result in loss of fungal diversity. Fungi are a vital link in the functioning of forest ecosystems. Number of fungi and dead wood present in forest are positively correlated. So, conserving the latter will be resulted in conservation of former. This can be achieved via establishing protection area. Götmark and Thorell (2003) during their study in Sweden found a negative density-area relationship between the number of large trees, snags and logs per unit area. This could
lead to the conclusion that that smaller protection areas could be more efficient as they seem to contain a higher density of deadwood. However, rare species are disproportionately distributed in small patches of high habitat quality (Berglund and Jonsson 2003) but they also find through species accumulation curve that large oldgrowth forest patches are more species-rich in polypore species than combinations of small patches of an equal area. In order to protect the other 75–80% of endangered species, mature forests need thus to be preserved in more extensive patches (Lonsdale et al., 2007).

The average deadwood volumes in managed forests are so low that hundreds of wood-inhabiting fungal species are now threatened and many of them are confined to protected areas (Rouvinen and Kouki, 2002). Complementarity analyses (Juutinen and Mönkkönen, 2004) are needed so as to select a network of protected forests containing enough naturally occurring deadwood that would be needed to meet conservation targets.

2.13 Monitoring of Wood decaying fungi

Monitoring programs are designed for determining population trends (rather than overall richness), extend for longer periods, generally focus on fewer taxa (often indicator species), and include many more sites (O’Dell et al., 2004). Indicator species are more frequent in less affected areas and prefer to colonize larger and more decomposed logs, which become less frequent with selective logging (Norstedt et al., 2001; Sverdrup-Thygeson et al., 2003; Gibertoni et al., 2007). This aspect is very important for evaluation of fungal diversity because loss of plant diversity can lead to loss of fungal diversity (Gibertoni, 2008). Other aspects that can affect polypore diversity in ecosystems are the diversity, size and quality of plant species (Gibertoni et al., 2007) and the rainfall gradient (Linndblad, 2001). Monitoring efforts need to be carried out over long periods in many sites, archiving of data and careful documentation of sites and methods are priorities. One should consider the documentation required to facilitate the repetition of a study at a site 20 years in the future and plan accordingly. Pearson (1994) proposed criteria for the selection of indicator taxa, concluding that they should: (1) be taxonomically stable and well known; (2) have a well-known natural history; (3) have readily surveyed and manipulated populations; (4) be sensitive to some disturbances; (5) be a component of a widely distributed higher taxon; (6) include species exhibiting habitat specificity; (7) include species with economic value; and (8)
have distributions or patterns of species richness that are correlated with those of other, unrelated groups (O’Dell et al., 2004).

Macrofungi as indicator species are most useful for monitoring in areas for which long-term records of their occurrences are available (Arnolds, 1991; Ohenoja, 1993) or in which sites being compared follow a known environmental or disturbance gradient (Gulden et al., 1992; O’Dell et al., 1992a; North, 1993). Wood decaying fungi with their dependency on old trees and dead wood are potentially suitable as indicators for dead wood associated biodiversity in general (Christensen et al., 2004).

Monitoring of macrofungi is not so simple as it includes some limitations such as lack or limited taxonomic expertise, annual fluctuations in sporocarp occurrence and abundance, and lack of well-tested protocols for sampling. First problem can be overcome through careful selection of taxa as indicated by Pearson (1994). Annual variation in occurrence of species remains troublesome. The fact that a particular species may not fruit on a site for a number of consecutive years but then be abundant in other years detracts from the utility of macrofungi for monitoring efforts. Species once present at a site that fail to fruit at that site in subsequent years may be present and physiologically active but not fruiting, present as dormant propagules, or extirpated. The causes of such variation are poorly understood.

2.14 Problems

Learning taxonomy is quite a tedious task as one has to spent hours in field, on microscope as well as in comparing literature or monographs to gain command on the subject. Funding is another aspect. In a country like India fungi are overlooked and not much of attention has been given to them. It is easy to get funding for applied research (biotechnology) but difficult to get even a small budget for taxonomic research projects as it does not fall in priority or doesn’t look ‘attractive’. Mycologists in India are poorly equipped, to extent that they lack research quality microscopes and even the basic mycological literature that is resulting in decrease in number of mycologists.

Substantial funding, training and study are required to address this imbalance. To further overcome this imbalance long term studies are needed to obtain a comprehensive and complete understanding of the diversity and functioning of mycobiota in Chakrata forest or in other western Himalayan ecosystems.