Current Research in Environmental & Applied Mycology 4 (1): 117–124 (2014) ISSN 2229-2225

www.creamjournal.org **Article** CREAM

Online Edition

Doi 10.5943/cream/4/1/10

Wood-rotting fungi in East Khasi Hills of Meghalaya, northeast India, with special reference to *Heterobasidion perplexa* (a rare species – new to India)

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Lyngdoh A, Dkhar MS 2014 – Wood-rotting fungi in East Khasi Hills of Meghalaya, Northeast India, with special reference to *Heterobasidion perplexa* (a rare species – new to India). Current Research in Environmental & Applied Mycology 4 (1): 117–124, Doi 10.5943/cream/4/1/10

Abstract

Field surveys and collection of the basidiocarps of wood-rotting fungi were carried out in eight forest stands of East Khasi Hills district of Meghalaya, India. Seventy eight wood-rotting fungi belonging to 23 families were identified. The undisturbed Mawphlang sacred grove was found to harbour a much larger number of the wood-rotting fungi (33.54 %) as compared to the other forest stands studied. Similarly, logs also harboured the maximum number of wood-rotting fungi (59.7 %) while living trees harboured the least (7.8%). *Microporus xanthopus* had the highest frequency percentage of occurrence with 87.5 %, followed by *Cyclomyces tabacinus*, *Microporus affinis* and *Trametes versicolor* with 62.5 %. Majority of the wood-rotting fungi are white-rot fungi (89.61%) and only few are brown-rots. A rare species of wood-rotting fungus, *Heterobasidion perplexa* which has been reported only from Nepal, was found growing on stumps and logs of *Pinus kesiya* in two collection sites. This fungus is new to India.

Keywords – diversity – new record – sacred grove – wood logs

Introduction

East Khasi Hills District forms a central part of the state of Meghalaya in northeast India and covers a total geographical area of 2,748 km^2. It is mostly hilly with deep gorges and ravines on the southern portion. It is endowed with rich natural vegetation which ranges from tropical to sub-tropical or evergreen to mixed deciduous forests. These forests in turn harbour a large number of wood-rotting fungi.

Wood-rotting fungi are those fungi that have the ability to decompose wood causing it to rot. A good number of these fungi produce large and conspicuous fruiting bodies. They comprise 10% of total fungal diversity, of which 16 - 41% have been described to date (Rossman 1994, Mueller et al. 2007). Polyporoid and corticoid fungi are some of the most common and important wood-inhabiting fungi in forests. These species account for the majority of the fruit bodies found on woody debris (deVries 1990). Some fungi attack living trees, others invade dead or felled timber and slash on the forest floor. Wood-decaying basidiomycetes colonize and degrade wood using enzymatic and mechanical processes. Brown-rot fungi preferentially attack and rapidly depolymerise structural

Submitted 10 January 2014, Accepted 6 March 2014, Published online 25 March 2014
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carbohydrates (celluloses and hemicelluloses) in the cell wall leaving the modified lignin behind. White-rot fungi can progressively utilize all major cell wall components, including both carbohydrates and lignin (Jasalavich et al. 2000).

The study of polypores gained momentum in the middle of the 20th century. Extensive studies of the polypores causing diseases of oaks and other economically important forest trees were made (Bagchee 1950, 1954, 1957, 1958, 1961, Bagchee & Bakshi 1950, 1951). Similar contributions from other countries include those from New Zealand (Overholts 1963, Cunningham 1965), Costa Rica (Carranza- Morse 1993, Carranza & Ryvarden 1998), America (Grand & Vernia 2002), Panama (Gilbert et al. 2002) among others. In India wood decay fungi belonging to Polyporaceae were also described by many workers (Bakshi 1971, Harsh & Bisht 1982, Leelavathy & Ganesh 2000, Sharma 2000).

The study of wood-rotting fungi is fundamental to the understanding of fungal diversity in forests. Their decomposition role in the recycling of wood and wood debris in forest ecosystems attracted the mycologists' attention on the survey of wood-rotting fungi. These fungi have received special attention of researchers in the last decades due to their potential applications in pollutant purification, soil bioremediation and antibiotic production (Blanchette 1995, Kotterman et al. 1994, Smânia et al. 2003). Additionally, many polypores are listed in red data books (Arnolds 1989, Benkert et al. 1996, Bendiksen et al. 1997, Larsson 1997) and are important targets for conservation.

An increased understanding of fungal diversity and natural history of fungi will contribute to the knowledge of the local biota and will greatly strengthen initiatives to protect and to sustainably use our natural resources (Rossman et al. 1998). Studies on wood-rotting fungi of India, particularly in the northeast region are scanty. Therefore, in view of this, the present work was carried out to study the wood-rotting fungi in East Khasi Hills district of Meghalaya, India.

Materials & Methods

Study area

The present study was carried out in East Khasi Hills District of Meghalaya, northeast India. It lies between 25°07" & 25°41" N Latitude and 91°21" & 92°09" E Longitude. The climate of the district ranges from temperate in the plateau region to the warmer tropical and sub-tropical pockets on the northern and southern regions. The weather is humid for the major portion of the year except for the relatively dry spell usually between December and March. Here a unique array of vegetation ranging from tropical, sub-tropical and temperate forest is found. Diverse topography, varied climatic and edaphic conditions favour the diversity in vegetation. Eight forest-stands in East Khasi Hills district (4 sacred groves and 4 community forests), viz., Laitkor forest, Lawbah forest, Mawphlang Sacred Grove, Mawsmai Sacred Grove, Mawlai forest, Nongkrem Sacred Grove, Pynursla forest and Swer Sacred Grove were selected as collection sites for the present study. Among the collection sites, Mawphlang sacred grove which is one of the largest and best conserved sacred grove, is regarded as undisturbed as it is free from disturbances like encroachment from the villagers and collection of fallen wood. The remaining seven collection sites show certain degree of disturbances.

Collection and identification of the wood-rotting fungi

The fruit bodies of the wood-rotting fungi were collected at regular intervals during the period 2008 to 2010. They were photographed in the field and all important morphological characters including substrata were noted. Substrata were treated as living trees, logs, tree stumps and twigs. The fruit bodies were then brought to the laboratory where close-up images were taken and detailed observations made. The specimens were preserved by air drying and liquid preservation. Voucher numbers were given to the specimens and stored in the Microbial Ecology Laboratory, Department of Botany, North Eastern Hill University, Shillong (India) for future reference.

The collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literature (Gilbertson & Ryvarden 1986; Núñez & Ryvarden 2000). Host tree species were identified with the help of experts and herbarium curators.

Data analysis

The frequency percentage of occurrence (F %) of each fungal species was calculated as follows:

$$F\,\% = \frac{\text{No. of sites in which species is present}}{\text{Total number of sites}} \times 100$$

Results

Diversity

Seventy eight wood-rotting fungi were identified belonging to 23 families. Maximum number of wood-rotting fungal species belonged to the family Polyporaceae (14 genera and 25 species) (Table 1). Some common wood-rotting fungi include *Armillaria mellea*, *Auricularia auricula*, *Cyclomyces tabacinus*, *Hymenochaete tabacina*, *Hypholoma fasciculare*, *Microporus affinis*, *Microporus xanthopus* and *Schizophyllum commune* (Fig. 1). The frequency percentage of occurrence was highest in *Microporus xanthopus* with 87.5 %, followed by *Cyclomyces tabacinus*, *Microporus affinis* and *Trametes versicolor* with 62.5 %, while the frequency percentage of occurrence of the rest of the species ranged between 12.5 - 50 %. Among all the collection sites, the undisturbed sacred grove in Mawphlang was found to harbour a much larger number of the wood-rotting fungi i.e., 33.54 % (Fig. 2A). Majority of the identified fungi are white-rot fungi (89.61 %) and only 10.39 % are brown-rot fungi. The brown-rot fungi include *Antrodia albida*, *Fistulina hepatica*, *Fomitopsis carneus*, *F. pinicola*, *Gloeophyllum odoratum*, *G. subferrugineum*, *Laetiporus sulphureus* and *Oligoporus tephroleucus*.

The rare wood-rotting fungus, *Heterobasidion perplexa*

Heterobasidion perplexa Ryv. nov. sp. (Synonym: *Wrightoporia perplexa*) is here reported as new to India as this is its first report from India. The fungus was collected from stumps and logs of *Pinus kesiya* at two different sites i.e., Mawphlang sacred grove (91˚55’ E, 25˚34’N) and Mawlai forest (91˚52’ E, 25˚35’N) in East Khasi Hills of Meghalaya at altitudes of 1900 m and 1430 m respectively (Fig. 3). The fruit-body of this fungus is pileate, annual, pileus up to 3 - 5 cm wide, 5 - 6 cm long and 1 cm thick at the base, soft when fresh, rigid and hard when dry, upper surface ochraceous to pale brown, slightly zonate, glabrous, radially striate to slightly wrinkled, margin sharp and deflexed in dry specimens, pore surface ochraceous to pale leather coloured, pores round to angular, 2-4 per mm, tubes up to 5 mm deep, pale ochraceous.

Fig. 1 – Common wood-rotting fungi. A, *Armillaria mellea*. B, *Auricularia auricula*. C, *Cyclomyces tabacinus*. D, *Hypholoma fasciculare*. E, *Hymenochaete tabacina*. F, *Microporus affinis*. G, *Microporus xanthopus*. H, *Schizophyllum commune*.

Table 1 Wood-rotting fungi collected from East Khasi Hills of Meghalaya, India

ASCOMYCETES	
Helotiaceae –	*Ascocoryne sarcoides, Bisporella citrina, Chlorociboria aeruginosa*
Xylariaceae –	*Daldinia concentrica, Ustilina deusta , Xylaria hypoxylon, X. longipes, X. polymorpha*
BASIDIOMYCETES	
Auriculariaceae –	*Auricularia auricula*
Bankeraceae –	*Hydnellum aurantiacum*
Bondarzewiaceae –	*Bondarzewia berkeleyi, Heterobasidion insulare, H. annosum, H. perplexa*
Fistulinaceae –	*Fistulina hepatica*
Fomitopsidaceae –	*Antrodia albida, Fomitopsis carneus, F. pinicola*
Ganodermataceae –	*Amauroderma rugosum, Ganoderma applanatum*
Gloeophyllaceae –	*Gloeophyllum odoratum, G. subferrugineum*
Hericiaceae –	*Laxitextum bicolor*
Hymenochaetaceae –	*Coltricia tomentosa, Cyclomyces tabacinus, Hymenochaete tabacina, Phellinus allardii, P. gilvus, P. wahlbergii, P. xeranticus*
Marasmiaceae –	*Lentinula edodes*
Meripilaceae –	*Grifola frondosa*
Meruliaceae –	*Abortiporus biennis, Bjerkandera adusta, Junghuhnia nitida, Podoscypha nitidula*
Nidulariaceae –	*Cyathus olla*
Phanerochaetaceae –	*Antrodiella serpula, A. zonata, Irpex vellereus, Porostereum crassum, Steccherinum ochraceum*
Physalacriaceae –	*Armillaria mellea*
Polyporaceae –	*Cerrena consors, Coriolopsis strumosa, Datronia mollis, Hexagonia apiara, H. glaber, H. tenuis, Laetiporus sulphureus, Lenzites acuta, Microporus affinis, M. xanthopus, Nigroporus durus, N. vinosus, Oligoporus tephroleucus, Perenniporia ochroleuca, P. subacida, Polyporus dictyopus, P. hemicapnodes, P. tuber aster, Pycnoporus sanguineus, Trametes hirsuta, T. modesta, T. ochracea, T. versicolor, Trichaptum biforme, T. fuscoviolaceum*
Schizophyllaceae –	*Schizophyllum commune*
Stereaceae –	*Stereum hirusta, S. ostrea, S. versiforme, Xylobolus subpileatus*
Strophariaceae –	*Hypholoma fasciculare, Pholiota squarossa*
Tremellaceae –	*Tremella fuciformis, T. mesenterica*
Trichocomaceae –	*Trichocoma paradoxa*

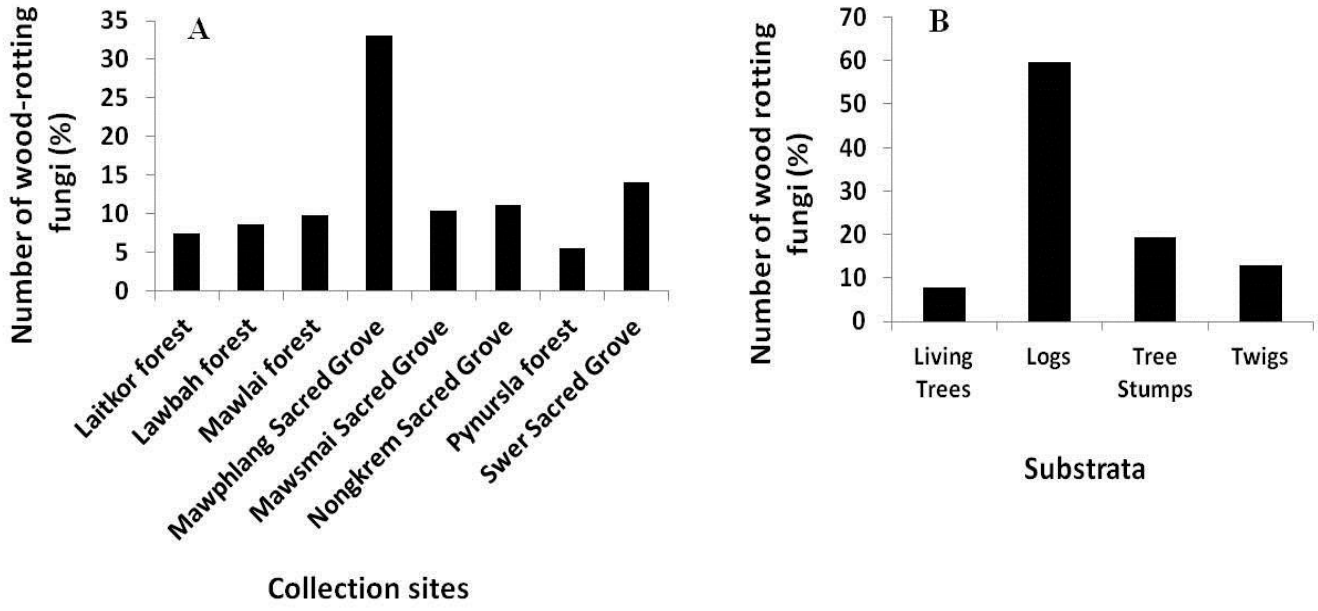

Fig. 2 – Number of wood-rotting fungi in percentage: A, in different collection sites in East Khasi Hills of Meghalaya. B, on different substrata

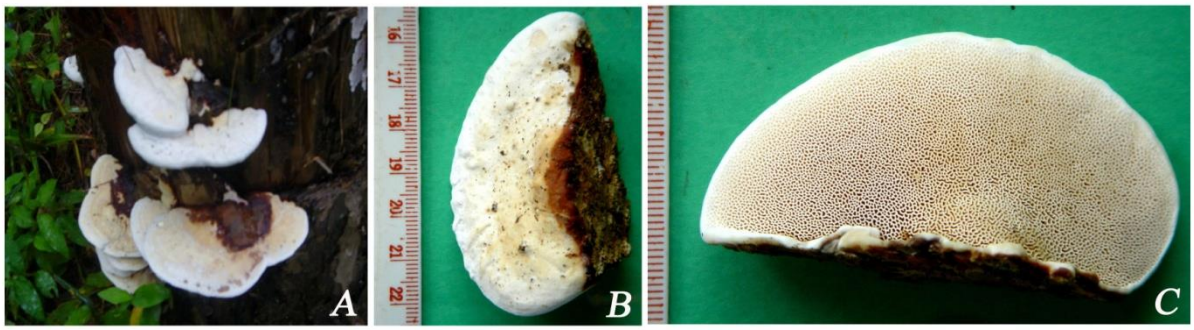

Fig. 3 – *Heterobasidion perplexa.* A, Attached to *Pinus kesiya* stump. B, Upper surface. C, Pore surface

Occurrence of wood-rotting fungi

The wood-rotting fungi were found to occur on a variety of substrata ranging from living trees to dead fallen twigs, tree stumps and wood logs of different sizes. 59.7 % of wood-rotting fungi occurred on logs. Tree stumps and twigs had lesser number of wood-rotting fungi while living trees had the least (Fig. 2B). The majority of the host trees were angiosperms. *Pinus kesiya* was the only gymnosperm host tree recorded. Common angiosperm host tree species include *Betula alnoides, Castanopsis hystrix, C. indica, Cinnamomum glanduliferum, Elaeocarpus lancifolius, Michelia champaca, Myrica esculenta, Prunus cerasoides, Pyrus pashia, Quercus dealbata, Q. fenestrata, Q. glauca, Q. serrata, Rhododendron arboreum, Schima wallichii, Symplocos glauca, S. glomerata* and *S. sumnitia.*

Discussion

Diversity

The observation that species of the Polyporaceae family were more common than the other families conforms to the findings of many other workers which include those in Phulwari Wildlife Sanctuary, Rajasthan, in three islands in the Yellow sea, Korea and in different forest stands of Meghalaya, Himachal Pradesh and Uttarakhand (Sharma 2007, Kim et al. 2009, Sailo 2010, Prasher & Ashok 2013, Prasher & Lalita 2013).

The findings that the undisturbed sacred grove harboured more number of wood-rotting fungi are similar to results obtained in the Western Ghats where sacred groves had the highest sporocarp abundance and the greatest morphotype richness per sample area, whereas the large areas of degraded and modified forest had the lowest sporocarp abundance (Brown et al. 2006). These observations show that habitat degradation is a serious threat to fungal diversity. The sacred groves which are usually believed to be associated with some sort of taboo (when disturbed) by the local inhabitants are important for fungus conservation because they provide unique types of habitat that sustain a distinct fungal assemblage.

The low number of wood-rotting fungi in the disturbed forests is due to several reasons such as encroachment and disturbances from the villagers, removal of fallen dead wood and decrease in under storey vegetation (Sailo 2010). 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. Numerous studies in recent years have also shown a strong decrease in the diversity of wood-decaying fungi with increasing management intensity or logging activity (Bader et al. 1995, Penttila et al. 2004).

In the present study white-rot fungi were found to be more common than brown-rot fungi. Similar results were obtained in temperate Himalayas where only 13 % of the wood-rotting fungi cause brown rots (Sharma 2006), while in North America only 7 % produce brown rots (Gilbertson 1980). It was suggested that brown-rot has been repeatedly derived from white-rot (Gilbertson 1980). In contrast, it was also suggested that brown-rot is the plesiomorphic form in the

homobasidiomycetes, and that white-rot has been repeatedly derived by elaboration of wood decay mechanisms (i.e., gaining the ability to degrade lignin) (Nobles 1965, 1971). However more recent authors have supported Gilbertson's view that the brown-rot fungi are derived from white-rot (Ryvarden 1991, Worrall et al. 1997).

The rare wood-rotting fungus, *Heterobasidion perplexa*

Heterobasidion perplexa Ryv., was earlier reported only from Nepal (Ryvarden 1989), growing on *Tsuga* sp. above 2500 m altitude. Here it was found growing on logs and stumps of *Pinus kesiya* at two different sites i.e., Mawphlang sacred grove and Mawlai forest in East Khasi Hills of Meghalaya, India at altitudes of 1900 m and 1430 m respectively. From these observations, it can be said that the fungus is host specific to gymnosperms and grows in areas above 1400 m altitude. This specificity to gymnosperms might be one of the reasons for it to be rare in its occurrence.

Occurrence of wood-rotting fungi

Among the substrata, logs harboured the maximum number of wood-rotting fungi. This may be due to the different species adaptations to the defence mechanisms present in the living trees, and not in logs, tree stumps and twigs, as well as differences in the microclimate within each substrate (Boddy 2001). Logs especially the larger ones are more prone to harbour high species richness which is partially due to greater surface area and volume (Bader et al. 1995, Kruys et al. 1999). Additionally, the decay rate varies even on the same log, resulting in heterogeneous microhabitats (Crites & Dale 1998). A broad diversity of host tree species, of various volumes and diameters, i.e., logs, branches or twigs, and degree of decomposition seems to be major factors contributing to the diversity of the wood-rotting fungi (Kuffer & Senn-Irlet 2005).

Many macro fungal species fruit sporadically, with no consistent pattern of occurrence from year to year (Watling 1995). Furthermore, their sporocarps are ephemeral and, even when produced, may last only a few days before decomposing or being eaten (Tofts & Orton 1998). Hence, many years of thorough surveys are required to adequately describe the macro fungal communities of a particular area.

Acknowledgements

The authors thank Prof. Lief Ryvarden, Norway, Dr. N.S.K. Harsh (Scientist – G), Forest Research Institute, Dehradun, India, for identification of the fungi and the Head, Department of Botany, North Eastern Hill University for laboratory facilities.

References

Arnolds E. 1989 – A preliminary red data list of macro fungi in the Netherlands. Persoonia 14, 77–125.

Bader P, Jansson S, Jonsson BG. 1995 – Wood inhabiting fungi and substratum decline in selectively logged boreal spruce forests. Biological Conservation72, 355–362

Bagchee K. 1950 – Progress of forest pathology in India during the quinquennium 1944–49. Indian Forester 76 (5), 216–220.

Bagchee K. 1954 – The fungal disease of Sal (*Shorea robusta* Gaertn. f. & Fils.), Part II, Secondary parasites of Sal. Indian Forest Records 1 (8), 97–184.

Bagchee K. 1957 – The fungal disease of Sal (*Shorea robusta* Gaertn. f. & Fils.), Part III. The root disease of Sal due to *Polyporus shoreae* Wakef. (Patrridge wood rot).Indian Forester 1(9), 185–195.

Bagchee K. 1958 – The fungal disease of Sal (*Shorea robusta* Gaertn. f. & Fils.), V. The heart rot of Sal caused by *Trametes incerta* (Currey) Cokke. Indian Forester 2(4), 61–69.

Bagchee K. 1961 – The fungal disease of Sal (*Shorea robusta* Gaertn. f. & Fils.), IV. *Fomes caryophylii* (Rac.) Bres. A destructive heart rot of Sal. Indian Forester 2(3), 25–28.

Bagchee K, Bakshi BK. 1950 – Some fungi as wound parasites of Indian trees. Indian Forester 76, 244–253.
Bagchee K, Bakshi BK. 1951 – *Poria monticola* Murr. On Chir (*Pinus longifolia* Roxb.) in India. Nature 167, 824.
Bakshi BK. 1971 – Indian Polyporaceae (on trees and timber). ICAR, New Delhi, pp 246.
Bendiksen E, Høiland K, Brandrud TE, Jorda JB. 1997 – Truedeogsårbaresopparter I Norgeenkommentertrødliste. Fungiflora, Norway.
Benkert D, Dörfelt H, Hardtke HJ, Hirsch G, Kreisel H, Krieglsteiner GJ, Lüderitz M, Runge A, Schmid H, Schmitt JA, Winterhoff W, Wöldecke K, Zehfuss HD. 1996 – Rote Liste der Grosspilze Deutschlands. In: BundesamtfürNaturschutz (ed), Rote Listegefährdeter Pflanzen Deutschlands, Bundesamtfür Naturschutz, Germany, pp 377–426.
Blanchette RA. 1995 – Degradation of the lignocellulose complex in wood. Canadian Journal of Botany 73 (1), 999–1010.
Boddy L. 2001 – Fungal community ecology and wood decomposition processes in angiosperms: from standing tree to complete decay of coarse woody debris. Ecological Bulletins 49, 43–56.
Brown N, Bhagwat S, Watkinson S. 2006 – Macrofungal diversity in fragmented and disturbed forest of the Western Ghats of India. Journal of Applied Ecology 43 (1), 11–17.
Carranza-Morse J. 1993 – Pore fungi of Costa Rica. III. Mycotaxon 48, 45–57.
Carranza J, Ryvarden L. 1998 – Additional list of Pore fungi of Costa Rica. Mycotaxon 69, 377–390.
Crites S, Dale MRT. 1998 – Diversity and abundance of bryophytes, lichens, and fungi in relation to woody substrate and successional stage in aspen mixed wood boreal forests. Canadian Journal of Botany 76, 641–651.
Cunningham GH. 1965 – Polyporaceae of New Zealand. New Zealand Department of Science. Indian Research Bulletin 164, pp 304.
deVries BWL. 1990 – On the quantitative analysis of wood-decomposing macrofungi in forests. Wageningen Agricultural University Papers 90, 93–101.
Gilbert GS, Ferrer A, Carranza J. 2002 – Polypore fungal diversity and host density in a moist tropical forest. Biodiversity and Conservation11, 947–957.
Gilbertson RL. 1980 – Wood-rotting fungi of North America. Mycologia 72, 1–49.
Gilbertson RL, Ryvarden L. 1986 – North American Polypores. Fungiflora, Oslo.
Grand LF, Vernia CS. 2002 – New Taxa and Hosts of Poroid Wood-Decay Fungi in North Carolina. Castanea 67 (2), 193–200.
Harsh NSK, Bisht NS.1982 – Altitudinal Distribution of some common wood-decaying fungi in Kumaun, India.Transactions of the British Mycological Society 79, 182–186.
Jasalavich CA, Ostrofsky A, Jellison J. 2000 – Detection and identification of decay fungi in spruce wood by restriction length polymorphism analysis of amplified genes encoding rRNA. Applied and Environmental Microbiology 66, 4725–4734.
Kim C, Lee JS, Jung HS, LimYW. 2009 – The Wood-rotting Fungal Flora of Three Islands in the Yellow Sea, Korea. Mycobiology 37(2), 147-151.
Kotterman M, Heessels E, Jong E, Field JA. 1994 – The physiology of anthracene biogradation by the white rot fungus *Bjerkandera* sp. Strain BOS55. Applied Microbiology and Biotechnology 42, 179–186.
Kruys N, Jonsson BG. 1999 – Fine woody debris is important for species richness on logs in managed boreal spruce forests of northern Sweden. Canadian Journal of Forest Research 29, 1295–1299.
Kuffer N, Senn-Irlet B. 2005 – Diversity and ecology of wood inhabiting aphylophoroid Basidiomycetes on fallen woody debris in various forests types in Switzerland. Mycological Progress 4 (1), 77–86.
Larsson KH. 1997 – Rödlistadesvampari Sverige Artfakta. Art Databanken, Sweden.
Leelavathy KM, Ganesh PN. 2000 – Polypores of Kerela. Daya Publishing House, Delhi.

Mueller GM, Schmit JP. 2007 – Fungal biodiversity: what do we know? What can we predict? Biodiversity and Conservation 16 (1), 1–5.
Nobles MK. 1965 – Identification of cultures of wood-inhabiting Hymenomycetes. Canadian Journal of Botany 43, 1097–1139.
Nobles MK. 1971 – Cultural characters as a guide to the taxonomy of the Polyporaceae. In: RH Petersen (ed.), Evolution in the higher basidiomycetes. University of Tennessee Press, Knoxville, pp 169–196.
Núñez M, Ryvarden L. 2000 – East Asian Polypores. Fungiflora, Oslo.
Overholts LO. 1963 – ThePolyporaceae of the United States, Alaska and Canada. Univ. of Michigan Press, Ann. Arbor, Michigan. pp 466.
Penttila R, Siitonen J, Kuusinen M. 2004 – Polypore diversity in managed and old-growth boreal *Picea abies* forests in southern Finland. Biological Conservation 117, 271–283.
Prasher IB, Ashok D. 2013 – A Checklist of Wood Rotting Fungi (non-gilled Agaricomycotina) of Himachal Pradesh. Journal on New Biological Reports 2(2), 71–98.
Prasher IB, Lalita. 2013 – A Checklist of Wood rotting fungi (non-gilled Agaricomycotina) of Uttarakhand. Journal on New Biological Reports 2(2), 108–123.
Rossman A. 1994 – A strategy for an all-taxa inventory of fungal biodiversity. In: Peng CI, Chou CH (eds), Biodiversity and terrestrial ecosystems. Academia Sinica Monograph Series No.14, Taipei, pp 169–194.
Rossman AY, Tulloss RE, O'Dell TE, Thorn RG. 1998 – Protocols for an all taxa biodiversity inventory of fungi in a Costa Rican conservation area. Parkway Publications, Inc., Boone, North Carolina, pp 163.
Ryvarden L. 1989 – *Wrightoporia perplexa* nov. sp. (Polyporaceae). Opera Botanica 100, 225–227.
Ryvarden L. 1991. Genera of polypores: Nomenclature and taxonomy. Synopsis Fungorum 5, 1–363.
Sailo JZ. 2010 – Studies on the wood rotting fungi of Meghalaya. PhD Thesis. North Eastern Hill University, Shillong, India.
Sharma JR. 2000 – Genera of Indian Polypores. Botanical Survey of India, Calcutta. pp 188.
Sharma JR. 2006 – Wood rotting fungi of Temperate Himalaya. In: Mukerji KG and Manoharachary C (eds), Current concepts in Botany, IK International Publishing House Pvt. Ltd., New Delhi, pp 101–120.
Sharma SK. 2007 – Some macrofungi of Phulwari Wildlife Sanctuary, Rajasthan. Zoos' Print Journal 22 (3), 2616.
Smânia A, Marques CJS, Smânia EFA, Zanetti CR, Carobrez SG, Tramonte R, Loguercio-Leite C. 2003 – Toxicity and antiviral activity of cinnabarin obtained from *Pycnoporus sanguineus*. Phytotherapy Research 17, 1069–1072.
Tofts RJ, Orton PD. 1998 – The species accumulation curve for Agarics and Boleti from a Caledonian Pinewood. Mycologist 12, 98–102.
Watling R. 1995 – Assessment of fungal diversity: macromycetes, the problems. Canadian Journal of Botany 73, S15–S24.
Worral JW, Anagnost SE, Zabel RA. 1997 – Comparison of wood decay among diverse lignicolous fungi. Mycologia 89, 199–219.