Regular Article
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 34, No. 2, pp. 126-135, April, 2018
https://doi.org/10.7747/JFES.2018.34.2.126

JFES
Journal of Forest and Environmental Science

Diversity and Distribution of Wood Decay Fungi in Korea

Nam Kyu Kim[1,3], Dae Ho Kim[1], Sang Kuk Han[3], Du Song Cha[2,*] and Jong Kyu Lee[1,*]
[1]*Tree Pathology and Mycology Laboratory, College of Forest and Environmental Sciences, Kangwon National University, Chuncheon 24341, Republic of Korea*
[2]*Department of Forest Environment Management, College of Forest and Environmental Sciences, Kangwon National University, Chuncheon 24341, Republic of Korea*
[3]*Forest Biodiversity Division, Korea National Arboretum, Pocheon 11186, Republic of Korea*

Abstract

Wood decay fungi were collected in 47 different locations in eight provinces of South Korea from 2011 to 2013. One thousand and five hundreds three fruiting bodies of wood-decay fungi were collected, identified, and classified into 2 phyla, 7 classes, 19 orders, 56 families, 159 genera and 365 species. The most dominant genus and species found were *Trametes* and *T. versicolor*. The highest species diversity was found in broad-leaved forest (273 species), and was also found at elevations of 500-1,000 m (227 species). A total of 333 species were collected from broad-leaved trees, 87 species from coniferous trees, and 55 species were collected from both forest types. *Gymnopilus liquiritiae* was the most dominant species in coniferous trees, while *T. versicolor*, which was mostly collected from tree trunks below 500 m in elevation, was dominant in broad-leaved trees. Results from the quantitative cluster analysis of wood decay fungi showed that the highest species diversity index was 1.80 in the mixed forests, while the highest similarity among forest types was shown between the broad-leaved and mixed forests.

Key Words: Wood decay fungi, *Trametes versicolor*, species diversity, distribution

Introduction

Wood decay fungi play an important role in forest ecosystem as decomposers by disintegrating and mineralizing lignin and cellulose, cell wall components of dead woods (Jung 1994). In addition to forests, wood decay fungi commonly inhabits wood structures of buildings such as fences, ladders, floors, walls (Gilbertson 1980), which has a negative impact on the economy (Manion 1981). In addition, wood decay fungi are also found on street or landscape trees as well as wood products, which can be hazardous (Eriksson 1958). However, wood decay fungi are potentially useful for the environment-friendly treatment of waste water from the dye industry (Kim et al. 1995; Gu et al. 2012), soil improvements (Min et al. 2006), and medicinal drug development (Wasser 2002).

In order to avoid damage by wood decay fungi and to

Received: February 22, 2018. Revised: April 2, 2018. Accepted: April 3, 2018.

Corresponding author: Du Song Cha
Department of Forest Environment Management, College of Forest and Environmental Sciences, Kangwon National University, Chuncheon 24341, Republic of Korea
Tel: 82-33-250-8336, Fax: 82-33-242-4484, E-mail: dscha@kangwon.ac.kr
Corresponding author: Jong Kyu Lee
Tree Pathology and Mycology Laboratory, College of Forest and Environmental Sciences, Kangwon National University, Chuncheon 24341, Republic of Korea
Tel: 82-33-250-8364, Fax: 82-33-259-5617, E-mail: jongklee@kangwon.ac.kr

more efficiently apply potential positive attributes of wood decay fungi, a basic understanding of species diversity, distribution, ecological characteristics and decay patterns are necessary. However, most research of wood decay fungi in Korea was conducted in the diversity and distribution of the limited areas and taxons (Jung 1993; Jung 1994).

Presently, approximately 600 species of wood decay fungi have been identified in Korea, most of which belongs to the Basidiomycota and, to a lesser degree, the Ascomycota (Lee et al. 2015). We expect that there are many unrecorded species in Korea, where forest area covers 64% of the total national land area.

Since species diversity and distribution of wood decay fungi in forest ecosystems are mainly influenced by tree species and vegetations, which generally depended on geological and climatic characteristics (Jung 1994), research of the relationship between host diversity and geological characteristics as it relates to the distribution of wood decay fungi is required. Thus, this study was conducted in order to provide basic information on diversity and distribution of wood decay fungi as it relates to different host trees and environmental factors, i.e., region, forest type, elevation, host tree and tree parts, and also to enhance the management of wood decay fungi in forest ecosystem.

Materials and Methods

Survey sites

Wood decay fungi were surveyed and collected from 47 areas located in eight provinces in Korea. Most of the survey sites were in forest areas, but parks and schools in urban area were also included. The forest areas surveyed were Seoraksan National Park, Odaesan National Park, Sobaeksan National Park, Woraksan National Park, Soknisan National Park, Deugyusan National Park, Jirisan National Park as well as the Baekdudaegan mountains (Table 1).

Table 1. Collection sites of wood decay fungi in this study

Province	City	Site
Chungbuk	Boeun	Mt. Songni
	Chungju	Mt. Boryoen
	Danyang	Mt. Sobaek, Mt. Youngsanbong
	Goesan	Mt. Parkdal, Mt. Songni
	Gyeryong	Mt. Gyeryong
	Jecheon	Mt. Worak, Mt. Sukkiam
Gangwon	Chuncheon	Chuncheon Mech. Tech. High School, Dearyong Park, Geunhwa Park, Kangwon Nat'l Univ., Mt. Gujeol, Soyang Park
	Gangneung	Mt. Seokbyung
	Goseong	Hwaam temple, Mt. Hyangnobong
	Hongcheon	Mt. Gari, Mt. Gyebang, Mt. Odae
	Inje	Mt. Jeombong, Wontong High School, Yongdae Elementary School
	Pyeongchang	Mt. Odae
	Samcheok	Mt. Duta
	Sokcho	Mt. Seorak
	Taebae	Mt. Keumdeabong, Mt. Hambaek
Gyeongbuk	Bonghwa	Mt. Munsu
	Gimcheon	Mt. Hwangak
	Sangju	Mt. Beakhak, Mt. Songni
	Uljin	Mt. Tonggo
	Ulleung	Nari basin, Sukpo, Teaha pass
	Yeongcheon	Mt. Bohyeon
	Yeongdeok	Mt. Chilbo
	Yeongju	Mt. Sobaek
Gyeonggi	Gapyeong	Mt. Yeonin
Geongnam	Sancheong	Mt. Jiri
Jeonbuk	Muju	Mt. Deogyu, Mt. Namdeogyu
	Namwon	Mt. Jiri
Jeonnam	Gurye	Mt. Jiri

Field survey and wood decay fungi collections

Fruiting bodies of wood decay fungi were collected from April to October every year for three years (2011-2013). Whenever we found fruiting bodies in survey areas, geological characters such as elevation and GPS (Global Positioning System) coordinates as well as vegetation information such as forest type, dominant tree species and density were recorded. In addition, ecological and morphological characters were recorded. For instance, periods, patterns, and amounts of fruiting body development as well as host tree species associated, shape of pileus, the presence, shape and colors of gill/pore, volva, annulus were observed. Before collecting fruiting bodies, photos were taken to provide supplemental documents used for morphological identification. Tree parts such as trunk, twig/branch, or stump, where fruiting bodies of wood decay fungi developed, were recorded to analyze the diversity and distribution of wood decay fungi by tree parts (Fig. 1). After microscopic observations of the collected fruiting bodies were

conducted, fruiting bodies were dried with heating blow at below 40°C to make dried specimens and then preserved in the specimen herbarium for further examination.

Wood decay fungi identification

The collected mushrooms were identified by morphological and genetical characteristics. Morphological identi-

Trunk *Branch* *Stump*

Fig. 1. Fruiting bodies of wood decay fungi developed on different parts of host tree.

Table 2. Survey plots for analyzing the diversity of wood decay fungi

Type	No.	Location	Dominant tree	Altitude (m)
Broad-leaved	B1	Mt. Odae	*Quercus* spp.	1,313
	B2	Mt. Odae	*Betula platyphylla*	1,297
	B3	Mt. Odae	Broad-leaved tree	676
	B4	Mt. Odae	*Quercus* spp.	297
	B5	Mt. Odae	*Quercus* spp.	1,090
	B6	Mt. Odae	Broad-leaved tree	865
	B7	Mt. Bohyeon	*Quercus* spp.	676
	B8	Mt. Chilbo	*Quercus* spp.	257
	B9	Mt. Tonggo	*Quercus* spp.	745
	B10	Mt. Munsu	*Quercus* spp.	833
Coniferous	C1	Mt. Odae	*Pinus koraiensis*	907
	C2	Mt. Odae	*Abies holophylla*	860
	C3	Mt. Odae	*Pinus densiflora* + *A. holophylla*	658
	C4	Mt. Odae	*A. holophylla*	659
	C5	Mt. Odae	*Larix kaempferi*	668
	C6	Mt. Odae	*P. densiflora*	261
	C7	Mt. Odae	*A. holophylla*	929
	C8	Mt. Bohyeon	*P. densiflora* + *P. koraiensis*	526
	C9	Mt. Tonggo	*P. densiflora*	718
	C10	Mt. Munsu	*P. densiflora*	836
Mixed	M1	Mt. Odae	*A. holophylla* + Broad-leaved tree	1,325
	M2	Mt. Odae	*A. holophylla* + *Quercus* spp.	1,309
	M3	Mt. Odae	Broad-leaved tree + *P. densiflora*	683
	M4	Mt. Odae	*Quercus* spp. + *P. densiflora*	286
	M5	Mt. Odae	Broad-leaved tree + *P. densiflora*	874
	M6	Mt. Bohyeon	*Quercus* spp. + *P. densiflora*	588
	M7	Mt. Bohyeon	*Quercus* spp. + *P. densiflora*	588
	M8	Mt. Chilbo	*Quercus* spp. + *P. densiflora*	270
	M9	Mt. Tonggo	Broad-leaved tree + *P. densiflora*	745
	M10	Mt. Munsu	*Quercus* spp. + *P. densiflora*	841

fication was performed by observing dried specimen, visual document and field recording sheet according to the identification key (Stunz 1973; Breitenbach and Kränzlin 1984; Breitenbach and Kränzlin 1986; Gilbertson and Ryvarden 1986a, 1986b; Imazeki and Hongo 1989; Breitenbach and Kränzlin 1991; Ryvarden and Gilbertson 1993) and Index Fungorum system (www.indexfungorum.org). Genomic DNA was extracted from fruiting body (Rogers and Bendich 1994), and the ITS (Internal Transcribed Spacer) (Gardes and Bruns 1993) and LSU (Large SubUnit) regions were amplified by PCR. The amplified products were sequenced, and the results were BLAST-searched on the NCBI GenBank to find sequences with high similarity.

Collection plots of wood decay fungi by forest type for cluster analysis

For the quantitative cluster analysis of wood decay fungi by forest type, total 30 collection plots, which were 10 plots for each forest type (broad-leaved, coniferous, and mixed forest) and 20×20 m in size, were established in Odaesan, Bohyeonsan, Chilbosan, Tonggosan and Munsusan. For each plot, dominant tree species, DBH (diameter at breast height), tree density, elevation, and site characters of collection plots were recorded and collection of fruiting bodies was conducted once a week from June to September (Table 2).

Species diversity, Evenness and similarity analysis

Species diversity index (H') was analysed by Shannon-Wiener formula, $H' = -\Sigma Pi \log Pi$ (here, Pi is the proportion of species i relative to the number of species) (Magurran 2004). Species evenness index (J') was calculated by the formula, J'=H/Hmax (here, Hmax=logS, S is the total number of species) (Pielou 1966). Species similarity (QS) was analysed by the formula, QS=2C/(S1+S2) (here, S1 is the number of species surveyed in Group 1, S2 is the number of species surveyed in Group 2, C is the number of species surveyed in both Groups 1 and 2) (Brower and Zar 1977).

Results and Discussion

A total of 1,503 wood decay fungi samples were collected from various locations in Korea from 2011 to 2013. Wood decay fungi were identified and classified into 2 phyla, 7 classes, 19 orders, 159 genera, and 365 species. Among these, 188 specimens belonged to the genus *Trametes*, which is the dominant genus (12.5% of species), followed by the genera *Sterum*, *Mycena*, *Pluteus*, *Daldinia*, *Phellinus*, and *Ganoderma* (Table 3). The dominant species was *Trametes versicolor* (L.) Lloyd, for which 175 specimens were identified, followed by the species *Stereum subtomentosum*, *Stereum peculiar*, *Daldinia concentrica*, *Microporus vernicipes*, *Ganoderma applanatum*, *Daedalea dickinsii*, *Cyptotrama asprata*, *Armillaria mellea*, *Gymnopilus liquiritiae* (Table 3, Fig. 2).

Diversity and distribution of wood decay fungi by region were analyzed by grouping four regions located at the same latitude into the same category, i.e., Gangwon/Gyeonggi, Gyeongsang, Jeonla and Chungcheong. The Gangwon/

Table 3. Diversity and frequency of wood decay fungi

Genus			Species		
Total No.	Common genus	No. of specimens (%)	Total No.	Common species	No. of specimens (%)
159	*Trametes*	188 (12.5%)	365	*Trametes versicolor*	175 (11.6%)
	Stereum	166 (7.7%)		*Stereum subtomentosum*	60 (4.0%)
	Mycena	75 (5.0%)		*Stereum peculiar*	32 (2.1%)
	Pluteus	31 (2.1%)		*Daldinia concentrica*	30 (2.0%)
	Daldinia	30 (2.0%)		*Microporus vernicipes*	26 (1.7%)
	Phellinus	30 (2.0%)		*Ganoderma applanatum*	26 (1.7%)
	Ganoderma	30 (2.0%)		*Daedalea dickinsii*	25 (1.7%)
	Others	1,003 (66.7%)		*Cyptotrama asprata*	25 (1.7%)
				Armillaria mellea	22 (1.5%)
				Gymnopilus liquiritiae	22 (1.5%)
				Other	1,060 (70.5%)

Gyeonggi provinces, where 228 species in 118 genera were collected, had the highest species diversity, followed by Chungcheong, Gyeongsang, and Jeonla provinces (Table 4). *Trametes* was confirmed as the dominant genus in all regions except Jeonla province, but the most dominant species was *T. versicolor* in all regions. The collection percent of *T. versicolor* in Chungcheong and Gyeongsang provinces was higher than in other regions. Fruiting bodies of *T. versicolor* have a hard and leathery surface, which confers tolerance to temperature changes, moisture and attack by disintegrating microorganisms. These characteristics allow fruiting bodies to remain active relatively longer than other genera or species.

Trametes versicolor | *Stereum subtomentosum* | *Stereum peculiare*

Daldinia concentrica | *Microporus vernicipes* | *Ganoderma applanatum*

Daedalea dickinsii | *Cyptotrama asprata* | *Armillaria mellea*

Gymnopilus liquiritiae

Fig. 2. Common species of wood decay fungi developing fruiting bodies on wood.

Table 4. Diversity and frequency of wood decay fungi by region

Region (Province)	Genus			Species		
	No.	Common genus	No. of specimens (%)	No.	Common species	No. of specimens (%)
Gangwon & Gyeonggi	118	*Trametes*	63 (10.5%)	228	*Trametes versicolor*	53 (8.8%)
		Mycena	50 (8.3%)		*Ganoderma applanatum*	20 (3.3%)
		Stereum	30 (5.0%)		*Stereum subtomentosus*	17 (2.8%)
		Ganoderma	20 (3.3%)		*Oudemansiella mucida*	15 (2.5%)
		Oudemansiella	17 (2.8%)		*Daidinia concentrica*	11 (1.8%)
		Others	419 (69.9%)		Others	483 (80.6%)
Chungcheong	97	*Trametes*	67 (14.5%)	160	*Trametes versicolor*	65 (14.1%)
		Stereum	45 (9.7%)		*Stereum subtomentosus*	21 (4.5%)
		Daedaleopsis	15 (3.2%)		*Stereum peculiar*	17 (3.7%)
		Daedalea	12 (2.6%)		*Daedaleopsis tricolor*	13 (2.8%)
		Armillaria	11 (2.4%)		*Cyptotrama asprata*	11 (2.4%)
		Others	312 (67.5%)		Others	335 (72.5%)
Gyeongsang	94	*Trametes*	49 (14.2%)	134	*Trametes versicolor*	49 (14.2%)
		Stereum	35 (10.2%)		*Stereum subtomentosus*	22 (6.4%)
		Pluteus	12 (3.5%)		*Cyptotrama asprata*	10 (2.9%)
		Irpex	9 (2.6%)		*Stereum peculiar*	9 (2.6%)
		Daldinia	8 (2.3%)		*Daidinia concentrica*	8 (2.3%)
		Others	231 (67.2%)		Others	246 (71.5%)
Jeolla	51	*Mycena*	10 (10.2%)	66	*Trametes versicolor*	8 (8.2%)
		Trametes	9 (9.2%)		*Mycena haematopus*	5 (5.1%)
		Stereum	6 (6.1%)		*Cyptotrama asprata*	4 (4.1%)
		Cyptotrama	4 (4.1%)		*Stereum peculiar*	3 (3.1%)
		Pluteus	3 (3.1%)		*Microporus vernicipes*	3 (3.1%)
		Others	66 (67.3%)		Others	75 (76.5%)

Diversity and distribution of wood decay fungi by forest type showed that the broad-leaved forest had the highest species diversity with 273 species in 129 genera, while the coniferous forest had the lowest with 122 species in 85 genera. *Trametes* and *T. versicolor* were the dominant genus and species, respectively, in all forest types (Table 5). Among 1,503 specimens collected, 46 specimens, which were classified as 19 genera 22 species, were collected from non-forest areas such as roadside or landscape area. In non-forest area, the dominant genus and species were *Trametes* and *T. versicolor* as it were in the forest area.

Diversity and distribution of wood decay fungi by elevation showed the highest species diversity with 227 species in 123 genera at an elevation of 501-1,000 m. *Trametes* was the dominant genus in the below 1,000 m, while *Mycena* was dominant in the above 1,001 m. *T. versicolor* was the dominant species in all ranges of elevation (Table 6).

Diversity and distribution of wood decay fungi by collection period showed the lowest species diversity with 19 species in 16 genera in April to May, gradually increasing over time, with the highest diversity (209 species in 107 genera) in September. *Trametes* and *T. versicolor* were the dominant genus and species, respectively, in all periods (Table 7). *T. versicolor* could be collected from April to October, since *Trametes* species have the wide range (15-35°C) of growth temperature compared to other wood decay fungi (Jang 2005).

Diversity and distribution of wood decay fungi in relation to host trees showed the highest species diversity (333 species in 143 genera) in broad-leaved trees. Most of the host tree were *Quercus* spp., *Acer* spp., *Betula* spp., and *Prunus* spp. *Trametes* and *T. versicolor* were the dominant genus and species, respectively. The lowest species diversity was shown in coniferous trees with 87 species in 66 genera. The highest diversity in coniferous trees was shown in *Pinus densiflora* with 42 species in 33 genera, followed by *Abies holophylla*, *Larix kaempferi*, *Pinus koraiensis* and other coniferous

Table 5. Diversity and frequency of wood decay fungi by forest type

Forest type	Genus			Species		
	No.	Common genus	No. of specimens (%)	No.	Common species	No. of specimens (%)
Broad-leaved forest	129	*Trametes*	109 (12.3%)	273	*Trametes versicolor*	103 (11.6%)
		Stereum	76 (8.6%)		*Stereum subtomentosus*	40 (4.5%)
		Mycena	55 (6.2%)		*Stereum peculiar*	21 (2.4%)
		Phellinus	23 (2.6%)		*Ganoderma applanatum*	20 (2.3%)
		Ganoderma	22 (2.5%)		*Daidinia concentrica*	17 (1.9%)
		Others	603 (67.9%)		Others	687 (77.4%)
Coniferous forest	85	*Trametes*	23 (10.3%)	122	*Trametes versicolor*	22 (9.8%)
		Gymnopilus	10 (4.5%)		*Gymnopilus liquiritiae*	10 (4.5%)
		Stereum	10 (4.5%)		*Armillaria mellea*	7 (3.7%)
		Mycena	8 (3.6%)		*Stereum subtomentosus*	6 (2.7%)
		Armillaria	7 (3.1%)		*Cyptotrama asprata*	6 (2.7%)
		Others	166 (74.1%)		Others	173 (77.2%)
Mixed	93	*Trametes*	42 (12.2%)	145	*Trametes versicolor*	42 (12.2%)
		Stereum	30 (8.7%)		*Stereum subtomentosus*	14 (4.1%)
		Mycena	12 (3.5%)		*Cyptotrama asprata*	9 (2.6%)
		Daldinia	9 (2.6%)		*Daidinia concentrica*	9 (2.6%)
		Armillaria	9 (2.6%)		*Stereum hirsutum*	8 (2.3%)
		Others	243 (70.4%)		Others	263 (76.2%)

Table 6. Diversity and frequency of wood decay fungi by elevation

Elevation (m)	Genus			Species		
	No.	Common genus	No. of specimens (%)	No.	Common species	No. of specimens (%)
Below 500	108	*Trametes*	106 (18.0%)	188	*Trametes versicolor*	89 (15.1%)
		Stereum	54 (9.2%)		*Stereum subtomentosus*	27 (4.6%)
		Daedaleopsis	18 (3.1%)		*Stereum peculiar*	19 (3.2%)
		Irpex	16 (2.7%)		*Daidinia concentrica*	15 (2.5%)
		Microporus	14 (2.4%)		*Daedaleopsis tricolor*	14 (2.4%)
		Others	382 (64.7%)		Others	426 (72.2%)
501-1,000	123	*Trametes*	80 (11.5%)	227	*Trametes versicolor*	76 (9.8%)
		Stereum	56 (8.0%)		*Stereum subtomentosus*	30 (4.5%)
		Mycena	37 (5.3%)		*Ganoderma applanatum*	17 (2.4%)
		Pluteus	22 (3.2%)		*Cyptotrama asprata*	14 (2.0%)
		Ganoderma	17 (2.4%)		*Mycena haematopus*	13 (1.9%)
		Others	485 (69.6%)		Others	547 (78.5%)
Over 1,001	83	*Mycena*	28 (13.0%)	128	*Trametes versicolor*	10 (4.6%)
		Trametes	12 (5.6%)		*Ganoderma applanatum*	8 (3.7%)
		Oudemansiella	8 (3.7%)		*Mycena galericulata*	7 (3.2%)
		Ganoderma	8 (3.7%)		*Oudemansiella mucida*	6 (2.8%)
		Stereum	6 (2.8%)		*Daedalea dickinsii*	5 (2.3%)
		Others	154 (71.3%)		Others	180 (83.3%)

trees. *Gymnopilus* and *G. liquiritiae* were the dominant genus and species, respectively, in coniferous trees (Table 8).

Species of wood decay fungi distributed only in coniferous and broad-leaved forests were 32 and 278 species, respectively, while the number of species distributed in both forests was 55 species (Fig. 3). This suggests that coniferous trees have a de-

Table 7. Diversity and frequency of wood decay fungi by collection period

Month	Genus			Species		
	No.	Common genus	No. of specimens (%)	No.	Common species	No. of specimens (%)
Apr. & May	16	*Trametes*	13 (32.5%)	19	*Trametes versicolor*	13 (32.5%)
		Stereum	4 (10.0%)		*Lenzites betulina*	3 (7.5%)
		Lenzites	5 (12.5%)		*Stereum hirsutum*	2 (5.0%)
		Others	18 (45.0%)		Others	22 (55.0%)
Jun.	49	*Trametes*	13 (10.0%)	71	*Trametes versicolor*	12 (9.2%)
		Mycena	13 (10.0%)		*Cyptotrama asprata*	10 (4.7%)
		Cyptotrama	10 (7.7%)		*Ganoderma applanatum*	4 (3.0%)
		Others	94 (72.3%)		Others	104 (80.0%)
Jul.	78	*Trametes*	17 (7.3%)	121	*Trametes versicolor*	15 (6.5%)
		Mycena	17 (7.3%)		*Stereum subtomentosus*	11 (4.7%)
		Stereum	17 (7.3%)		*Ganoderma applanatum*	7 (3.0%)
		Others	181 (78.0%)		Others	99 (85.8%)
Aug.	96	*Trametes*	59 (7.3%)	147	*Trametes versicolor*	56 (13.5%)
		Stereum	44 (7.3%)		*Stereum subtomentosus*	22 (5.3%)
		Daldinia	13 (7.3%)		*Stereum peculiar*	16 (3.8%)
		Others	300 (78.0%)		Others	322 (77.4%)
Sep.	107	*Trametes*	63 (11.3%)	209	*Trametes versicolor*	57 (10.2%)
		Mycena	34 (6.1%)		*Armillaria mellea*	19 (3.4%)
		Stereum	33 (5.9%)		*Stereum subtomentosus*	15 (2.7%)
		Others	430 (76.8%)		Others	469 (83.8%)
Oct.	50	*Trametes*	23 (18.4%)	62	*Trametes versicolor*	22 (17.6%)
		Stereum	13 (10.4%)		*Stereum subtomentosus*	9 (7.2%)
		Fomitopsis	5 (4.0%)		*Daedaleopsis tricolor*	5 (4.0%)
		Others	84 (67.2%)		Others	89 (71.2%)

Table 8. Diversity and frequency of wood decay fungi by host tree

Host tree	Genus			Species		
	No.	Common genus	No. of specimens (%)	No.	Common species	No. of specimens (%)
Broad-leaved	143	*Trametes*	117 (13.2%)	333	*Trametes versicolor*	168 (12.5%)
		Stereum	116 (8.7%)		*Stereum subtomentosus*	60 (4.5%)
		Mycena	69 (5.1%)		*Stereum peculiar*	32 (2.4%)
		Daldinia	30 (2.2%)		*Daidinia concentrica*	30 (2.2%)
		Phellinus	29 (2.2%)		*Microporus vernicipes*	26 (1.9%)
		Others	920 (68.6%)		Others	1,025 (76.4%)
Coniferous	66	*Gymnopilus*	16 (10.1%)	87	*Gymnopilus liquiritiae*	16 (10.1%)
		Trametes	8 (5.1%)		*Hymenochaete yasudae*	7 (4.4%)
		Hymenochaete	8 (5.1%)		*Xeromphalina campanella*	6 (3.8%)
		Xeromphalina	7 (4.4%)		*Fomitopsis pinicola*	6 (3.8%)
		Fomitopsis	6 (3.8%)		*Hypholoma fasciculare*	6 (3.8%)
		Others	113 (71.5%)		*Trametes versicolor*	6 (3.8%)
					Others	111 (70.3%)

fense mechanism against wood decay fungi by producing resinous exudates, which inhibit the growth of fungi as well as other microorganisms inhabiting on trees. Wood decay fungi grew and developed fruiting bodies at various parts of tree. On the trunk, 251 species in 119 genera were surveyed, while 182 species in103 genera were recorded on twigs and branches. Most of the wood decay fungi collected from trunks and branches were hard and leather like, but the flesh of the fruiting bodies such as *Armillaria mellea* and *Hypholoma fasciculare* from the stumps were soft. The dominant species on trunks, branches, and stumps were *T. versicolor* (Table 9).

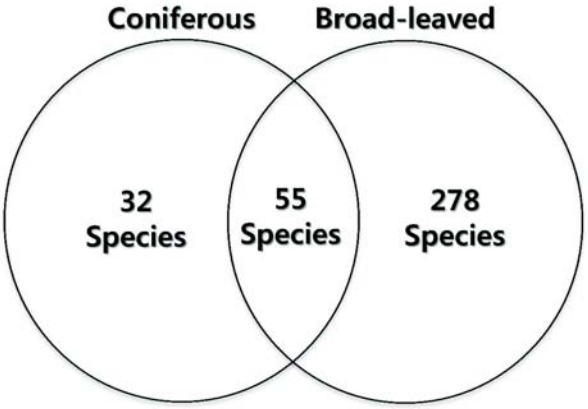

Fig. 3. Species diversity of wood decay fungi by host tree type.

Community analyses of wood decay fungi by forest types in 30 survey plots, which were composed of 10 plots for each forest type, showed that wood decay fungi comprised 26.6% of the higher fungi collected. The rates of wood decay fungi were 34.6%, 24.2% and 21.0% in mixed, broad-leaved and coniferous forests, respectively. The number of species was 65, 50, and 43, respectively. The species diversity index was the highest at 1.80 in mixed forest, followed by broad-leaved (1.62) and coniferous (1.60), while the evenness index was the highest as 0.98 in the coniferous forests, followed by broad-leaved and mixed forests at 0.95 (Table 10). It is likely that the higher diversity of wood decay fungi in the mixed forests compared to coniferous or broad-leaved forests is due to the high diversity of tree species associated. The similarity index was the highest (0.37) between the broad-leaved and mixed forests followed by coniferous and broad-leaved forests (0.33) and between the mixed and coniferous forest (0.30) (Table 11).

In this study, 1,503 fruiting bodies of wood decay fungi collected from different locations throughout South Korea were identified as 365 species in 159 genera, and the most

Table 9. Diversity and frequency of wood decay fungi by the part of host tree

Parts of host tree	Genus			Species		
	No.	Common genus	No. of specimens (%)	No.	Common species	No. of specimens (%)
Trunk	119	*Trametes*	102 (13.3%)	251	*Trametes versicolor*	94 (12.3%)
		Stereum	49 (6.4%)		*Stereum subtomentosus*	35 (4.6%)
		Mycena	45 (5.9%)		*Ganoderma applanatum*	24 (3.1%)
		Ganoderma	25 (3.3%)		*Daedalea dickinsii*	19 (2.5%)
		Daedalea	21 (2.7%)		*Daidinia concentrica*	18 (2.3%)
		Others	525 (68.4%)		Others	577 (75.2%)
Branch	103	*Stereum*	66 (12.5%)	182	*Trametes versicolor*	37 (7.0%)
		Trametes	38 (7.2%)		*Stereum peculiare*	29 (5.5%)
		Mycena	22 (4.2%)		*Stereum subtomentosus*	25 (4.7%)
		Microporus	20 (3.8%)		*Microporus vernicipes*	20 (3.8%)
		Crustodontia	17 (3.2%)		*Cyptotrama asprata*	17 (3.2%)
		Others	365 (69.1%)		Others	400 (75.8%)
Stump	68	*Trametes*	45 (22.1%)	90	*Trametes versicolor*	43 (21.1%)
		Armillaria	16 (7.8%)		*Armillaria mellea*	15 (7.4%)
		Hypholoma	11 (5.4%)		*Hypholoma fasciculare*	11 (5.4%)
		Lenzites	8 (3.9%)		*Lenzites betulina*	8 (3.9%)
		Mycena	8 (3.9%)		*Irpex consors*	5 (2.5%)
		Others	154 (56.9%)		Others	122 (59.8%)

Table 10. Species diversity indices of the wood decay fungi by forest type

	Broad-leaved	Coniferous	Mixed
H'	1.62	1.60	1.80
J'	0.95	0.98	0.95

Table 11. Species similarity indices by forest type

	Broad-leaved	Coniferous	Mixed
Broad-leaved	-	0.33	0.37
Coniferous	-	-	0.30

dominant genus and species were *Trametes* and *T. versicolor*, respectively. *T. versicolor* were confirmed as the most dominant species in all criteria (regions, elevations, forest types, periods, and parts of host tree). This may be due to the ecological characteristics of *T. versicolor*, which is a wood decay fungus that produces fruiting bodies from the spring to the fall, maintaining shape and surviving for a long period, and having a wide host range of the coniferous as well as the broad-leaved trees. It is expected that the results obtained from this research will provide basic information for the ecological management of forests as well as the related research fields including decay patterns and protection of forests from wood decay fungi.

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (NRF 2011-0014303).

References

Breitenbach J, Kränzlin F. 1984. Fungi of Switzerland Vol. 1. Ascomycota. Verlag Edition Mykologia, Luzern.

Breitenbach J, Kränzlin F. 1986. Fungi of Switzerland Vol. 2. Nongilled Fungi. Verlag Edition Mykologia, Luzern.

Breitenbach J, Kränzlin F. 1991. Fungi of Switzerland. Vol. 3. Boletes and agarics, Part 1. Verlag Edition Mykologia, Luzern.

Brower JE, Zar JH. 1977. Field and laboratory methods for general ecology. W.C. Brown Co., Dubque, Iowa.

Erikssn J. 1958. Studies in the Heterobasidiomycetes and Homobasidiomycetes-Aphyllophorales of Muddus National Park in North Sweden. Lundequistska Bokhandeln, Uppsala, 172 pp.

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes--application to the identification of mycorrhizae and rusts. Mol Ecol 2: 113-118.

Gilbertson RL. 1980. Wood-rotting fungi of North America. Mycologia 72: 1-49.

Gilbertson RL, Ryvarden L. 1986a. North American polypores. Vol. 1. *Abortiporus - Lindtneria*. Fungiflora, Oslo.

Gilbertson RL, Ryvarden L. 1986b. North American polypores. Vol. 2. *Megasporoporia- Wrightoporia*. Fungiflora, Oslo.

Gu BJ, Kim MS, Kim YM, Kim SW, Choi WH, Lee MH, Cho HJ, Lee TS. 2012. Decolorization of synthetic dyes and ligninolytic enzymes production by white rot fungi. Korean J Mycol 40: 98-103.

Imazeki R, Hongo T. 1989. Colored illustrations of mushrooms of Japan. Hoikusha Publishing Co., Osaka.

Index Fungorum system. www.indexfungorum.org.

Jang GY. 2005. Studies on physiological characteristics and environmental function of indigenous and introduced ligno-degrading basidiomycota. MS thesis. Kangwon National University, Chuncheon, Korea.

Jung HS. 1993. Floral studies on Korean wood-rotting fungi (I) -on the flora of the Aphyllophorales (Basidiomycotina)-. Korean J Mycol 21: 51-63.

Jung HS. 1994. Floral Studies on Korean Wood-rotting Fungi (II) -on the flora of the Aphyllophorales (Basidiomycotina)-. Korean J Mycol 22: 62-99.

Kim HY, Lee YE, Choi HT, Song HG. 1995. Decolorization of dyes by white rot fungi. Korean J Mycol 23: 298-304.

Kim NK, Park JY, Park MS, Lee H, Cho HJ, Eimes JA, Kim C, Lim YW. 2016. Five new wood decay fungi (Polyporales and Hymenochaetales) in Korea. Mycobiology 44: 146-154.

Lee YS, Lim YW, Kim JJ, Yun HY, Kim C, Park JY. 2015. National list of species of Korea: basidiomycota. National Institute of Biological Resources, Incheon.

Magurran AE. 2004. Meausuring biological diversity. Blackwell Pub, Malden.

Manion PD. 1981. Tree disease concepts. Prentice Hall Inc., Englewood Cliff.

Min KH, Kim JY, Yoon YH, Park H. 2006. Development of soil conditioner using wood decay fungus and forest residue. J Korean Wood Sci Technol 34: 61-67.

Pielou EC. 1966. The measurement of diversity in different types of biological collections. J Theoret Biol 13: 131-144.

Rogers SO, Bendich AJ. 1994. Extraction of total cellular DNA from plants, algae and fungi. In: Plant molecular biology manual (Gelvin SB, Schilperoort RA, eds). 2nd ed. Kluwer Academic Press, Dordrecht, pp 183-190.

Ryvarden L, Gilbertson RL. 1993. European polypores Vol: 1-2, Synopsis Fungorum 6. Fungiflora, Oslo.

Stuntz DE. 1973. How to identify mushrooms to genus IV: keys to families and genera. Mad River Press Inc, Eureka, CA.

Wasser SP. 2002. dicinal mushrooms as a source of antitumor and immunomodulating polysaccharides. Appl Microbiol Biotechnol 60: 258-274.