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Research Article

Diversity of Wood-Inhabiting Polyporoid and Corticioid Fungi in Odaesan National Park, Korea

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Abstract Polyporoid and corticioid fungi are among the most important wood-decay fungi. Not only do they contribute to nutrient cycling by decomposing wood debris, but they are also valuable sources for natural products. Polyporoid and corticioid wood-inhabiting fungi were investigated in Odaesan National Park. Fruit bodies were collected and identified based on morphological and molecular analyses using 28S and internal transcribed spacer regions of DNA sequences. As a result, a total of 149 species, 69 genera, 22 families, and 11 orders were recognized. Half (74 species) of the species were polypores, and the other half (75 species) were corticioid fungi. Most of the species belonged to Polyporales (92 species) followed by Hymenochaetales (33 species) and Russulales (11 species). At the genus level, a high number of species was observed from *Steccherinum*, *Hyphodontia*, *Phanerochaete*, *Postia*, and *Trametes*. Concerning distribution, almost all the species could be found below 1,000 m, and only 20% of the species were observed from above 1,000 m. *Stereum subtomentosum*, *Trametes versicolor*, *T. hirsuta*, *T. pubescens*, *Bjerkandera adusta*, and *Ganoderma applanatum* had wide distribution areas. Deciduous wood was the preferred substrate for the collected species. Sixty-three species were new to this region, and 21 species were new to Korea, of which 17 species were described and illustrated.

Keywords Corticioid fungi, ITS, nLSU, Polyporoid fungi, Taxonomy

Wood-inhabiting polyporoid and corticioid fungi are taxonomically diverse groups of fungi. They are the major wood decomposers causing brown and white rots of wood decay, and they play important roles in nutrient cycling and soil formation in forest ecosystems [1]. Although some corticioid species are mycorrhizal and not involved in wood decay, they help contribute to forest health [2].

Polyporoid and corticioid fungi are important sources of natural products. They produce a number of biologically active compounds, and some of them have long been used in medicine [3]. In addition, white rot fungi have the ability to produce diverse ligninolytic enzymes, which have broad substrate specificities, so they could be used in various biotechnological applications, including biopulping, wastewater treatment, and bioremediation of polycyclic aromatic hydrocarbons, 2,4,6-trinitrotoluene (TNT), and chlorinated hydrocarbons [4, 5].

In Europe, many wood-decay fungi are endangered due to the forestry in the 20th century [6]. In Finland, there are 119 fungi belonging to Aphyllophorales, which are red-listed [7]. According to Magnusson [8], about 25% of the 750 polyporoid and corticioid fungi are red-listed in Sweden. Due to their importance in ecosystems and the need for conservation, wood-decay fungi have been studied intensively, particularly the relationships between species diversity and the amount of available wood substrates and between species diversity and wood decomposition rate (functioning) [1]. Since each species has a different host preference, it is important to keep the full size range of wood debris in forests to support high diversity [1, 9].

In Korea, diversity studies regarding indigenous species

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are ongoing. Currently, about 200 polyporoid and 180 corticioid fungi have been reported [10]. Among them, about 64% have been recorded in national parks, according to the Korea National Park Research Institute [11]. National parks located in the Taebaek Mountain Range have especially high biodiversity, and three species of wood-decay fungi—*Cerrena aurantiopora*, *Fomitopsis incarnatus*, and *Irpex hydnoides*—are described based on the samples collected from the regions [12-14].

For the identification of polyporoid and corticioid fungi, morphological features are examined and compared to those of known species. The molecular identification method of fungal fruiting bodies with 28S (large subunit; LSU) or internal transcribed spacer (ITS) regions of rDNA sequences has also been used to confirm the morphological identification results in recent works due to the high morphological similarities among closely related species [13, 15-24]. When nucleotide sequences are generated from the morphologically identified species, the molecular identification method can be used solely when the collected specimens are not suitable for morphological analysis. This method is widely used when fungal strains are identified [25-30]. With the large number of LSU and ITS sequences of polyporoid and corticioid fungi available in public databases such as GenBank, it is possible to identify previously unreported fungal fruit bodies in the study sites.

Odaesan (Mt. Odae) National Park is one of the national parks located in the Taebaek Mountain Range, and ca. 91 species of polyporoid and corticioid wood-inhabiting fungi have been reported in this area [14, 24, 31-35]. However, only three species—*Irpex hydnoides*, *Polyporus brumalis*, and *Polyporus tuberaster*—were identified with the support of molecular analysis [14, 24]. To better understand the diversity of polyporoid and corticioid wood-inhabiting fungi, fruit bodies were collected in this region and identified using a combination of morphological and molecular methods.

MATERIALS AND METHODS

Sampling. Wood-inhabiting polyporoid and corticioid fungi were collected 22 times (once in June 2008, once in August 2011, four times in October and November 2012, and 16 times in April to October 2013) from Mt. Odae in Odaesan National Park. The collection was conducted along the mountain trails that stretch from the main entrance to the Birobong, Sangwangbong, Durobong, and

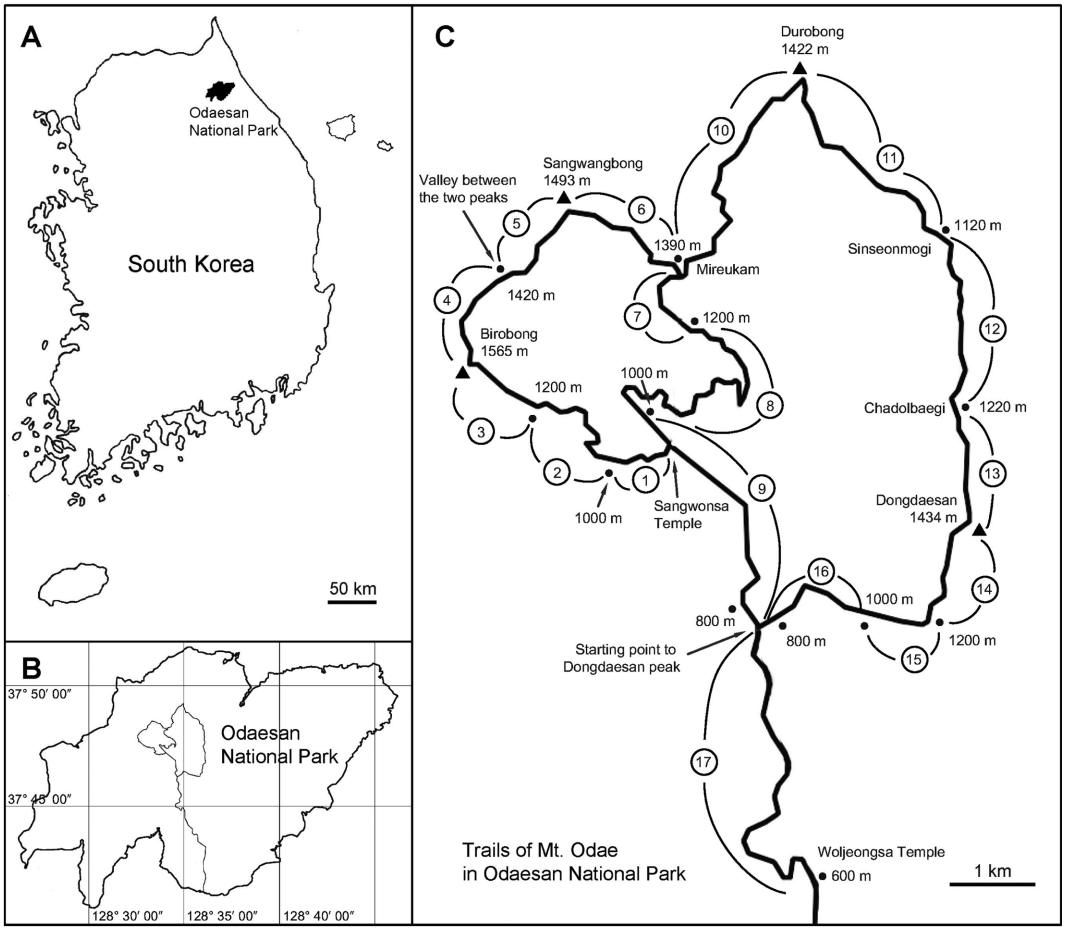


Fig. 1. A, Location of Odaesan (Mt. Odae) National Park in Korea; B, Latitudes and longitudes of Odaesan National Park and the trails of Mt. Odae surveyed in this study; C, Detailed description of the study area with the 17 divided study segments.

Table 1. List of wood-inhabiting polyporoid and corticioid fungi in Odaesan National Park

Classification				GenBank accesion No.		Substrates	Occurrences	
Order or above	Family	Genus	Species	ITS[a]	LSU[a]		Seg[b]	No.[c]
Fungi								
Basidiomycota								
Agaricomycotina								
Agaricomycetes								
Agaricales	**Cyphellaceae**	***Gloeostereum***	*Gloeostereum incarnatum*	KJ668540[d]	KJ668393	*Abies holophylla*	9	1
		Granulobasidium	*Granulobasidium vellereum*	KJ668538	KJ668391	Deciduous wood	9	1
	Physalacriaceae	***Cylindrobasidium***	*Cylindrobasidium laeve*	KJ652553	KJ668411	*Acer* and other deciduous wood	9, 16, 17	5
	Porotheleaceae	***Porotheleum***	*Porotheleum fimbriatum*	KJ668472	KJ668324	Wood	9	1
Auriculariales	**Auriculariaceae**		*Auriculariaceae* sp. 1	KJ668532	KJ668384	Deciduous wood	9,17	2
			Auriculariaceae sp. 2	KJ668531	KJ668383	Deciduous wood	9	1
Boletales	**Coniophoraceae**	***Coniophora***	*Coniophora* sp.	KJ668560	KJ668414	Wood	9	1
Cantharellales	**Botryobasidiaceae**	***Botryobasidium***	*Botryobasidium subcoronatum*	KJ668569	KJ668424	Deciduous wood	16	1
Corticiales	**Corticiaceae**	***Corticium***	*Corticium roseocarneum*	KJ668559	KJ668413	Deciduous wood	(3), 17	1
		Corticium	*Corticium roseum* Pers.	KJ668558[d]	KJ668412	*Abies holophylla*	9	1
Gomphales	**Lentariaceae**	***Hydnocristella***	*Hydnocristella himantia*	KJ668530	KJ668382	Deciduous wood	17	1
Hymenochaetales	**Hymenochaetaceae**	***Botryodontia***	*Botryodontia millavensis*	KJ668501	KJ668423	Deciduous wood	16	1
		Fomitiporia	*Fomitiporia punctata*	KJ668549	KJ668402	Deciduous wood	9, 17	4
		Fuscoporia	*Fuscoporia ferrea*	KJ668546	KJ668399	Deciduous wood	9	3
			Fuscoporia ferruginosa	KJ668545	KJ668398	Deciduous wood	16, 17	4
			Fuscoporia gilva	KJ668544	KJ668397	Deciduous wood	16, 17	5
			Fuscoporia sp.	KJ668543	KJ668396	Deciduous wood	9	2
		Hymenochaete	*Hymenochaete corrugata*	KJ668528	KJ668380	*Acer* and other deciduous wood	9, (12), 17	9
			Hymenochaete intricata	KJ668527	KJ668379	*Querqus* and other deciduous wood	(4), 9, 17	7
			Hymenochaete sp.	KJ668526	KJ668378	Wood	17	1
			Hymenochaete yasudae	KJ668525[d]	KJ668377	*Abies holophylla* and deciduous wood	9, 17	5
		Inonotus	*Inonotus baumii*	KJ668511	KJ668363	Deciduous wood	(9), 17	2
		Phellinus	*Phellinus laevigatus*	KJ668486	KJ668339	*Betula platyphylla* var. *japonica* and other deciduous wood	(9), 16	2
			Phellinus tuberculosus	KJ668485	KJ668338	Deciduous wood	2, 5, 9, 17	5
	Rickenellaceae	***Peniophorella***	*Peniophorella odontiiformis*	KJ668497	KJ668350	Deciduous wood	17	1
			Peniophorella praetermissa	KJ668523	KJ668375	Deciduous wood	9, 17	4
		Resinicium	*Resinicium pinicola*	KJ668463	KJ668316	Deciduous wood	9	2
			Resinicium rimulosum	KJ668464	KJ668315	Wood	9	1
	Schizoporaceae	***Basidioradulum***	*Basidioradulum radula*	KJ668571	KJ668426	Deciduous wood	9, (14), 16, 17	6

Table 1. Continued

Classification				GenBank accesion No.		Substrates	Occurrences	
Order or above	Family	Genus	Species	ITS[a]	LSU[a]		Seg[b]	No.[c]
		Hyphodontia	*Hyphodontia crustosa*	KJ668519	KJ668371	Deciduous wood	9	3
			Hyphodontia nespori	KJ668518	KJ668370	Wood	17	1
			Hyphodontia sp. 1	KJ668517	KJ668369	Deciduous wood	17	1
			Hyphodontia sp. 2	KJ668516	KJ668368	Deciduous wood	1, 9, 16	6
			Hyphodontia sp. 3	KJ668515	KJ668367	Deciduous wood	16, 17	2
			Hyphodontia subalutacea	KJ668514	KJ668366	Deciduous wood	9	1
			Hyphodontia tropica	KJ668513	KJ668365	Deciduous wood	9, (11), 12, 16, 17	5
		Oxyporus	*Oxyporus corticola*	KJ668502	KJ668354	Deciduous wood	17	1
			Oxyporus populinus	KJ668500	KJ668353	Deciduous wood	11	1
		Schizopora	*Schizopora flavipora*	KJ668462	KJ668314	*Querqus* and other deciduous wood	9, 16, 17	6
	Incertae sedis	***Fibricium***	*Fibricium rude*	KJ668552	KJ668405	*Abies holophylla*	17	1
			Fibricium sp.	KJ668551	KJ668404	Deciduous wood	16	1
		Trichaptum	*Trichaptum abietinum*	KJ668437[d]	KJ668289	*Abies holophylla*	17	1
			Trichaptum fusco-violaceum	KJ668436[d]	KJ668288	*Abies holophylla*, *Prunus sargentii*, and other coniferous and deciduous wood	9, 16, 17	11
			Hymenochaetales sp.	KJ668529[d]	KJ668381	*Abies holophylla*	9, 16, 17	5
Polyporales	**Fomitopsidaceae**	***Antrodia***	*Antrodia albida*	KJ668574	KJ668429	Deciduous wood	9, 17	3
			Antrodia heteromorpha	KJ668573	KJ668428	Deciduous wood	14, 17	3
		Dacryobolus	*Dacryobolus* sp.	KJ668557	KJ668410	Deciduous wood	11	1
		Daedalea	*Daedalea dickinsii*	KJ668556	KJ668409	Deciduous wood	10, 12	2
		Fomitopsis	*Fomitopsis incarnatus*	KJ668548	KJ668401	Deciduous wood	16	1
			Fomitopsis pinicola	KJ668547[d]	KJ668400	*Abies holophylla* and deciduous wood	9, 17	5
		Laetiporus	*Laetiporus* sp.	KJ668507	KJ668359	Deciduous wood	6, 10, 12	3
		Postia	*Postia* sp. 1	KJ668470	KJ668322	Wood	17	1
			Postia sp. 2	KJ668469	KJ668321	Deciduous wood	17	1
			Postia sp. 3	KJ668468	KJ668320	Deciduous wood	17	1
			Postia sp. 4	KJ668467	KJ668319	Taxus cuspidata	3	1
			Postia sp. 5	KJ668466	KJ668318	Deciduous wood	9	1
			Postia sp. 6	KJ668465	KJ668317	Deciduous wood	9	1
			Postia sp. 7	KJ668471	KJ668323	*Abies holophylla* and deciduous wood	17	3
	Ganodermataceae	***Ganoderma***	*Ganoderma applanatum*	KJ668542[d]	KJ668395	*Abies holophylla*, *Betula platyphylla* var. *japonica*, and other deciduous wood	9, 12, 13, 15, 16, 17	14
	Meruliaceae	***Bjerkandera***	*Bjerkandera adusta*	KJ668570	KJ668425	*Pinus*, *Querqus*, and other coniferous and deciduous wood	(3), (7), 9, (11), 16, 17	11
		Gloeoporus	*Gloeoporus dichrous*	KJ668541[d]	KJ668394	*Abies holophylla* and deciduous wood	9, 17	4

Table 1. Continued

Classification				GenBank accesion No.		Substrates	Occurrences	
Order or above	Family	Genus	Species	ITS[a]	LSU[a]		Seg[b]	No.[c]
		Hyphoderma	*Hyphoderma mutatum*	KJ668524	KJ668376	Deciduous wood	9, 17	4
			Hyphoderma setigerum	KJ668521	KJ668373	Coniferous and deciduous wood	9, 17	3
			Hyphoderma sp.	KJ668522	KJ668374	Deciduous wood	9	1
			Hyphoderma transiens	KJ668520	KJ668372	Deciduous wood	17	1
		Hypochnicium	*Hypochnicium karstenii*	KJ668512[d]	KJ668364	*Abies holophylla* and deciduous wood	9, 17	2
		Irpex	*Irpex hydnoides*	KJ668510	KJ668362	*Acer* and other deciduous wood	9, 16, 17	6
			Irpex lacteus (Fr.) Fr.	KJ668509	KJ668361	Coniferous and deciduous wood	9, (10), (13), (15), 16, 17	12
		Junghuhnia	*Junghuhnia nitida*	KJ668508	KJ668360	Deciduous wood	2, 9, 17	7
		Phlebia	*Phlebia acanthocystis*	KJ668484	KJ668337	Deciduous wood	17	1
			Phlebia acerina	KJ668483	KJ668336	Deciduous wood	16	1
			Phlebia chrysocreas	KJ668482	KJ668335	*Ulmus davidiana* var. *japonica* and other deciduous wood	(1), 9, 16, 17	4
			Phlebia tremellosa	KJ668481	KJ668334	Deciduous wood	(6), 9, (17)	1
		Steccherinum	*Steccherinum cf. fimbriatum*	KJ668456	KJ668307	*Larix kaempferi*	17	1
			Steccherinum fimbriatum	KJ668455	KJ668306	Deciduous wood	9	1
			Steccherinum murashkinskyi	KJ668454	KJ668305	Deciduous wood	9, 16, 17	3
			Steccherinum ochraceum	KJ668453	KJ668304	Deciduous wood	9, 17	7
			Steccherinum sp. 1	KJ668452[d]	KJ668303	*Abies holophylla* and deciduous wood	9,17	6
			Steccherinum sp. 2	KJ668451	KJ668302	Deciduous wood	9	1
			Steccherinum sp. 3	KJ668450	KJ668301	Coniferous wood	16	1
			Steccherinum sp. 4	KM279619	KM279618	Wood	9	1
	Phanerochaetaceae	***Antrodiella***	*Antrodiella semisupina*	KJ668572[d]	KJ668427	*Abies holophylla*, *Betula platyphylla* var. *japonica*, and other deciduous wood	9, 16, 17	6
		Byssomerulius	*Byssomerulius corium*	KJ668568	KJ668422	Deciduous wood	17	1
		Ceriporia	*Ceriporia bubalinomarginata*	KJ668567	KJ668421	Deciduous wood	16	1
			Ceriporia pseudocystidiata	KJ668566[d]	KJ668420	*Abies holophylla*	17	1
			Ceriporia purpurea	KJ668565	KJ668419	Deciduous wood	17	1
			Ceriporia sp.	KJ668564[d]	KJ668418	*Abies holophylla*	9, 17	2
			Ceriporia viridans	KJ668563	KJ668417	Deciduous wood	9	1
		Ceriporiopsis	*Ceriporiopsis gilvescens*	KJ668562	KJ668416	Deciduous wood	9, (11)	2
		Phanerochaete	*Phanerochaete laevis*	KJ668493	KJ668345	Wood	9	1
			Phanerochaete sordida	KJ668491	KJ668344	Deciduous wood	17	1
			Phanerochaete sp. 1	KJ668490	KJ668343	Coniferous wood	9	1
			Phanerochaete sp. 2	KJ668489	KJ668342	Deciduous wood	17	2

Table 1. Continued

Classification				GenBank accesion No.		Substrates	Occurrences	
Order or above	Family	Genus	Species	ITS[a]	LSU[a]		Seg[b]	No.[c]
			Phanerochaete sp. 3	KJ668488	KJ668341	Deciduous wood	9, 16	2
			Phanerochaete sp. 4	KJ668492	KJ668346	Deciduous wood	9, 16, 17	12
			Phanerochaete sp. 5	KJ668487[d]	KJ668340	*Abies holophylla* and deciduous wood	9, 16, 17	3
		Porostereum	*Porostereum spadiceum*	KJ668473	KJ668325	Deciduous wood	9, 16, 17	3
	Polyporaceae	***Abundisporus***	*Abundisporus pubertatis*	KJ668575	KJ668430	Wood	17	1
		Cerrena	*Cerrena aurantiopora*	KJ668561	KJ668415	Deciduous wood	9	3
		Daedaleopsis	*Daedaleopsis confragosa*	KJ668555[d]	KJ668408	*Abies holophylla* and deciduous wood	(1), (5), 9, (16), 17	2
		Datronia	*Datronia mollis*	KJ668554	KJ668407	Deciduous wood	17	1
		Dentocorticium	*Dentocorticium ussuricum*	KJ668553	KJ668406	Deciduous wood	9, 16, 17	4
		Fomes	*Fomes fomentarius*	KJ668550	KJ668403	Deciduous wood	9, 17	2
		Haploporus	*Haploporus* cf. *odorus*	KJ668537	KJ668390	Deciduous wood	17	1
			Haploporus cf. *subtrameteus*	KJ668536	KJ668389	Coniferous wood	9	1
			Haploporus papyraceus	KJ668535	KJ668388	Coniferous wood	9, 17	2
			Haploporus sp.	KJ668534	KJ668387	Wood	9	1
		Lenzites	*Lenzites betulina*	KJ668506	KJ668358	Deciduous wood	9, 12, (16)	3
		Lopharia	*Lopharia mirabilis*	KJ668505	KJ668357	Coniferous and deciduous wood	9, 16, 17	5
		Megasporoporiella	*Megasporoporiella subcavernulosa*	KJ668504	KJ668356	Coniferous and deciduous wood	9, (16), 17	4
		Microporus	*Microporus vernicipes*	KJ668503	KJ668355	Deciduous wood	9, 17	7
		Perenniporia	*Perenniporia maackiae*	KJ668496	KJ668349	Deciduous wood	12, 16	2
			Perenniporia narymica	KJ668495	KJ668348	Deciduous wood	17	1
			Perenniporia ohiensis	KJ668494	KJ668347	Wood	9	1
		Polyporus	*Polyporus alveolaris*	KJ668478[d]	KJ668330	*Abies holophylla*	17	1
			Polyporus brumalis	KJ668477	KJ668329	Deciduous wood	17	2
			Polyporus dictyopus	KJ668476	KJ668328	Wood	9	1
			Polyporus sp.	KJ668475	KJ668327	Wood	9	1
			Polyporus tuberaster	KJ668474	KJ668326	Deciduous wood	17	1
		Skeletocutis	*Skeletocutis nivea*	KJ668459	KJ668311	Deciduous wood	9, 17	4
			Skeletocutis sp.	KJ668457	KJ668309	*Larix kaempferi* and deciduous wood	9, 17	3
		Spongipellis	*Spongipellis* sp.	-	KJ668308	Wood	17	1
		Trametes	*Trametes conchifer*	KJ668445	KJ668297	Deciduous wood	9, 17	5
			Trametes hirsuta	KJ668444	KJ668296	Deciduous wood	(1), (6), 9, 10, 12, (16), 17	5
			Trametes pubescens	KJ668443	KJ668295	Deciduous wood	(1), 9, (11), (12), (14), (15), 16	2
				KJ668442	KJ668294	Coniferous and deciduous wood	(5), 9, (15), 16, 17	6

Table 1. Continued

Classification				GenBank accesion No.		Substrates	Occurrences	
Order or above	**Family**	**Genus**	**Species**	**ITS[a]**	**LSU[a]**		**Seg[b]**	**No.[c]**
			Trametes suaveolens	KJ668441	KJ668293	Deciduous wood	9, 17	3
			Trametes trogii	KJ668440	KJ668292	Deciduous wood	17	2
			Trametes versicolor	KJ668439	KJ668291	Deciduous wood	(2), (4), (7), 9, (13), (15), (16), 17	9
		Trametopsis	*Trametopsis cervina*	KJ668438	KJ668290	Deciduous wood	9	1
		Tyromyces	*Tyromyces chioneus*	KJ668435	KJ668287	Wood	17	1
			Polyporaceae sp.	KJ668479	KJ668332	Deciduous wood	17	1
	Xenasmataceae	***Xenasmatella***	*Xenasmatella* sp.	KJ668432	KJ668284	Deciduous wood	9	1
			Xenasmataceae sp.	KJ668480	KJ668333	Deciduous wood	17	1
	Incertae sedis		*Polyporales* sp. 1	-	KJ668331	Wood	17	1
			Polyporales sp. 2	KJ668458	KJ668310	Wood	16	1
Russulales	**Bondarzewiaceae**	***Heterobasidion***	*Heterobasidion orientale*	KF218833[d]	KJ668385	*Abies holophylla* and deciduous wood	9, 17	8
	Lachnocladiaceae		*Lachnocladiaceae* sp. 1	KJ668461	KJ668313	Deciduous wood	17	2
			Lachnocladiaceae sp. 2	KJ668460	KJ668312	Deciduous wood	16	1
			Lachnocladiaceae sp. 3	KJ668434	KJ668286	Wood	9	1
	Peniophoraceae	***Gloiothele***	*Gloiothele* sp.	KJ668539	KJ668392	Coniferous and deciduous wood	9	2
		Peniophora	*Peniophora incarnata*	KJ668499	KJ668352	*Acer* and other deciduous wood	9, 16	3
			Peniophora sp.	KJ668498	KJ668351	Deciduous wood	9	1
	Stereaceae	***Stereum***	*Stereum hirsutum*	KJ668449	KJ668300	Deciduous wood	5, 9, 11, 17	8
			Stereum sanguinolentum	KJ668448	KJ668299	Coniferous wood	17	1
			Stereum subtomentosum	KJ668447	KJ668298	*Acer* and other deciduous wood	(2), (3), (4), (5), 9, 10, (11), (12), (13), (14), (15), 16, 17	13
		Xylobolus	*Xylobolus frustulatus*	KJ668431	KJ668283	Deciduous wood	9, (11), (13)	2
Thelephorales	**Thelephoraceae**	***Tomentella***	*Tomentella* sp.	KJ668446	-	*Larix kaempferi*	9	1
Pucciniomycotina Pucciniomycetes								
Helicobasidiales	**Helicobasidiaceae**	***Helicobasidium***	*Helicobasidium* sp.	KJ668533	KJ668386	Coniferous wood	9	1
			Total					**424**

[a]ITS, internal transcribed spacer; LSU, large subunit.

[b]Numbers indicate 17 divided study segments in Odaesan National Park designated in Fig. 1C. Numbers in parenthesis refer segments where species were observed but not collected.

[c]Total number of the collected specimens in each species.

[d]The sequences retrieved from GenBank, NCBI.

Dongdaesan peaks (Fig. 1). At least two independent surveys were performed for all locations. The study area is huge, and the mountain peaks in the study area are very high, so we did not collect all the observed fruit bodies. Instead, we divided the study area into 17 segments, and if possible, identified and listed the fruit bodies on site. Only the representative specimens of each species were collected for microscopic observation and DNA analysis.

Morphological identification of fruit bodies. Macroscopic and microscopic features of fruit bodies were observed with the dried specimens according to Jang *et al.* [19]. All the measurements of microscopic characteristics were performed with slide preparations mounted in Melzer's reagent. The abbreviations used in this study are as follows: L = mean spore length, W = mean spore width, and Q = the ratio of L/W of the specimens studied. The two nomenclatural sources, Index Fungorum (http://www.indexfungorum.org/) and MycoBank (http://www.mycobank.org/), were referred for the taxonomic information of each species. When there were taxonomic conflicts, recent articles were followed. The studied specimens of polyporoid and corticioid fungi were deposited at the National Institute of Biological Resources, Korea (KB) and the Korea University Culture Collection, Korea (KUC).

Molecular identification of fruit bodies. Genomic DNA extraction was performed from the representative specimens of each species using an AccuPrep Genomic DNA Extraction Kit (Bioneer, Daejeon, Korea). PCR reactions were performed using an AccuPower PCR Premix Kit (Bioneer) for LSU using the primers LR0R/LR3, LR0R/LR5, or LR0R/LR7 [36] and/or for ITS using the primers ITS1F [37]/ITS4 [38], or ITS1/ITS4 [38]. PCR amplification conditions followed Jang *et al.* [17]. PCR products were purified using an AccuPrep PCR Purification Kit (Bioneer). DNA sequencing was performed by the sequencing company, Macrogen Ltd. (Seoul, Korea). When the sequencing failed, purified PCR products were cloned using a TOPO TA Cloning Kit (Invitrogen, Carlsbad, CA, USA) according to

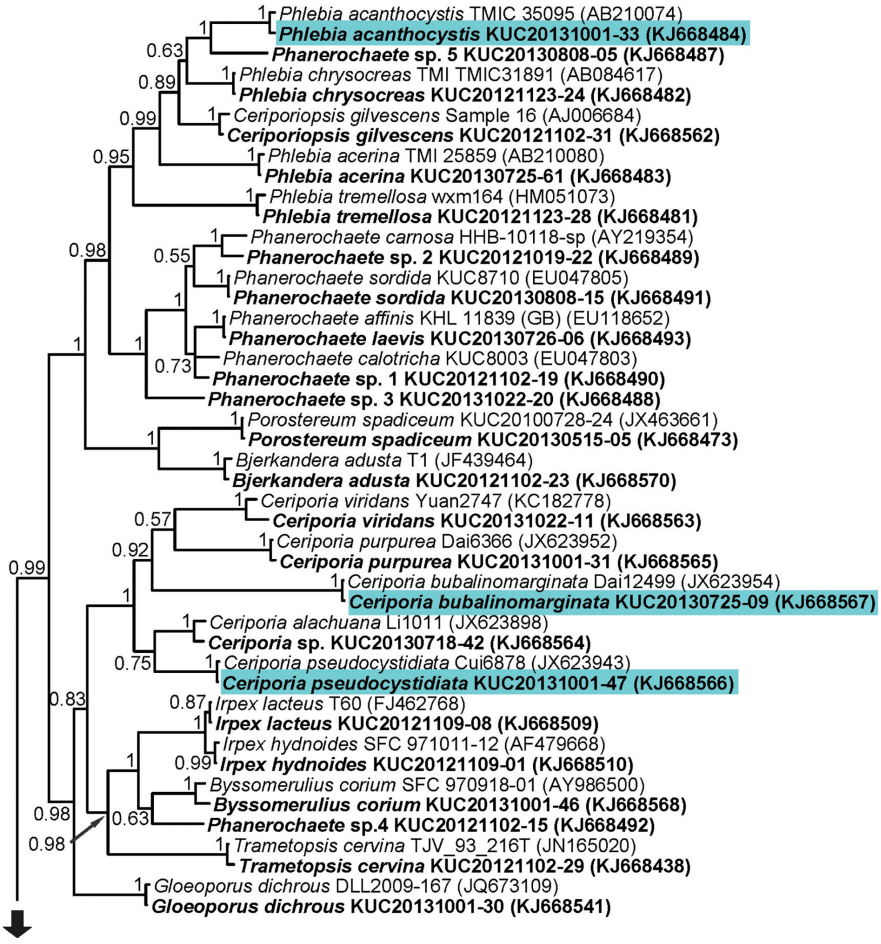


Fig. 2. 50% majority-rule consensus tree of the polyporoid and corticioid fungi collected from Odaesan National Park in Korea. Internal transcribed spacer (ITS) dataset composed of 277 taxa and 1,258 characters. The 9,602 trees from Bayesian analysis were used to construct the tree. The tree was rooted to the sequence of *Tremella aurantialba* ACCC 50219 (AY866425). Posterior probability values ≥ 0.5 are shown above or below branches. Specimens found in this study are in bold. Species new to Korea are highlighted. GenBank accession numbers of the ITS sequences are shown in parentheses.

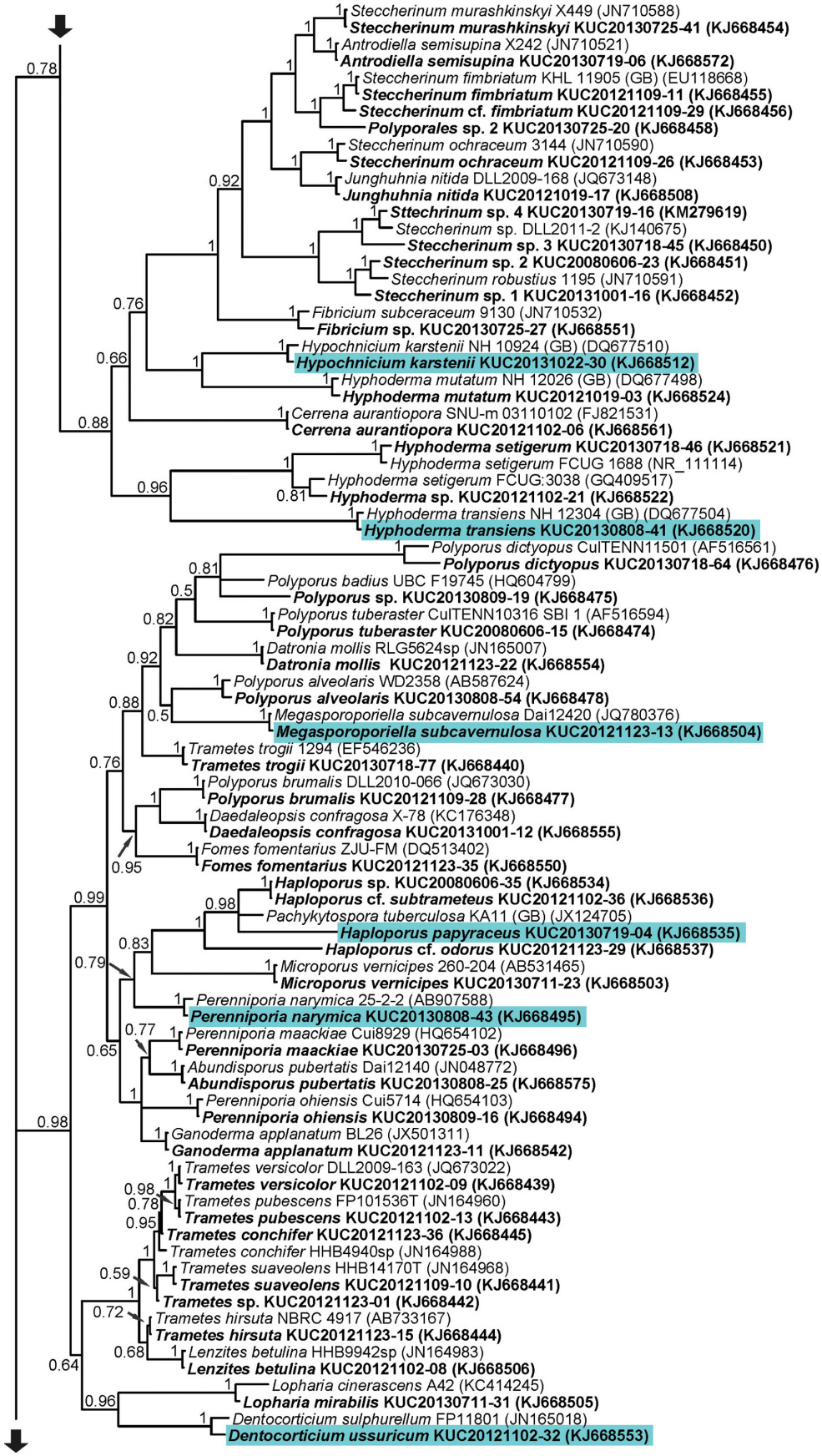
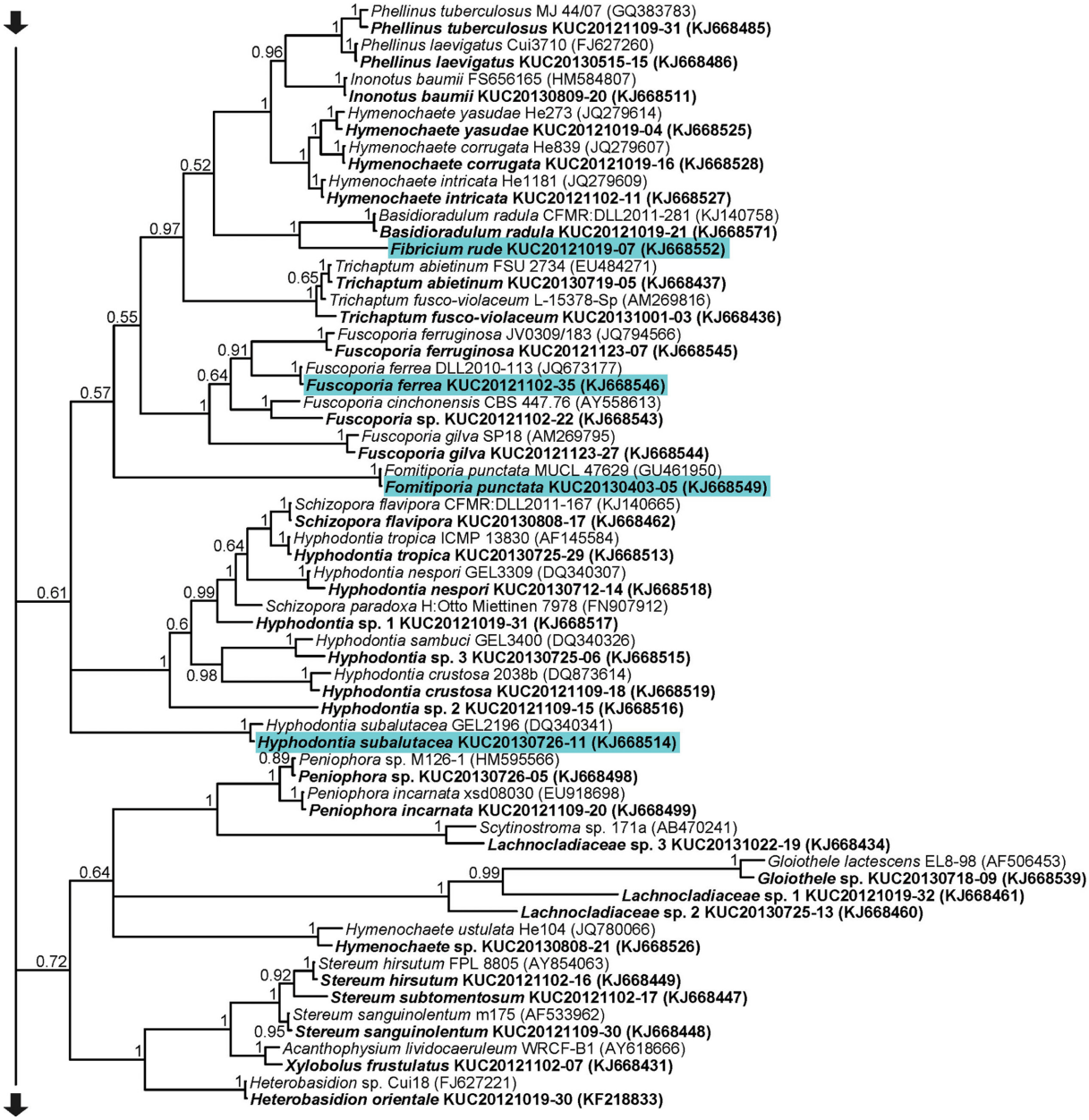


Fig. 2. Continued.

the manufacturer's instructions and sequenced. The sequences obtained in this study were deposited in GenBank, and the accession numbers are in Table 1. With the obtained LSU and ITS sequences, a BLASTn search was performed (http://blast.ncbi.nlm.nih.gov/Blast.cgi). Bayesian analysis was carried out with the ITS sequences. Sequence alignment was performed using MAFFT 7.130 [39], and the aligned dataset was edited with MacClade 4.08 [40]. For the Bayesian analysis, the best-fit model was calculated by MrModeltest 2.3 [41] under Akaike information criterion criterion. Phylogenetic analysis was performed with MrBayes 3.2.1 [42] according to Jang *et al.* [19]. The reliability of each node was evaluated by posterior probability. The tree was viewed using FigTree 1.4.0 (http://tree.bio.ed.ac.uk/software/figtree/).

RESULTS AND DISCUSSION

The diversity of the polyporoid and corticioid fungi. Through the surveys in Odaesan National Park, a total of 424 specimens were collected as voucher specimens. By combining morphological and molecular analyses, 149 species, 69 genera, 22 families, and 11 orders (without incertae sedis) were recognized, including the species identified on site (Table 1, Fig. 2). Half of the species (74 species) were polyporoid, and the other half (75 species) were corticioid fungi. The majority of the species belonged to Polyporales, accounting for 61.7% (92 species) of the total species, followed by Hymenochaetales (33 species, 22.1%) and Russulales (11 species, 7.4%). The number of observed species was high



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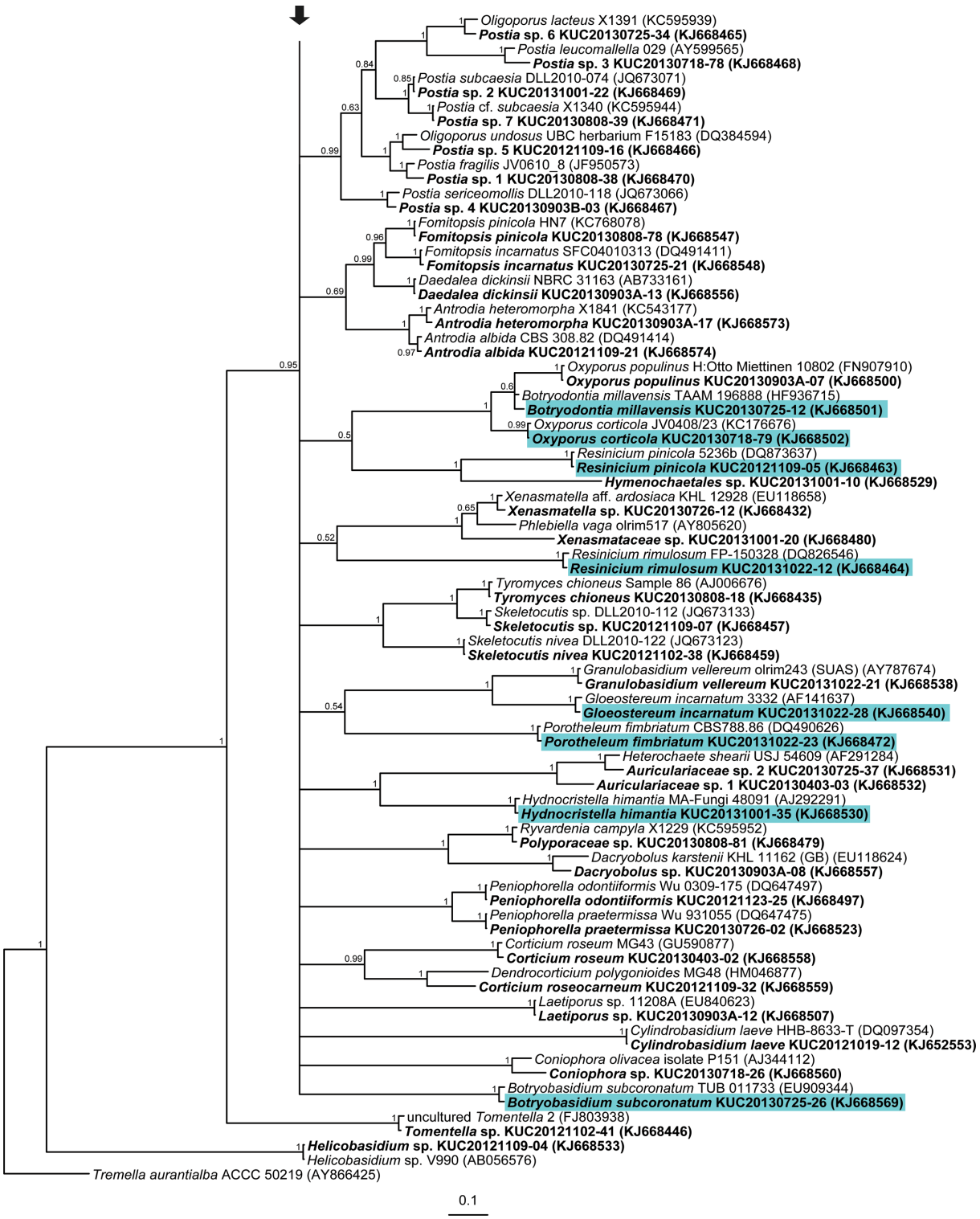

Fig. 2. Continued.

in the genera *Steccherinum*, *Hyphodontia*, *Phanerochaete*, *Postia*, and *Trametes*. 57 polyporoid and 42 corticioid fungi (66.4%) were identified to the species level. The rest of the species were identified to the genus level or above due to absence of microscopic features of the collected specimens, and lack of sequence information in GenBank. Further collection of the specimens are needed to properly identify the unidentified species.

The distribution of the polyporoid and corticioid fungi. The most widely distributed species was *Stereum subtomentosum*, which was found in all Segments. Moreover,

Trametes versicolor, *T. hirsuta*, *T. pubescens*, *Bjerkandera adusta*, and *Ganoderma applanatum* had relatively wide distribution areas (Table 1). Most of the fungi (144 species) were found below 1,000 m altitude (from Segment 9, 16, and 17). From above 1,000 m, 30 species were observed, and five species—*Dacryobolus* sp., *Daedalea dickinsii*, *Laetiporus* sp., *Oxyporus populinus*, and *Postia* sp. 4—were only found above 1,000 m. Considering the two fully identified species, *D. dickinsii* and *O. populinus*, were collected from below 1,000 m altitude in other regions at similar latitude (unpublished data) [20], they may simply be missed at low elevations. *Postia* sp. 4 may also be missed by chance below 1,000 m, or it might be found above 1,000 m because of its selectivity for *Taxus cuspidata*, which is only found in high altitudes. Similar results were observed by Gómez-Hernández *et al.* [43] (i.e., that species richness was high at low elevations (500~1,000 m) and low at high elevations (1,500~3,500 m) and certain species were only found at low or high elevations). In their study, these findings could be explained by environmental factors, such as slope and aspect, and biological factors, such as tree basal area (which was calculated by m^2/ha). According to Büntgen *et al.* [44], climatic factors, such as temperature and precipitation, also affected the fruiting of saprotrophic fungi. Microclimate, such as exposure to sunlight and soil moisture, is another important factor determining the species diversity of wood-decay fungi [45]. Although the abovementioned factors were not measured in this study, they might have affected the species distribution along the elevation gradient on Mt. Odae.

The substrates of the polyporoid and corticioid fungi. Each wood-decay fungus has a different host preference [46]. Although the wood substrates were not identified on many occasions, many species were found in deciduous wood (Fig. 3). It was found that 94 species (46 polyporoid and 48 corticioid fungi, 63.1%) were exclusively found in deciduous wood. On the other hand, only 17 species (7 polyporoid and 10 corticioid fungi, 11.4%) were exclusively found in coniferous wood. Twenty species (12 polyporoid and 8 corticioid fungi, 13.4%) were found in both coniferous and deciduous wood, and the substrates were not determined from the remaining 18 species (9 polyporoid and 9 corticioid fungi, 12.1%).

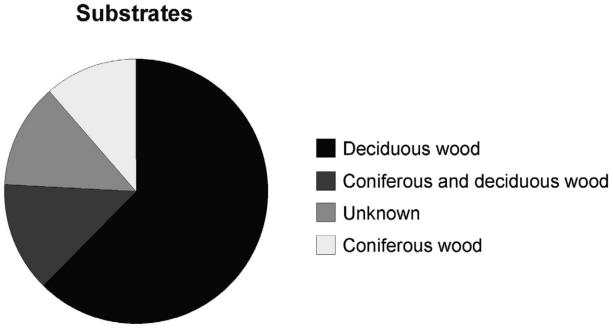

Fig. 3. Proportions of substrates of polyporoid and corticioid fungi in Odaesan National Park.

The newly reported polyporoid and corticioid species in Korea. In order to confirm the species records, the species from all available materials (e.g., previous papers, reports, national databases) were compared to those found in this study. Among the recorded species in Odaesan National Park, two *Heterobasidion* species, *Heterobasidion annosum* and *H. insulare*, were listed [33]. However, a recent taxonomic and phylogenetic study of Korean *Heterobasidion* spp. revealed that those two species reported in Korea are actually *H. ecrustosum* and *H. orientale* [21]. As shown in Table 1, *H. orientale* was found on Mt. Odae in this study.

Among the 99 identified species, 63 species were newly recorded in this region [14, 24, 31-35]. Among them, 21 species were new to Korea: *Botryobasidium subcoronatum*, *Botryodontia millavensis*, *Ceriporia bubalinomarginata*, *C. pseudocystidiata*, *Dentocorticium ussuricum*, *Fibricium rude*, *Fomitiporia punctata*, *Fuscoporia ferrea*, *Gloeostereum incarnatum*, *Haploporus papyraceus*, *Hydnocristella himantia*, *Hyphoderma transiens*, *Hyphodontia subalutacea*, *Hypochnicium karstenii*, *Megasporoporiella subcavernulosa*, *Oxyporus corticola*, *Perenniporia narymica*, *Phlebia acanthocystis*, *Porotheleum fimbriatum*, *Resinicium pinicola*, and *R. rimulosum* (Fig. 2). As for *Fomitiporia punctata* and *Haploporus papyraceus,* they are listed as Korean indigenous fungi in the database of KB, but there are actually no references reporting these two species. *Gloeostereum incarnatum* and *Hydnocristella himantia* are also listed as species of national parks, according to the Korea National Park Research Institute [11], but the reports cannot be validated, because no descriptions are provided. Therefore, the four above-mentioned species were regarded as newly reported species. Of the 21 species, we could not observe microscopic features of four species, *Ceriporia bubalinomarginata*, *Hydnocristella himantia*, *Porotheleum fimbriatum*, and *Resinicium pinicola*; thus only the rest 17 species were described and illustrated.

The proportions of the recorded, newly reported, and unidentified species. The proportions of the recorded species, newly reported species, and unidentified species differed between the two morphological groups (Fig. 4). Concerning the polyporoid fungi, most of the species were recorded species (64.8%) followed by unidentified ones (23.0%) and newly reported ones (12.2%). On the other hand, most corticioid fungi were unidentified species (44.0%) followed by recorded ones (40.0%) and newly reported ones (16.0%). This suggests that the diversity of corticioid fungi was not represented well compared to that of polyporoid fungi (Fig. 4). This might have been due to the size of the fruit bodies. Polyporoid fungi have conspicuous fruit bodies, and they can be detected easily even by a single survey. On the contrary, the fruit bodies of corticioid fungi are usually thin and small, and they are not as

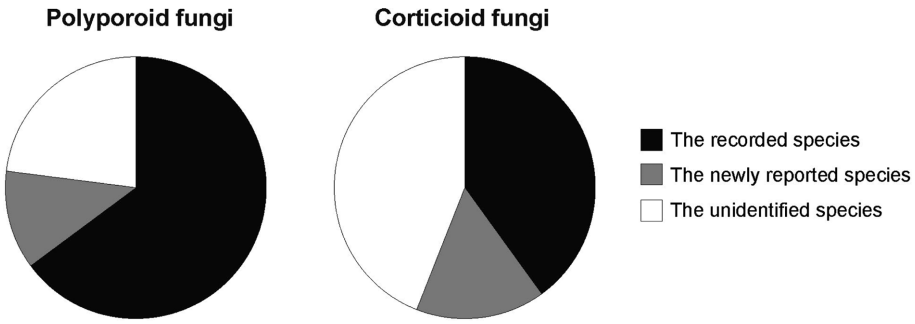

Fig. 4. Proportions of recorded species, newly reported species, and unidentified species for polyporoid and corticioid fungi in Odaesan National Park.

immediately recognizable as the fruit bodies of polyporoid fungi. For corticioid fungi, at least several surveys are recommended to detect all the fruit bodies in a study site and properly understand their diversity. Concerning the unidentified species, they were large in number among the corticioid fungi, and finding undescribed or unreported species among them was more likely.

This study shows the diversity of the wood-inhabiting polyporoid and corticioid fungi in Odaesan National Park. Although fruit body collection was performed only in the areas near the mountain trails along the elevation gradient, this revealed diverse polyporoid and corticioid fungi, including many previously unreported ones. The results of this study provide basic information on the distribution of the fungi in mountenous regions. They will form an important basis for further research in assessing the diversity of Korean polyporoid and corticioid fungi.

Taxonomy.

Botryobasidium subcoronatum (Höhn. & Litsch.) Donk, Medded. Nedl. Mycol. Ver. 18~20: 117 (1931) (Fig. 5)

Basidiome resupinate and membranaceous. Hymenophore hypochnoid, vinaceous buff to buff (10YR8/2-8/3) when dry. Margin not differentiated. Hyphal system monomitic; hyphae with clamps at all septa, interwoven, richly ramified, generative hyphae thin to thick-walled, 4~8 μm wide. Cystidia and other sterile elements absent. Basidia subcylindrical, 12.5~16.5 × 6~7 μm, with 6-sterigmata, and with a basal clamp. Basidiospores narrowly navicular, smooth, thin-walled, 5.7~7 (~7.4) × (2.7~) 2.9~3.6 μm (L = 6.44 μm, W = 3.21 μm, Q = 2.0), negative in Melzer's reagent.

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°46′20″ N, 128°34′52″ E, alt. 861 m, on the branch of deciduous wood, 25 Jul 2013 (NIBRFG0000134995, KUC20130725-26).

Notes: *Botryobasidium subcoronatum* is different from the other *Botryobasidium* species recorded in Korea by having smaller basidiospores (6~9 × 3~3.5 μm in *B. aureum*, 7~9 × 2.5~3 μm in *B. conspersum*, 9~12 × 5~6 μm in *B. medium*, and 7.5~12 × 3.5~5 μm in *B. optusisporum*) [47].

Botryodontia millavensis (Bourdot & Galzin) Duhem & H. Michel, Bull. Soc. Mycol. Fr. 121: 43 (2006) (Fig. 6)

Basidiocarp resupinate and confluent. Pores shallow, often incomplete, angular, 1~3 per mm; dissepiments dentate; pore surface smoke grey (2.5Y8/1) when dry. Marginal sterile zone indistinct, white. Hyphal system monomitic; generative hyphae simple septate, thin to slightly thick-walled, 2~4 μm wide. Cystidioles conical with narrow and round apex, basally simple septate, 21~25 × 4.5~6 μm. Gloeocystidia clavate, basally simple septate, pale yellowish in Melzer's reagent, 13~16 × 5~6 μm. Basidia short cylindrical, basally simple septate, 15~22 × 4.5~6.5 μm, with 4-sterigmata.

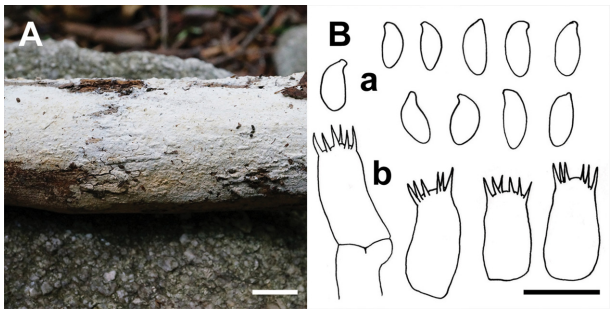

Fig. 5. *Botryobasidium subcoronatum* (KUC20130725-26). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia (scale bars: A = 1 cm, B = 10 μm).

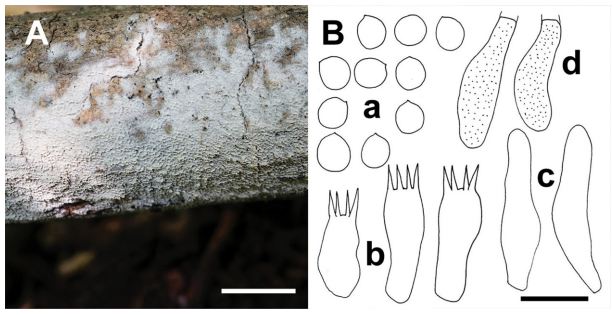

Fig. 6. *Botryodontia millavensis* (KUC20130725-12). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidioles; d, gloeocystidia (scale bars: A = 1 cm, B = 10 μm).

Basidiospores globose to subglobose, smooth, thin-walled, 4.3~5.7 (~6.2) × 3.9~4.9 (~5.4) µm (L = 5.01 µm, W = 4.40 µm, Q = 1.1), negative in Melzer's reagent.

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°45′26″ N, 128°34′56″ E, alt. 956 m, on the branch of deciduous wood, 25 Jul 2013 (NIBRFG0000134994, KUC20130725-12).

Notes: This is the first report of the genus *Botryodontia* in Korea. *B. millavensis* is recognized by its greyish, shallow, and incomplete pores, monomitic hyphal system, and the presence of gloeocystida.

Ceriporia pseudocystidiata B. S. Jia & Y. C. Dai, Mycol. Prog. 13: 86 (2014) (Fig. 7)

Basidiocarp annual, resupinate, confluent. Pores round to irregular, 4 per mm; dissepiments thin, entire; pore surface cinnamon (7.5YR6/6-7/6) to buff (7.5YR8/4) when dry. Margin thin, white to cream. Context white to cream. Tubes concolorous with the pore surface. Hyphal system monomitic; generative hyphae without clamps, thin to slightly thick-walled, 2.5~4.5 µm wide, interwoven, encrusted by small crystals. Cystidia scattered, clavate, hyaline, 25~35 × 4.6~7 µm. Basidia clavate, with four sterigmata and a simple basal septum, 13~20.5 × 3.1~4.5 µm. Basidiospores allantoid, hyaline, smooth, thin-walled, (3.2~) 3.4~4.1 (~4.3) × 1.2~1.7 µm (L = 3.74 µm, W = 1.41 µm, Q = 2.7), negative in Melzer's reagent.

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°44′04″ N, 128°35′24″ E, alt. 677 m, on the branch of *Abies holophylla*, 01 Oct 2013 (NIBRFG0000135040; KUC20131001-47).

Notes: This species was reported from China [48]. The difference between *Ceriporia bubalinomarginata and C. pseudocystidiata* is the size of the pores. The former has smaller pores (6 per mm) compared to the latter (4 per mm).

Dentocorticium ussuricum (Parm.) Larsen & Gilbertson, Nor. J. Bot. 21: 226 (1974) (Fig. 8)

Basidiocarp annual, coriaceous, firmly attached to the substrate. Hymenophore livid vinaceous (10R6/3-6/4) when dry with scattered bluntly conical warts. Subiculum white.

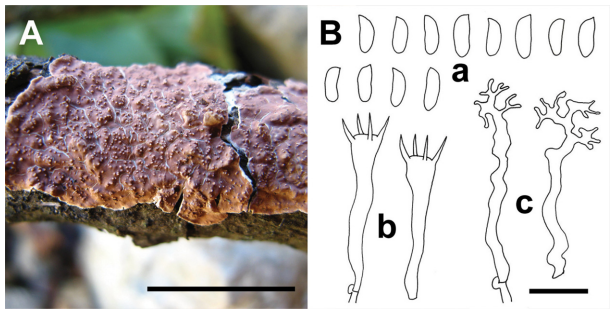

Fig. 8. *Dentocorticium ussuricum*. A, Basidiocarp (KUC20121102-32); B, Microscopic features (KUC20121123-16). a, basidiospores; b, basidia; c, dendrohyphidia (scale bars: A = 1 cm, B = 10 µm).

Hyphal system monomitic; generative hyphae with clamp connections, 2~4 µm diam. Dendrohyphidia abundant, highly branched at the apex, 30~40 × 1.5~2.5 µm, with a basal clamp. Basidia clavate, 4-sterigmate, 30~32 × 4~6.5 µm, with a basal clamp. Basidiospores cylindrical, straight to slightly bent, smooth, thin-walled, (5.3~) 5.8~7.2 (~7.3) × 2~2.6 (~3) µm (L = 6.31, W = 2.35, Q = 2.7).

Specimens examined: Korea, Gangwon-do, Mt. Odae, 37°42′13″ N, 128°33′59″ E, alt. 872 m, on the branch of deciduous wood, 2 Nov 2012 (NIBRFG0000125148, KUC20121102-32); 37°44′19″ N, 128°35′08″ E, alt. 674 m, on the log of deciduous wood, 9 Nov 2012 (KUC20121109-36); 37°44′30″ N, 128°35′03″ E, alt. 661 m, on the log of deciduous wood, 23 Nov 2012 (KUC20121123-16); 37°46′24″ N, 128°34′54″ E, alt. 932 m, on the branch of deciduous wood, 25 Jul 2013 (KUC20130725-60).

Notes: This is the first report of *Dentocorticium* in Korea. *D. ussuricum* is easily recognized by its livid vinaceous hymenophore with warts in the field.

Fibricium rude (P. Karst.) Jülich, Persoonia 8: 81 (1974) (Fig. 9)

Basidiome resupinate, effused, membranaceous. Hymenophore smooth, white to pale grey (2.5Y8/1). Margin with rhizomorphs. Hyphal system dimitic; generative hyphae with clamps, thin-walled, 1.5~2.5 µm wide; skeletal hyphae

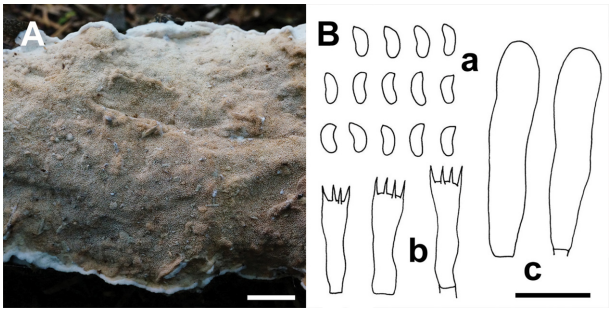

Fig. 7. *Ceriporia pseudocystidiata* (KUC20131001-47). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidia (scale bars: A = 1 cm, B = 10 µm).

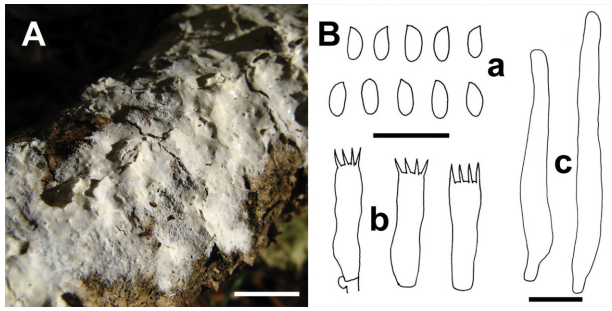

Fig. 9. *Fibricium rude* (KUC20121019-07). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidia (scale bars: A = 1 cm, B = 10 µm).

thick-walled, narrow, 1.5~2 µm wide. Cystidia tubular with round apex, 40~60 × 5~7 µm. Basidia clavate, 12~16 × 3~4 µm, with 4-sterigmata and a basal clamp. Basidiospores narrowly ellipsoid to subcylindrical, smooth, thin-walled, 3.6~4.9 (~5.2) × 1.7~2.4 µm (L = 4.26 µm, W = 2.08 µm, Q = 2.1), negative in Melzer's reagent.

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°44′06″ N, 128°35′25″ E, alt. 690 m, on the branch of *Abies holophylla*, 19 Oct 2012 (NIBRFG0000135205, KUC20121019-07).

Notes: This is the first report of *Fibricium* together with *Fibricium* sp. in Korea (Table 1). The smooth and white hymenophore, rhizomorphs in the margin, and dimitic hyphal system with tubular cystidia are characteristic to *F. rude*. *Fibricium* sp. is characterized by its odontoid hymenophore and apically encrusted utriform cystidia. Basidiospores of *Fibricium* sp. were not observed.

Fomitiporia punctata (P. Karst.) Murrill, Lloydia 10: 254 (1947) (Fig. 10)

Basidiocarp perennial, resupinate, effused, woody, difficult to separate from the substrate. Pores round, 5~6 per mm, mostly oblique, tubes up to 4 mm thick, distinctly stratified, about 1 mm thick in each layer; dissepiments entire; pore surface sepia (7.5YR4/3) to greyish sepia (7.5YR5/3) when dry. Sterile margin indistinct. Context sepia, very thin. Tubes concolorous with the pore surface. Hyphal system dimitic; generative hyphae without clamps, thin to slightly thick-walled, 1.5~3.5 µm wide; skeletal hyphae thick-walled with a distinct lumen, brown to yellowish, 3~5 µm wide. Cystidioles thin-walled, hyaline, ventricose with a tubular apex, 10~20 × 5~7 µm. Basidia broadly clavate, 4-sterigmate, and a simple basal septum, 13.5~17 × 7.5~9 µm. Basidiospores globose to subglobose, smooth, thick-walled, (5.6~) 6~7.5 (~7.7) × (5.3~) 5.6~7 (~7.4) µm (L = 6.82 µm, W = 6.45 µm, Q = 1.1), variably dextrinoid in Melzer's reagent.

Specimens examined: Korea, Gangwon-do, Mt. Odae, 37°46′55″ N, 128°34′31″ E, alt. 820 m, on the log of deciduous wood, 3 Apr 2013 (NIBRFG0000134975, KUC20130403-05); 37°43′37″ N, 128°33′40″ E, alt. 872 m, on the branch of dead wood, 11 Jul 2013 (KUC20130711-04); on deciduous wood, 25 Jul 2013 (KUC20130725-51); 37°44′45″ N, 128°35′01″ E, alt. 687 m, on the branch of dead wood, 19 Jul 2013 (KUC20130719-12).

Notes: *Fuscoporia punctata* is characterized by the lack of setae, ventricose cystidioles, and dextrinoid basidiospores.

Fuscoporia ferrea (Pers.) G. Cunn., Bull. N. Z. Dept. Sci. Industr. Res., Pl. Dis. Div. 73: 7 (1948) (Fig. 11)

Basidiocarp resupinate, effused, woody, difficult to separate from the substrate. Pores round, 5 per mm, tubes 2 mm thick; dissepiments entire; pore surface olivaceous (7.5YR3/2) to umber (7.5YR3/4) when dry. Margin cinnamon (7.5YR6/6). Context cinnamon, very thin. Tubes concolorous with the pore surface. Hyphal system dimitic; generative hyphae simple septate, hyaline to pale yellow, thin to slightly thick-walled, 1.5~3 µm wide; skeletal hyphae yellow to brown, thick-walled with a distinct lumen, 2.5~4.5 µm wide. Setae subulate, thick-walled, 25~41 × 5~7.5 µm. Basidia clavate, 4-sterigmate, 14~17 × 4.5~6.5 µm, simple-septate at the base. Basidiospores cylindrical, hyaline, smooth, and thin-walled, (5~) 5.5~7 (~7.6) × (1.8~) 2.1~2.7 µm (L = 6.27 µm, W = 2.30 µm, Q = 2.7), negative in Melzer's reagent.

Specimens examined: Korea, Gangwon-do, Mt. Odae, on the log of deciduous wood, 2 Nov 2012 (NIBRFG0000125151, KUC20121102-35); 37°46′54″ N, 128°34′31″ E, alt. 816 m, on the branch of dead wood, 18 Jul 2013 (KUC20130718-44); 37°47′16″ N, 128°34′01″ E, alt. 855 m, on the branch of deciduous wood, 26 Jul 2013 (KUC20130726-04).

Notes: *Fuscoporia senex* is different from *F. ferrea* by having smaller pores (10~11 per mm) and smaller basidiospores (3.8~4.2 × 2.5~3 µm) [17]. *F. gilva* is different from *F. ferrea* by having smaller pores (6~8 per mm) and smaller basidiospores (4~5 × 3~3.5 µm) [49]. *F. ferruginosa* is different from *F. ferrea* by having smaller pores (7~9 per mm) and thicker basidiospores (5~7 × 3~3.5 µm). *F. contigua* is different from *F. ferrea* by having larger pores (2~3 per mm). *F. viticola* is different from *F. ferrea* by having thinner basidiospores (5.5~8 × 1.5~2 µm).

Gloeostereum incarnatum S. Ito & S. Imai, Trans. Sapporo Nat. Hist. Soc. 13: 11 (1933) (Fig. 12)

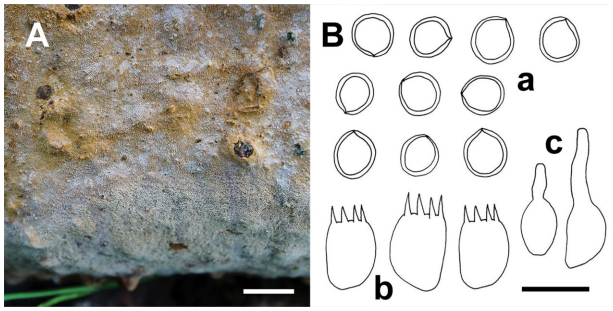

Fig. 10. *Fomitiporia punctata*. A, Basidiocarp (KUC20130725-51); B, Microscopic features (KUC20130711-04). a, basidiospores; b, basidia; c, cystidioles (scale bars: A = 1 cm, B = 10 µm).

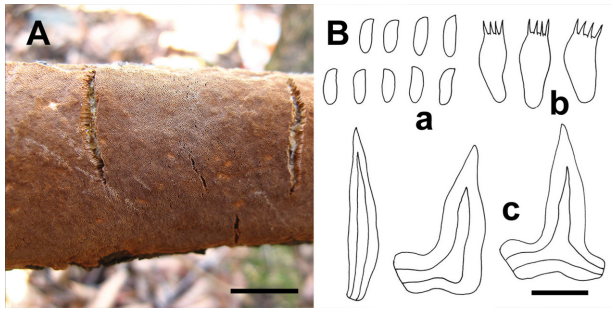

Fig. 11. *Fuscoporia ferrea* (KUC20121102-35). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, setae (scale bars: A = 1 cm, B = 10 µm).

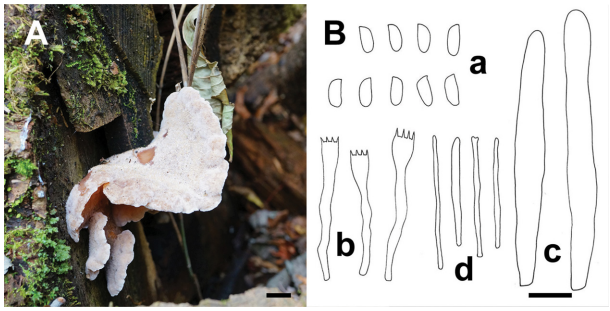

Fig. 12. *Gloeostereum incarnatum* (KUC20131022-28). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, gloeocystidia; d, hyphidia (scale bars: A = 1 cm, B = 10 μm).

Basidiome reniform or flabellate, broadly attached to the substrate, ca. 9 × 6 cm, 0.5~1 cm thick when fresh, ca, 5 × 2.5 × 0.25 cm when dry, very hard. Pileus surface strigose, salmon (7.5YR8/4) to ochraceus (7.5YR7/8) when dry. Hymenophore irregularly rugulose or coarsely tuberculate, dark mouse grey (7.5YR3/1) to sepia (7.5YR3/3). Margin incurved. Context jelly-like, distinctly zonate. Hyphal system monomitic; generative hyphae with clamp connections, thin-walled, 2~3 μm wide. Gloeocystidia cylindrical or tubular with obtuse apex, often projecting beyond hymenium, 50~70 × 4.5~8 μm. Hyphidia numerous, undulate, 25~40 × 1.5~3.5 μm. Basidia elongate-clavate, 4-sterigmate, 28~40 × 3.5~5.4 μm. Basidiospores ellipsoid to subcylindrical, smooth, thick-walled, (5~) 5.6~7 (~7.3) × (2.4~) 2.6~3.4 μm (L = 6.30 μm, W = 2.89 μm, Q = 2.2), negative in Melzer's reagent.

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°47′12″ N, 128°34′01″ E, alt. 862 m, on the stump of *Abies holophylla*, 22 Oct 2013 (NIBRFG0000135060, KUC20131022-28).

Notes: This is the first report of *Gloeostereum* in Korea. *G. incarnatum* is recognized by its jelly-like basidiome, the presence of gloeocystidia, and numerous hyphidia.

Haploporus papyraceus (Cooke) Y. C. Dai & Niemelä, Ann. Bot. Fenn. 39: 181 (2002) (Fig. 13)

Basidiocarp annual, resupinate, round, then confluent. Pores round to angular, 2~3 per mm; dissepiments entire; pore surface buff (10YR7/4-8/4) when dry. Sterile margin white. Context white. Tubes concolorous with the pore surface. Hyphal system dimitic; generative hyphae with clamp connections, hyaline, thin-walled, 1.5~2.5 μm wide; skeletal hyphae hyaline, thick-walled to almost solid, frequently branched, 1.5~4 μm wide. Cystidia none, fusoid cystidioles present, thin-walled, 15~25 × 4.5~7 μm, with a basal clamp. Basidia clavate, 4-sterigmate, 31~34 × 9.5~12 μm, with a basal clamp. Basidiospores ellipsoid to cylindrical, hyaline, tuberculate, thick-walled, (13.4~) 14~17 (~17.4) × (6.4~) 6.6~7.8 (~8.0) μm (L = 15.41 μm, W = 7.26 μm, Q = 2.1), negative in Melzer's reagent.

Specimens examined: Korea, Gangwon-do, Mt. Odae, 37°46′54″ N, 128°34′31″ E, alt. 816 m, on the branch of a coniferous tree, 18 Jul 2013 (NIBRFG0000134992, KUC20130718-43); 37°45′02′ N 128°34′32″ E, alt. 718 m, on the branch of a coniferous tree, 19 Jul 2013 (KUC20130719-04).

Notes: This is the first report of *Haploporus* in Korea. In this study, four species of *Haploporus*, *Haploporus* cf. *odorus*, *Haploporus* cf. *subtrameteus*, *H. papyraceus*, and *Haploporus* sp. were recognized. *Haploporus* cf. *odorus* is different from *H. papyraceus* by having pileate basidiocarp and smaller basidiospores (4.7~7.4 × 3.7~5.7 μm). On the contrary, both *Haploporus* cf. *subtrameteus* and *Haploporus* sp. have resupinate basidiocarps. However, the basidiospores of *Haploporus* cf. *subtrameteus* (7.9~10.8 × 3.3~6.1 μm) and *Haploporus* sp. (8.1~12 × 4.8~6.3 μm) are smaller compared to the ones of *H. papyraceus*.

Hyphoderma transiens (Bres.) Parmasto, Consp. System. Corticiac. (Tartu): 114 (1968) (Fig. 14)

Basidiome resupinate, adnate, effused. Hymenial surface white to orange white (10YR9/2), smooth to odontoid, cracked in some parts. Margin white to yellowish white (2.5Y9/1), thinning out, pruinose. Hyphal system monomitic; generative hyphae with clamp connections, hyaline, thin-walled, 2~3.5 μm wide. Cystidia scattered, subcylindrical, hyaline, thin-walled, 30~60 × 6~8.5 μm. Basidia narrowly

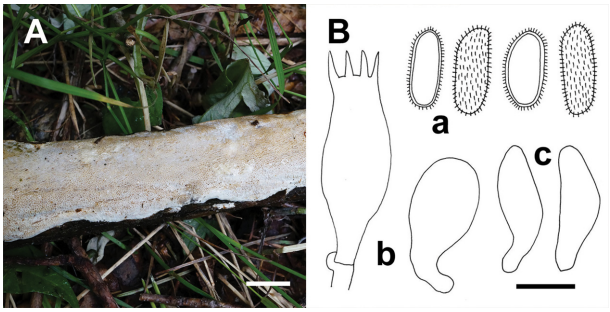

Fig. 13. *Haploporus papyraceus* (KUC20130718-43). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidioles (scale bars: A = 1 cm, B = 10 μm).

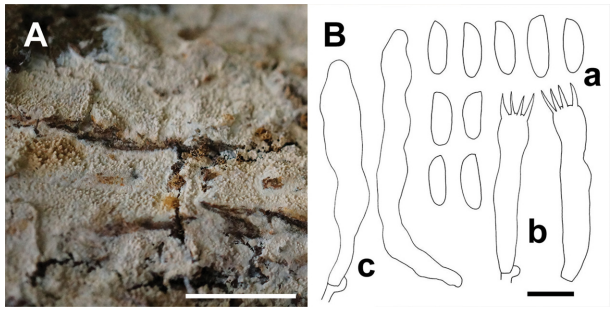

Fig. 14. *Hyphoderma transiens* (KUC20130808-41). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidia (scale bars: A = 1 cm, B = 10 μm).

clavate to subcylindrical, slightly constricted, 4-sterigmate, 35~40 × 5.5~7 µm, with a basal clamp. Basidiospores cylindrical, hyaline, smooth, thin-walled, 9.8~12.2 (~13.3) × (3.2~) 3.5~4.4 (~5) µm (L = 11.23 µm, W = 4.12 µm, Q = 2.7), negative in Melzer's reagent.

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°43′53″ N, 128°35′47″ E, alt. 631 m, on deciduous wood, 8 Aug 2013 (NIBRFG0000135007, KUC20130808-41).

Notes: *Hyphoderma transiens* is characterized by its smooth to odontoid hymenophore, generative hyphae with clamps, subcylindrical cystidia, and cylindrical basidiospores.

Hyphodontia subalutacea (P. Karst.) J. Erikss., Symb. Bot. Upsal. 16: 104 (1958) (Fig. 15)

Basidiome resupinate, adnate, effused. Hymenial surface vinaceous buff (10YR8/2) to buff (10YR8/3) when dry, smooth to grandinioid. Margin not differentiated. Hyphal system monomitic; generative hyphae with clamp connections, hyaline, thin to thick-walled, 1.5~3 µm wide. Cystidia numerous, cylindrical, hyaline, thick-walled, 70~95 × 5~8 µm. Basidia subclavate with suburniform constriction, 4-sterigmate, 13~14 × 4~6 µm, with a basal clamp. Basidiospores allantoid, hyaline, smooth, thin-walled, (5.6~) 5.8~6.8 (~7.3) × 1.4~1.8 µm (L = 6.30 µm, W = 1.68 µm, Q = 3.7), negative in Melzer's reagent.

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°47′17″ N, 128°34′02″ E, alt. 860 m, on the branch of deciduous wood, 26 Jul 2013 (NIBRFG0000125412; KUC20130726-11).

Notes: *Hyphodontia subalutacea* is characterized by its smooth to grandinioid hymenophore, generative hyphae with clamps, cylindrical cystidia, and allantoid basidiospores.

Hypochnicium karstenii (Bres.) Hallenb., Mycotaxon 16: 566 (1983) (Fig. 16)

Basidiome resupinate, effused, adnate. Hymenial surface white to orange white (10YR9/2) when dry, smooth, cracked. Margin thinning out. Hyphal system monomitic; generative hyphae with clamp connections, hyaline, thin to thick-walled, 3.5~6 µm wide. Cystidia none. Basidia more or less constricted and somewhat sinuous, 4-sterigmate, 35~45 × 7.5~10 µm, with a basal clamp. Basidiospores subglobose to ovoid, hyaline, smooth, thick-walled (7.6~) 8~9 (~10.4) × (7~) 7.3~8.6 (~9.3) µm (L = 8.56 µm, W = 7.89 µm, Q = 1.1), negative in Melzer's reagent.

Specimens examined: Korea, Gangwon-do, Mt. Odae, 37°45′54″ N, 128°34′43″ E, alt. 733 m, on the branch of deciduous wood, 9 Aug 2013 (NIBRFG0000139969, KUC20130809-06); 37°47′12″ N, 128°34′01″ E, alt. 862 m, on the log of *Abies holophylla*, 22 Oct 2013 (KUC20131022-30).

Notes: *Hypochnicium karstenii* is similar to *H. bombycinum*. Although the sizes of the spores of the two species are similar, the ratio of subglobose/ovoid is 2.0~4.3 in *H. karstenii*, and 1~1.3 in *H. bombycinum* [50]. The specimens examined in this study have the ratio of 2.0~2.9.

Megasporoporiella subcavernulosa (Y. C. Dai & Sheng H. Wu) B. K. Cui & Hai J. Li, Mycologia 105: 379 (2013) (Fig. 17)

Basidiocarp annual, resupinate, firmly attached to the substrate, hard corky when dry. Pores round, 2~4 per mm; dissepiments thin, entire; pore surface vinaceous buff (10YR8/2). Margin white. Context white, corky. Tubes concolorous with the pore surface, tubes hard corky. Hyphal system dimitic; generative hyphae with clamp connections, hyaline, thin-walled, 1.5~3 µm diam; skeletal hyphae hyaline, thick-walled to almost solid, frequently branched, 2~3 µm wide. Basidia not observed, but clavate basidioles present, 12~16.5 × 9~12 µm. Basidiospores few, cylindrical, hyaline,

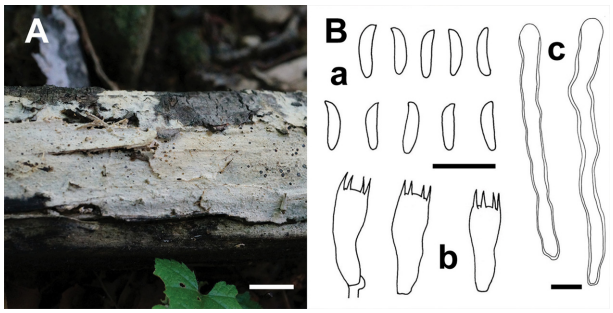

Fig. 15. *Hyphodontia subalutacea* (KUC20130726-11). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidia (scale bars: A = 1 cm, B = 10 µm).

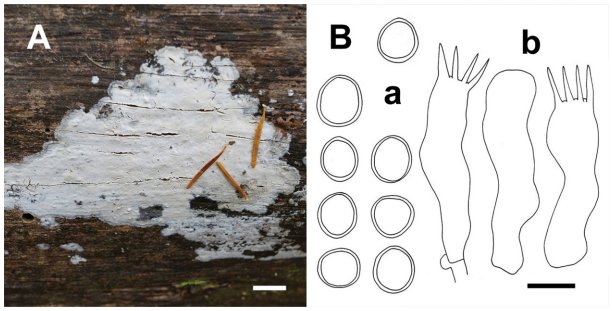

Fig. 16. *Hypochnicium karstenii* (KUC20131022-30). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia (scale bars: A = 1 cm, B = 10 µm).

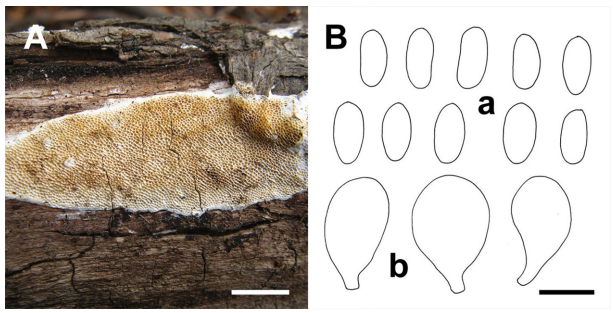

Fig. 17. *Megasporoporiella subcavernulosa* (KUC20121123-13). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidioles (scale bars: A = 1 cm, B = 10 µm).

smooth, thin-walled, (7.3~) 8.2~10.8 × (3.7~) 4~5.6 μm (L = 9.58 μm, W = 4.79 μm, Q = 2.0), negative in Melzer's reagent.
Specimens examined: Korea, Gangwon-do, Mt. Odae, 37°46′41″ N, 128°34′33″ E, alt. 808 m, on the branch of deciduous wood, 9 Nov 2012 (NIBRFG0000125158, KUC20121109-02); 37°44′30″ N, 128°35′03″ E, alt. 661 m, on the log of deciduous wood, 23 Nov 2012 (KUC20121123-13); 37°44′45″ N 128°35′01″ E, alt. 687 m, on a coniferous tree, 19 Jul 2013 (KUC20130719-07); 37°44′10″ N 128°35′16″ E, alt. 674 m, on the branch of deciduous wood, 1 Oct 2013 (KUC20131001-25).
Notes: This is the first report of *Megasporoporiella* in Korea. *M. subcavernulosa* is characterized by its resupinate basidiocarp, vinaceous buff pore surface, dimitic hyphal system, and cylindrical and relatively large basidiospores.

Oxyporus corticola (Fr.) Ryvarden, Persoonia 7: 19 (1972) (Fig. 18)
Basidiocarp annual, resupinate, and confluent. Pores round to angular, 4 per mm; dissepiments entire; pore surface straw (5Y9/3) when dry. Margin whitish, fimbriate, 1 mm wide. Context thin, white. Tubes concolorous with the pore surface. Hyphal system monomitic; generative hyphae, simple-septate, thin- to very thick-walled, 1.5~4.5 μm wide. Cystidia cylindrical, thin-walled, capitately encrusted, 14~17 × 5~5.5 μm; gloeocystidia cylindrical, thin-walled, with refractive contents, 17~20 × 4.5~6 μm. Basidia clavate, 4-sterigmate, 9.5~13 × 5~7 μm, simple-septate at the base. Basidiospores ovoid to broadly ellipsoid, hyaline, smooth, 4.8~6.2 × 3~4.4 μm (L = 5.41 μm, W = 3.62 μm, Q = 1.5), negative in Melzer's reagent.
Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°45′57″ N, 128°34′40″ E, alt. 726 m, on the branch of deciduous wood, 18 Jul 2013 (NIBRFG0000125351, KUC20130718-79).
Notes: *Oxyporus corticola* is characterized by its straw colored pore surface, capitately encrusted cystidia, cylindrical gloeocystidia, and ovoid to broadly ellipsoid basidiospores.

Perenniporia narymica (Pilát) Pouzar, Česká Mykol. 38: 204 (1984) (Fig. 19)

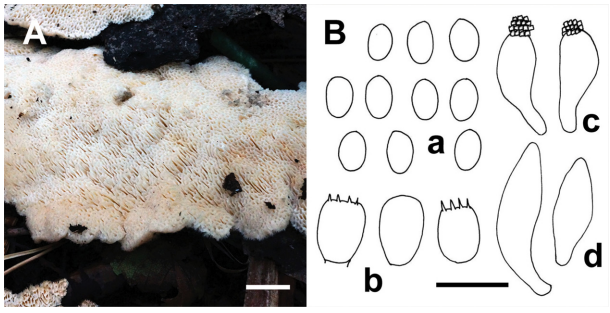

Fig. 18. *Oxyporus corticola* (KUC20130718-79). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidia; d, gloeocystidia (scale bars: A = 1 cm, B = 10 μm).

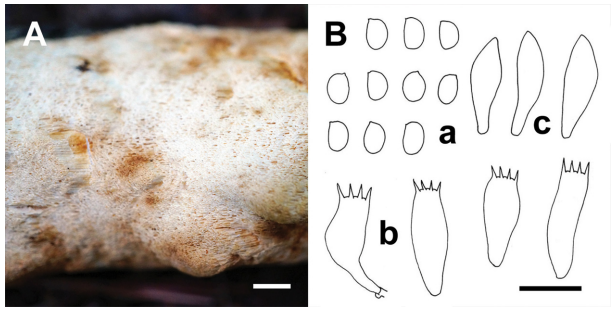

Fig. 19. *Perenniporia narymica* (KUC20130808-43). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidioles (scale bars: A = 1 cm, B = 10 μm).

Basidiocarp annual, resupinate, widely effused, adnate. Pores round to angular, 4~5 per mm; dissepiments lacerate; pore surface buff (10YR8/4-6), ochreous (10YR6/8) in some parts when dry. Margin white to light buff, finely fibrillose. Context thin, white to light buff. Tubes concolorous with the pore surface, up to 5 mm thick. Hyphal system dimitic; generative hyphae with clamps, thin-walled, 1.5~3 μm wide; skeletal hyphae thick-walled with a distinct lumen, 2.5~5 μm wide. Cystidioles thin-walled, hyaline, fusoid, 11~15 × 3.5~5 μm. Basidia clavate, 4-sterigmate with a basal clamp, 17.5~21.5 × 4.5~6.5 μm. Basidiospores ellipsoid to ovoid, smooth, thick-walled, (4~) 4.6~5.8 × 3.1~3.8 (~4.2) μm (L = 5.06 μm, W = 3.51 μm, Q = 1.4), negative in Melzer's reagent.
Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°43′53″ N, 128°35′47″ E, alt. 631 m, on deciduous wood, 8 Aug 2013 (NIBRFG0000135009, KUC20130808-43).
Notes: According to Gilbertson and Ryvarden [49], *Perenniporia narymica* has weakly amyloid skeletal hyphae, however, the skeletal hyphae of the collected specimen is inamyloid. Except amyloidity of the skeletal hyphae, the characteristics of the studied specimen are consistent with *P. narymica* described by Gilbertson and Ryvarden [49]. Furthermore, phylogenetic analysis with ITS region sequences supports its identity (Fig. 2).

Phlebia acanthocystis Gilb. & Nakasone, in Nakasone & Gilbertson, Folia Cryptog. Estonica 33: 85 (1998) (Fig. 20)
Basidiome resupinate, adnate. Hymenial surface odontoid to hydnoid, aculei conical to cylindrical, up to 1.5 mm long, rosy buff (7.5YR4/3) when dry, hymenium between aculei buff (10YR8/4), smooth. Margin not differentiated. Hyphal system monomitic; generative hyphae with clamps, thin-walled, 2~3 μm wide. Cystidia obclavate, tapering gradually toward the apex, sometimes with several small knobs at the apical part, 29~34 × 2.5~3.5 μm. Basidia narrowly clavate, 14~20 × 3.5~4.5 μm, 4-sterigmate, with a basal clamp. Basidiospores broadly ellipsoid, smooth, thin-walled, 3.5~4.4 × 2.1~2.8 μm (L = 3.91 μm, W = 2.38 μm, Q = 1.6), negative in Melzer's reagent.

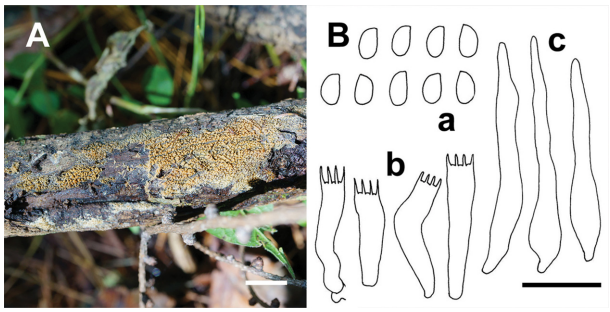

Fig. 20. *Phlebia acanthocystis* (KUC20131001-33). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, cystidia (scale bars: A = 1 cm, B = 10 μm).

Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°44′20″ N, 128°35′08″ E, alt. 654 m, on the branch of deciduous wood, 1 Oct 2013 (NIBRFG0000146523, KUC20131001-33).
Notes: *Phlebia acanthocystis* is characterized by its odontoid to hydnoid and rosy buff hymenophore, monomitic hyphal system, the presence of obclavate cystidia, and broadly ellipsoid basidiospores.

Resinicium rimulosum Nakasone, Can. J. Bot. 85: 432 (2007) (Fig. 21)
Basidiome resupinate, effused with numerous cracks. Hymenophore odontioid with small aculei, vinaceous buff (2.5Y8/2). Margin thinning out. Hyphal system monomitic; generative hyphae with clamps, thin-walled, 1.5~3.5 μm wide. Halocystidia numerous, sphaeropedunculate, 18~21 × 3~4 μm, with a basal clamp, apical bulb 4.5~6.5 μm in diameter enclosed by a vesicle, 9.5~15 μm in diameter. Astrocystidia aculeate to lageniform, 9~13 × 2~3 μm, with a basal clamp, apex acute. Basidia narrowly clavate, 12~15 × 3.5~4.5 μm, 4-sterigmate, with a basal clamp. Basidiospores rare, ellipsoid, smooth, thin-walled, 4.5~5.1 × 2.8~3.4 μm (L = 4.89 μm, W = 3.12 μm, Q = 1.6), negative in Melzer's reagent.
Specimen examined: Korea, Gangwon-do, Mt. Odae, 37°47′14″ N, 128°33′58″ E, alt. 863 m, on the branch of dead wood, 22 Oct 2013 (NIBRFG0000146524, KUC20131022-12).
Notes: *Resinicium rimulosum* is characterized by its rimose basidiome, vinaceous buff and odontoid hymenophore, the presence of halocystidia and asterocystidia, and ellipsoid basidiospores.

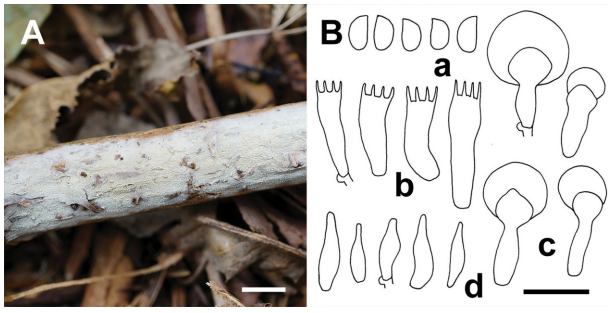

Fig. 21. *Resinicium rimulosum* (KUC20131022-12). A, Basidiocarp; B, Microscopic features. a, basidiospores; b, basidia; c, halocystidia; d, asterocystidia (scale bars: A = 1 cm, B = 10 μm).

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