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 Stechterinum, 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 submontosum, Trametes versicolor, T. hirsuta, T. pubescens, Bjerkandera adusta, and Canoderma 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
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

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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. Odac surveyed in this study; C, Detailed description of the study area with the 17 divided study segments.
| Classification | GenBank accession No. | Substrates | Occurrences |
|----------------|----------------------|------------|-------------|
| **Fungi**      |                      |            |             |
| Basidiomycota  |                      |            |             |
| Agaricomycotina|                      |            |             |
| **Auriculariales** |                    |            |             |
| Auriculariaceae|                      |            |             |
| Granulobasidium| KJ668540            | Abies holophylla | 9, 1    |
| Physalacriaceae| KJ668391            | Deciduous wood | 1       |
| Cylindrobasidium| KJ668411            | Acer and other deciduous wood | 9, 16, 17 |
| Porotheleaceae | KJ668324            | Wood       | 1         |
| Auriculariaceae| KJ668384            | Deciduous wood | 9, 17  |
| Auriculariaceae| KJ668383            | Deciduous wood | 9, 1    |
| Boletales      |                      |            |             |
| Coniophoraceae | KJ668414            | Wood       | 9         |
| Cantharellales |                      |            |             |
| Botryobasidiaceae| KJ668424            | Deciduous wood | 1       |
| Corticaceae    | KJ668413            | Deciduous wood | (3), 17 |
| Corticiaceae   |                      |            |             |
| Corticium      |                      |            |             |
| Corticium      | KJ668412            | Abies holophylla | 9     |
| Gomphales      |                      |            |             |
| Lentariaceae   |                      |            |             |
| Botryodonta    | KJ668423            | Deciduous wood | 16, 1    |
| Hymenochaeta   |                      |            |             |
| Hymenochaeta   | KJ668402            | Deciduous wood | 9, 17, 4 |
| Hymenochaeta   | KJ668399            | Deciduous wood | 9, 3    |
| Hymenochaeta   | KJ668398            | Deciduous wood | 16, 17  |
| Hymenochaeta   | KJ668397            | Deciduous wood | 16, 17  |
| Hymenochaeta   | KJ668396            | Deciduous wood | 9, 2    |
| Inonotus       |                      |            |             |
| Inonotus baunii| KJ668363            | Deciduous wood | (9), 17 |
| Phellinus      |                      |            |             |
| Phellinus laevigatus| KJ668339   | Betula platyphylla var. japonica and other deciduous wood | (9), 16 |
| Phellinus      | KJ668388            | Deciduous wood | 2, 5, 9, 17 |
| Rickenellaceae |                      |            |             |
| Peniophorella  | KJ668338            | Deciduous wood | 2, 5, 17  |
| Resinicium     |                      |            |             |
| Resinicium pinicola| KJ668350   | Deciduous wood | 17       |
| Schizoporellace| Basidioradulum      |            |             |
| Basidioradulum | KJ668464            | Wood       | 1         |

Table 1. List of wood-inhabiting polyporoid and corticioid fungi in Odaesan National Park
| Classification | Genus | Species | GenBank accession No. | Substrates | Occurrences |
|----------------|-------|---------|-----------------------|------------|-------------|
| Order or above | Family | | | | |
| Hyphodontia | Hyphodontia crustosa | KJ668519 KJ668371 | Deciduous wood | 9 | 3 |
| Hyphodontia | 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 | KJ668437a KJ668289 | Abies holophylla | 17 | 1 |
| | Trichaptum fusco-violaceum | KJ668436 KJ668288 | Abies holophylla, Prunus sargentii, and other coniferous and deciduous wood | 9, 16, 17 | 11 |
| Polyporales | Fomitopsidaceae | Antrodia albita | KJ668574 KJ668429 | Abies holophylla | 9, 17 | 3 |
| | | Antrodia heteromorpha | KJ668573 KJ668428 | Deciduous wood | 14, 17 | 3 |
| | | Dacryobolus | KJ668557 KJ668410 | Deciduous wood | 11 | 1 |
| | | Daedalea dickinsii | KJ668556 KJ668409 | Deciduous wood | 10, 12 | 2 |
| | | Fomitopsis incarnatus | KJ668548 KJ668401 | Deciduous wood | 16 | 1 |
| | | Fomitopsis pinicola | KJ668547a KJ668400 | Abies holophylla and deciduous wood | 9, 17 | 5 |
| | Laetiporus | Laetiporus sp. | KJ668507 KJ668359 | Deciduous wood | 6, 10, 12 | 3 |
| | Postia | Postia 1 | KJ668470 KJ668322 | Wood | 17 | 1 |
| | | Postia 2 | KJ668469 KJ668321 | Deciduous wood | 17 | 1 |
| | | Postia 3 | KJ668468 KJ668320 | Deciduous wood | 17 | 1 |
| | | Postia 4 | KJ668467 KJ668319 | Taxus cuspidata | 3 | 1 |
| | | Postia 5 | KJ668466 KJ668318 | Deciduous wood | 9 | 1 |
| | | Postia 6 | KJ668465 KJ668317 | Deciduous wood | 9 | 1 |
| | | Postia 7 | KJ668471 KJ668323 | Abies holophylla and deciduous wood | 17 | 3 |
| | Ganodermataceae | Ganoderma | Ganoderma applanatum | KJ668542a KJ668395 | Abies holophylla, Betula platyphylla var. japonica, and other deciduous wood | 9, 12, 13, 15, 16, 17 | 14 |
| | Merulaceae | Bjerkandera | Bjerkandera adusta | KJ668570 KJ668425 | Pinus, Querqus, and other coniferous and deciduous wood | (3), (7), (9), (11), 16, 17 | 11 |
| | Gloeoporus | Gloeoporus dichrous | KJ668541a KJ668394 | Abies holophylla and deciduous wood | 9, 17 | 4 |
| Classification | Genus | Species | GenBank accession No. | Substrates | Occurrences |
|----------------|-------|---------|-----------------------|------------|-------------|
|                |       |         |                       | ITS<sup>a</sup> | LSU<sup>a</sup> | Seg<sup>b</sup> | No.<sup>c</sup> |
| Order or above | Family | Genus | Species | Substrates | Occurrences |
|----------------|--------|-------|---------|------------|-------------|
| Phanerochaetae| Antrodiella | Antrodiella semisupina | KJ668572<sup>d</sup> | Abies holophylla, Betula platyphylla var. japonica, and other deciduous wood | 9, 16, 17 | 6 |
|                |        | Byssomerulus | Byssomerulus corium | KJ668568 | KJ668422 | Deciduous wood | 17 | 1 |
|                |        | Ceriporia | Ceriporia babalinomarginata | KJ668567 | KJ668421 | Deciduous wood | 16 | 1 |
|                |        | Ceriporia | Ceriporia pseudocyistiata | KJ668566<sup>e</sup> | KJ668420 | Abies holophylla | 17 | 1 |
|                |        | Ceriporia | Ceriporia purpurea | KJ668565 | KJ668419 | Deciduous wood | 17 | 1 |
|                |        | Ceriporia | Ceriporia sp. | KJ668564<sup>e</sup> | KJ668418 | Abies holophylla | 9, 17 | 2 |
|                |        | Ceriporiopsis | Ceriporiopsis gibescens | KJ668563 | KJ668417 | Deciduous wood | 9 | 1 |
|                |        | Phanerochaete | Phanerochaete laevis | KJ668493 | KJ668345 | Wood | 9 | 1 |
|                |        | Phanerochaete | Phanerochaete sordida | KJ668491 | KJ668344 | Deciduous wood | 17 | 1 |
|                |        | Phanerochaete | Phanerochaete sp. | KJ668490 | KJ668343 | Coniferous wood | 9 | 1 |
|                |        | Phanerochaete | Phanerochaete sp. | KJ668489 | KJ668342 | Deciduous wood | 17 | 2 |
|                |        | Phlebia | Phlebia acanthocystis | KJ668484 | KJ668337 | Deciduous wood | 17 | 1 |
|                |        | Phlebia | Phlebia acerina | KJ668483 | KJ668336 | Deciduous wood | 16 | 1 |
|                |        | Phlebia | Phlebia chrysocreas | KJ668482 | KJ668335 | Ulmus davidiana var. japonica and other deciduous wood | (1), 9, 16, 17 | 4 |
|                |        | Junghuhnia | Junghuhnia nitida | KJ668508 | KJ668360 | Deciduous wood | 2, 9, 17 | 7 |
|                |        | Hypochnicium | Hypochnicium karstenii | KJ668512 | KJ668364 | Abies holophylla and deciduous wood | 9, 17 | 2 |
|                |        | Irpex | Irpex hydnoides | KJ668510 | KJ668362 | Acer and other deciduous wood | 9, 16, 17 | 6 |
|                |        | Irpex | Irpex lacteus | KJ668509 | KJ668361 | Deciduous wood | 9, (10), (13), (15), 16, 17 | 12 |
|                |        | Phlebia | Phlebia tremelloso | KJ668481 | KJ668334 | Deciduous wood | (6), 9, (17) | 1 |
|                |        | Steccherinum | Steccherinum cf. fimбриatum | KJ668456 | KJ668307 | Larix kaempferi | 17 | 1 |
|                |        | Steccherinum | Steccherinum fimбриatum | KJ668455 | KJ668306 | Deciduous wood | 9 | 1 |
|                |        | Steccherinum | Steccherinum muroshinskii | KJ668454 | KJ668305 | Deciduous wood | 9, 16, 17 | 3 |
|                |        | Steccherinum | Steccherinum ochraceum | KJ668453 | KJ668304 | Deciduous wood | 9, 17 | 7 |
|                |        | Steccherinum | Steccherinum sp. | KJ668452<sup>i</sup> | KJ668303 | Abies holophylla and deciduous wood | 9, 17 | 6 |
|                |        | Steccherinum | Steccherinum sp. | KJ668451 | KJ668302 | Deciduous wood | 9 | 1 |
|                |        | Steccherinum | Steccherinum sp. | KJ668450 | KJ668301 | Coniferous wood | 16 | 1 |
|                |        | Steccherinum | Steccherinum sp. | KM279619 | KM279618 | Wood | 9 | 1 |
|                |        | Phanerochaete | Phanerochaete laevis | KJ668493 | KJ668345 | Wood | 9 | 1 |
|                |        | Phanerochaete | Phanerochaete sordida | KJ668491 | KJ668344 | Deciduous wood | 17 | 1 |
|                |        | Phanerochaete | Phanerochaete sp. | KJ668490 | KJ668343 | Coniferous wood | 9 | 1 |
|                |        | Phanerochaete | Phanerochaete sp. | KJ668489 | KJ668342 | Deciduous wood | 17 | 2 |
| Classification | Genus | Species | GenBank accession No. | Substrates | Occurrences |
|----------------|-------|---------|----------------------|------------|-------------|
| Order or above | Family | Genus   | Species | ITS' | LSU' | Seg' | No. |
| Polyporaceae   |       | Phanerochaete | sp. 3 KJ68488 | KJ668341 | Deciduous wood | 9, 16 | 2 |
|                |       | Phanerochaete | sp. 4 KJ68492 | KJ668346 | Deciduous wood | 9, 16, 17 | 12 |
|                |       | Phanerochaete | sp. 5 KJ68487$^a$ | KJ668340 | Abies holophylla and deciduous wood | 9, 16, 17, 3 |
|                |       | Porostereum  | spadiceum KJ68473 | KJ668325 | Deciduous wood | 9, 16, 17 | 3 |
|                |       | Abundisporus | Abundisporus pubertatis KJ68575 | KJ668430 | Wood | 17 | 1 |
|                |       | Cerrena     | Cerrena aurantiopa KJ68561 | KJ668415 | Deciduous wood | 9 | 3 |
|                |       | Daedaleopsis | Daedaleopsis confragosa KJ68555$^a$ | KJ668408 | Abies holophylla and deciduous wood | (1), (5), 9, (16), 17, 2 |
|                |       | Datronia    | Datronia mollis KJ68554 | KJ668407 | Deciduous wood | 17 | 1 |
|                |       | Dentocorticium | Dentocorticium ussuriicum KJ68553 | KJ668406 | Deciduous wood | 9, 16, 17 | 4 |
|                |       | Fomes       | Fomes fomentarius KJ68550 | KJ668403 | Deciduous wood | 9, 17 | 2 |
|                |       | Haploporus   | Haploporus cf. odorus KJ68537 | KJ668390 | Deciduous wood | 17 | 1 |
|                |       | Haploporus   | cf. subtrameus KJ68536 | KJ668389 | Coniferous wood | 9 | 1 |
|                |       | Haploporus   | papyraceus KJ68535 | KJ668388 | Coniferous wood | 9, 17 | 2 |
|                |       | Haploporus   | sp. KJ68534 | KJ668387 | Wood | 9 | 1 |
|                |       | Lenzites     | Lenzites betulina KJ68506 | KJ668358 | Deciduous wood | 9, 12, (16) | 3 |
|                |       | Lopharia     | Lopharia mirebili KJ68505 | KJ668357 | Coniferous and deciduous wood | 9, 16, 17 | 5 |
|                |       | Megasporoporiella | Megasporoporiella subcavernulosa KJ68504 | KJ668356 | Coniferous and deciduous wood | 9, (16), 17 | 4 |
|                |       | Microporus     | Microporus Vernicipes KJ68503 | KJ668355 | Deciduous wood | 9, 17 | 7 |
|                |       | Perenniporia | Perenniporia maackiae KJ68496 | KJ668349 | Deciduous wood | 12, 16 | 2 |
|                |       | Perenniporia | narymica KJ68495 | KJ668348 | Deciduous wood | 17 | 1 |
|                |       | Perenniporia | chuiensis KJ68494 | KJ668347 | Wood | 9 | 1 |
|                |       | Polyporus     | Polyporus alveolarius KJ68478$^a$ | KJ668330 | Abies holophylla | 17 | 1 |
|                |       | Polyporus     | brunalis KJ68477 | KJ668329 | Deciduous wood | 17 | 2 |
|                |       | Polyporus     | dictyopus KJ68476 | KJ668328 | Wood | 9 | 1 |
|                |       | Polyporus     | sp. KJ68475 | KJ668327 | Wood | 9 | 1 |
|                |       | Polyporus     | tuberaster KJ68474 | KJ668326 | Deciduous wood | 17 | 1 |
|                |       | Skeletocutis | Skeletocutis nivea KJ68459 | KJ668311 | Deciduous wood | 9, 17 | 4 |
|                |       | Skeletocutis | sp. KJ68457 | KJ668309 | Larix kaempferi and deciduous wood | 9, 17 | 3 |
|                |       | Spongipellis | Spongipellis sp. - | KJ668308 | Wood | 17 | 1 |
|                |       | Trametes     | Trametes conchifer KJ68445 | KJ668297 | Deciduous wood | 9, 17 | 5 |
|                |       | Trametes     | hirsuta KJ68444 | KJ668296 | Deciduous wood | (1), (6), 9, 10, 12, (16), 17 | 5 |
|                |       | Trametes     | pubescens KJ68443 | KJ668295 | Deciduous wood | (1), 9, (11), (12), (14), (15), 16 | 2 |
|                |       | -           | - | KJ668294 | Coniferous and deciduous wood | (5), 9, (15), 16, 17 | 6 |
| Classification | Genus | Species | GenBank accession No. | Substrates | Occurrences |
|----------------|-------|---------|-----------------------|------------|-------------|
| Polyporaceae   | 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 | cervina | KJ668438 KJ668290 | Deciduous wood | 9 | 1 |
|                | Tyromyces | Tyromyces chionaeus | KJ668435 KJ668287 | Wood | 17 | 1 |
|                | Polyporaceae sp. | | KJ668479 KJ668332 | Deciduous wood | 17 | 1 |
| Xenasmataceae  | Xenasmatella sp. | | KJ668432 KJ668284 | Deciduous wood | 9 | 1 |
|                | Xenasmataceae sp. | | KJ668480 KJ668333 | Deciduous wood | 17 | 2 |
|                | Polyporaceae sp. 1 | | KJ668331 | Wood | 17 | 1 |
|                | Polyporaceae sp. 2 | | KJ668458 KJ668310 | Wood | 16 | 1 |
| Russulales     | Bondarzewiaceae | Heterobasidion | KF218833d KJ668385 | Abies holophylla and deciduous wood | 9, 17 | 8 |
|                | Lachnocladiaceae | sp. 1 | KJ668461 | Deciduous wood | 17 | 2 |
|                | Lachnocladiaceae | sp. 2 | KJ668460 | Deciduous wood | 16 | 1 |
|                | Lachnocladiaceae | sp. 3 | KJ668434 | Wood | 9 | 1 |
| Peniophoraceae | Gloiothele | sp. | KJ668539 KJ668392 | Coniferous and deciduous wood | 9 | 2 |
|                | Peniophora | incarnata | KJ668498 KJ668352 | Acer and other deciduous wood | 9, 16 | 3 |
| Stereaceae     | Stereum | hirsutum | KJ668434 KJ668299 | Coniferous wood | 17 | 1 |
|                | Stereum | sanguinolentum | KJ668447 | Deciduous wood | (2), (3), (4), (5), 9, 10, (11), (12), (13), (14), (15), 16, 17 | 13 |
|                | Stereum | subtomentosum | KJ668447 | Acer and other deciduous wood | (2), (3), (4), (5), 9, 10, (11), (12), (13), (14), (15), 16, 17 | 13 |
|                | Xylobolus | frustulatus | KJ668431 KJ668283 | Deciduous wood | 9, 11, (13) | 2 |
| Thelephorales  | Thelephoraceae | Tomentella | KJ668446 | Larix kaempferi | 9 | 1 |
| Pucciniomycotina | Helicobasidiaceae | Helicobasidium sp. | KJ668533 KJ668386 | Coniferous wood | 9 | 1 |

**Table 1.** Continued

|ITS, internal transcribed spacer; LSU, large subunit. |
|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. |
|Total number of the collected specimens in each species. |
|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.](image-url)
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 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 61.2% (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.
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 dickinii, Laetiporus sp., Oxyporus populinus, and Postia sp. 4—were only found above 1,000 m. Considering the two fully identified species, D. dickinii 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 m²/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%).

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. ecristosum 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, Botryodendron millavensis, Ceriporia bubalinomarginata, C. pseudocystiditata, Dentocorticium ussuricum, Fibruticium rude, Fomitiporia punctata, Fuscoporia ferrae, Gloeostereum incarnatum, Haploporus papyraceus, Hydnocristella himantia, Hyphoderma transiens, Hyphodontia subalutacea, Hypochnicium karstenii, Megaporoporriella 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

![Substrates](image_url)

**Fig. 3.** Proportions of substrates of 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 montaneous 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, Meded. 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; 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. optisporum*) [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 gloeocystidia.

*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. Basidium 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.

**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, 23 Nov 2012 (KUC20121109-36); 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 clamp connections, 2–4 µm diam. Dendrohyphidia abundant, highly branched at the apex, 30–40 × 1.5–2.5 µm, with a basal clamp. Basidium 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, 23 Nov 2012 (KUC20121109-36); 37°46′24″ N, 128°34′54″ E, alt. 932 m, on the branch of deciduous wood, 25 Jul 2013 (KUC20130725-60).

**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).
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 sepias (7.5YR4/3) to greyish sepias (7.5YR5/3) when dry. Sterile margin indistinct. Context sepias, 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, 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 thick-walled, (5~7) × (7.6) × (1.8~2) 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 punctata is characterized by the lack of setae, ventricose cystidia, 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 umbre (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, single-septate at the base. Basidiospores cylindrical, hyaline, smooth, and thinner basidiospores (5~7 × 3~3.5 μm). Cystidia 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 cystidia, and dextrinoid basidiospores.

Fuscoporia ferrea

Wood Decay Fungi in Odaesan, Korea

Gloeostereum incarnatum S. Ito & S. Imai, Trans. Sapporo Nat. Hist. Soc. 13: 11 (1933) (Fig. 12)
Specimens examined: Korea, Gangwon-do, Mt. Odae, 6.30°N, 128°30′ E, alt. 862 m, on the stump of Abies holophylla, 22 Oct 2013 (KUC20130718-43); 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.

**Hypoderma transiens** (Bres.) Parmasto, Conspl. System. Corticiac. (Tartu): 114 (1968) (Fig. 14)
Basidiocarp resupinate, adnate, effused. Hymenial surface white to orange white (10YR9/2), smooth to odontoid, cracked in some parts. Margin white to yellowish white (2.5Y 9/1), thinning out, pruinose. Hyphal system monomitic; generative hyphae with clamp connections, hyaline, thick-walled, 2–3.5 μm wide. Cystidia scattered, subcylindrical, hyaline, thin-walled, 30–60 × 6–8.5 μm. Basidia narrowly tubular with obtuse apex, often projecting beyond hymenium, 1.5–3.5 μm 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.

**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.

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

**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. Hypoderma 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:** *Hyphodontia subalutacea* is characterized by its smooth to grandinioid 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-sterigate, 13–14 × 4–6 µm, with a basal clamp. Basidiospores allantoid, 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°47'17" N, 128°34'02" E, alt. 860 m, on the branch of deciduous wood, 8 Aug 2013 (NIBRFG0000139969, KUC20130808-41).

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

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

*Hyphonichium 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:** *Hypochonnicium 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, 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 (NIBRFG0000139969, KUC20130808-41).

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

*Hyphonichium 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** (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,
Specimen 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 (NIBRFG000125158, 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, dimytic 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; disseminations entire; pore surface straw (5Y9/3) when dry. Margin whitish, fimbriate, 1 mm wide. Context thin, white. Tubes concolorous with the pore surface, up to 5 mm thick. Hyphal system monomitic; generative hyphae with clamps, 1.5–3 μm wide; skeletal hyphae thick-walled with a distinct lumen, 2.5–5 μm wide. Cystidia thin-walled, hyaline, fusoid, 11–15 × 3.5–5 μm. Basidia clavate, 4-sterigate with a basal clamp, 17.5–21.5 × 4.5–6.5 μm. Basidiospores ellipsoid to ovoid, smooth, thick-walled, (4–)6.5–8.5 × 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°45′57″ N, 128°34′40″ E, alt. 726 m, on the branch of deciduous wood, 18 Jul 2013 (NIBRFG000125351, 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)

Basidiocarp annual, resupinate, widely effused, adnate. Pores round to angular, 4–5 per mm; disseminations 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. Cystidia thin-walled, hyaline, fusoid, 11–15 × 3.5–5 μm. Basidia clavate, 4-sterigate with a basal clamp, 17.5–21.5 × 4.5–6.5 μm. Basidiospores ellipsoid to ovoid, smooth, thick-walled, (4–)6.5–8.5 × 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 (NIBRFG000135009, 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-sterigate, 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.
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 odontoid 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′38″ 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 astrocystidia, and ellipsoid basidiospores.

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