Ten New Recorded Species of Macrofungi on Ulleung Island, Korea

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Abstract Ulleung Island is a biodiversity hotspot in South Korea. During a survey of indigenous fungal species from Ulleung Island conducted from 2015 to 2016, we discovered 10 unrecorded macrofungi in Korea. These macrofungi were identified to the species level using morphological features and phylogenetic analysis based on the internal transcribed spacer region: *Deconica phyllogena, Mycena zephirus, Phaeomarasmius proximans, Phlebia radiata, Pluteus semibulbosus, Postia alni, Resinicium pinicola, Scytinostroma portentosum, Tricholomopsis flammula, and Tyromyces kmetii. We also provide detailed morphological descriptions for these 10 species.*

Keywords Indigenous fungal species, Internal transcribed spacer, New record, Ulleung Island

Macrofungi are distinguished by their production of fruiting bodies that are visible without the need of a microscope [1]. Most macrofungi belong to the Basidiomycota, some are within the Ascomycota, and a few belong to the Zygomycota. Macrofungi play essential roles as decomposers, symbionts, and pathogens on the forest ecosystems [2]. In addition to their ecological roles, fruiting bodies are important biomaterials in the pharmaceutical industry and are popular food items for human consumption [3]. Because macrofungi are directly related to ecosystem health, investigating their diversity is a prerequisite to understanding ecosystems in general.

Macrofungal taxonomy has traditionally been based on morphology, often on microscopic features of their fruiting bodies. However, the identification of species based solely on morphology is difficult to apply due to the lack of a

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clear morphological distinction between closely related species and the extensive morphological variation among genera and sometimes even families [4, 5]. DNA sequence analysis has become a primary component in phylogenetic and taxonomic studies of macrofungi [6-9]. The internal transcribed spacer (ITS) region has been proposed as the primary fungal barcode and is commonly used as a molecular marker for fungal identification [10]. The combination of morphological data and ITS sequence analysis has considerably improved the accuracy, efficiency, and rapidity of species identification across diverse macrofungi [11-13].

Ulleung Island is one of a small group of volcanic islands located off the eastern coast of the Korean peninsula. The island has been recognized as a biodiversity hotspot in Korea. Approximately 600 species of vascular plants inhabit Ulleung Island, 39 of which are endemic to the island [14, 15]. Intensive surveys of macrofungi on Ulleung Island have been carried out since 1989 and 161 species have been reported [16-21]. Recently, 223 macrofungi species were reported based on morphological features and ITS sequence analysis [22, 23]. Interestingly, recent studies [22, 23] showed that only 27 macrofungi species overlapped, and 196 species were newly reported. Therefore, a total of 357 species have been detected on Ulleung Island to date.

During a recent project organized by the National Institute of Biological Resources (NIBR, Incheon, Korea; http://www. nibr.go.kr) to survey and excavate Korean indigenous fungi on Ulleung Island, we discovered 10 unrecorded macrofungi. The specimens were identified to the species level using morphological features and phylogenetic analysis based on the ITS region. In this paper, we provide the macro- and

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micro-morphological characteristics for these 10 species.

MATERIALS AND METHODS

Samples and morphological observations. Macrofungi were collected from Ulleung Island between 2015 and 2016. Specimens were dried and deposited in the Seoul National University Fungus Collection (SFC). The specimens were initially identified based on fruiting body morphology and microscopic characteristics [24-29] using a model 80i light microscope (Nikon, Tokyo, Japan). Dried tissue was rehydrated in 3% (w/v) KOH and stained with 1% (w/v) phloxine for measurements and drawings. Basidia (30 per



Fig. 1. Neighbor-joining tree of 10 unrecorded species constructed using internal transcribed spacer sequences. Bootstrap scores of > 50 are presented at the nodes. The scale bar indicates the number of nucleotide substitutions per site. The unrecorded species are marked with asterisks. A, *Deconica phyllogena*; B, *Mycena zephirus*; C, *Phaeomarasmius proximans*; D, *Phlebia radiata*; E, *Pluteus semibulbosus*; F, *Postia alni*; G, *Resinicium pinicola*; H, *Scytinostroma portentosum*; I, *Tricholomopsis flammula*; and J, *Tyromyces kmetii*.

sample) and basidiospores (10 per sample) were measured. The quotient (Q) refers to the length/width ratio of basidiospores.

DNA extraction, PCR, sequencing, and phylogenetic analysis. Genomic DNA was extracted using a modified cetyltrimethylammonium bromide extraction protocol [30]. PCR amplification of the ITS of each sample was performed as previously described [5] using the primers ITS1F and ITS4B [31]. DNA sequencing was performed at Macrogen (Seoul, Korea) using an ABI PRISM 3730XL Analyzer (Life Technologies, Gaithersburg, MD, USA) with the same primers used for PCR.



Fig. 1. Continued.

DNA sequences were assembled, proofread, and edited using MEGA ver. 5.0 [32]. Representative sequences were deposited in GenBank (accession Nos. MF437002–MF437013). Genus-by-genus phylogenetic analyses were carried out. Reference sequences were downloaded from GenBank. Multiple alignments were performed using the default settings of MAFFT v7 [33] and ambiguously aligned positions were adjusted manually. Neighbor-joining trees were constructed with MEGA 5 (Kimura 2-parameter model) with 1,000 bootstrap replicates [34].

RESULTS AND DISCUSSION

During the survey of indigenous fungal species from Ulleung Island in Korea from 2015 to 2016, we discovered ten species that were previously unrecorded in Korea by analyzing the ITS sequences and morphological characteristics. Here, we provide morphological characteristics for these ten species: *Deconica phyllogena, Mycena zephirus, Phaeomarasmius proximans, Phlebia radiata, Pluteus semibulbosus, Postia alni, Resinicium pinicola, Scytinostroma portentosum, Tricholomopsis flammula,* and *Tyromyces kmetii.*

Genus Deconica. SFC20160714-66 formed a monophyletic group with Deconica phyllogena with 100% bootstrap support (Fig. 1A). The ITS sequence of SFC20160714-66 was identical to that of D. phyllogena (FJ596920 and FJ596921), but had sequence similarity of 96.2-96.4% with D. novaezelandiae as the sister group. Deconica (Basidiomycota, Agaricales, and Strophariaceae) is a genus of agaricoid fungi and includes approximately 42 species (Index Fungorum; http://www.indexfungorum.org). Many Deconica species were often considered members of the genus Psilocybe s.l. [35] but Deconica has been recently separated from Psilocybe by phylogenetic analyses using nuclear large ribosomal subunit rRNA, 5.8S rRNA, and rpb1 markers [36]. Although Deconica shares several morphological characteristics with Psilocybe, it can be distinguished from Psilocybe by multigene-based phylogenies [36].

Genus *Mycena*. SFC20150903-13 and SFC20160615-06 formed a monophyletic group with *Mycena zephirus* with 68% bootstrap support (Fig. 1B). These specimens showed sequence similarity of 99.3–100% to *M. zephirus* and 98.7–99.7% to *M. algeriensis* as the sister group. *Mycena* (Basidiomycota, Agaricales, and Mycenaceae) is a genus of agaricoid fungi with approximately 1,000 species (Index Fungorum; http://www.indexfungorum.org). Thirty-four species have been reported in Korea [37]. The genus is characterized by the carpophores (mycenoid and omphalioid), presence or absence of bright or dull colored pigment, white to pale cream spore print, and strongly glutinous pileus and stipe [38].

Genus *Phaeomarasmius.* SFC20150903-34 formed a monophyletic group with *Phaeomarasmius proximans* with

100% bootstrap support and showed sequence similarity of 98.7–99.5% to *Phae. proximans* (Fig. 1C). *Phaeomarasmius* (Basidiomycota, Agaricales, and Inocybaceae) is a genus of agaricoid fungi with approximately 48 species (Index Fungorum; http://www.indexfungorum.org). Although *Flammulaster* is considered synonymous with *Phaeomarasmius* [38], *Phaeomarasmius* can be distinguished from *Flammulaster* by ellipsoid to subamygdaliform spores and the absence of distinctly cystidioid terminal cells in the pileipellis [39].

Genus *Phlebia.* SFC20151020-13 formed a monophyletic group with *Phlebia radiata* with 86% bootstrap support (Fig. 1D). The specimens showed sequence similarity of 99.7–100% to *Ph. radiata* and 99.2% to *Ph. rufa* as the sister group. *Phlebia* (Basidiomycota, Polyporales, and Meruliaceae) is a genus of corticioid fungi with approximately 89 species (Index Fungorum; http://www.indexfungorum.org). Among these, 8 species have been reported in Korea [37]. The genus is characterized by smooth, tuberculate, and thickening hymenia, and a waxy, gelatinous or mucous texture [40].

Genus *Pluteus.* SFC20150903-15 formed a monophyletic group with *Pluteus semibulbosus* with 100% bootstrap support and showed sequence similarity of 98.0–100% to *Pl. semibulbosus* (Fig. 1E). *Pluteus* (Basidiomycota, Agaricales, and Pluteaceae) is a genus of agaricoid fungi with approximately 89 species. Among these, 32 species have been reported in Korea [37]. The genus is characterized by free lamellae, cystidia metuloids or leptocystidia, inverse hymenophoral trama [38].

Genus *Postia*. SFC20160927-01 formed a monophyletic group with *Postia alni* with 100% bootstrap support (Fig. 1F). The specimens showed sequence similarity of 99.8–100% to *Po. alni* and 97.4–97.6% to *Po. caesia* as the sister group. *Postia* (Basidiomycota, Polyporales, and Fomitopsidaceae) is an important genus of brown-rot fungi with approximately 53 species. Among these, 7 recorded species have been reported in Korea [37]. The genus is characterized by an annual growth habit, a monomitic hyphal system with clamp connections, and thin-walled, allantoid to cylindrical or ellipsoid spores [41].

Genus *Resinicium.* SFC20151020-15 formed а monophyletic group with Resinicium pinicola with 100% bootstrap support and showed sequence similarity of 99.6-100% to R. pinicola (Fig. 1G). Resinicium (Basidiomycota, Hymenochaetales, and Rickenellaceae) is a genus of corticioid fungi with approximately 16 species (Index Fungorum; http://www.indexfungorum.org). Among these, one recorded species has been reported in Korea [37]. The genus is characterized by astrocystidia and halocystidia in hymenium [42]. R. pinicola was reported in the list of polyporoid and corticioid fungi without morphological description [43]. For this reason, we suggest R. pinicola as an unrecorded species in Korea.

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Genus *Scytinostroma*. SFC20160614-44 formed a monophyletic group with *Scytinostroma portentosum* with 100% bootstrap support and showed sequence similarity of 99.7% to *S. portentosum* (Fig. 1H). *Scytinostroma* (Basidiomycota, Russulales, and Lachnocadiaceae) is a genus of corticioid fungi with approximately 33 species (Index Fungorum; http://www.indexfungorum.org). Among these, *S. odoratum* has been reported in Korea [37]. The genus is characterized by a tough and leathery texture, a dimitic hyphal system, and dichotomously branched skeletal hyphae [44].

Genus Tricholomopsis. SFC20151020-25 and SFC20160927-37 formed a monophyletic group with *Tricholomopsis flammula* with 100% bootstrap support and showed sequence similarity of 98.7–100% to *Tr. flammula* (Fig. 11). *Tricholomopsis* (Basidiomycota, Agaricales, and Tricholomataceae) is a genus of agaricoid fungi with approximately 41 species (Index Fungorum; http://www. indexfungorum.org). Among these, 16 species have been reported in Korea [37]. The genus is characterized by yellow lamellae, and yellow and smooth to fibrillose pileus [45].

Genus Tyromyces. SFC20150902-43 formed a monophyletic group with *Tyromyces kmetii* with 100% bootstrap support and showed sequence similarity of 99.7–100% to *Ty. kmetii* (Fig. 1J). *Tyromyces* (Basidiomycota, Polyporales, and Polyporaceae) is a genus of polyporoid fungi with approximately 140 species (Index Fungorum; http://www. indexfungorum.org). Among these, 3 species have been reported in Korea [37]. The genus is characterized by white pileate to resupinate basidiocarps, and a monomitic or dimitic hyphal system with clamp connections [46].

Taxonomy.

Deconica phyllogena (Peck) Noordeloos, Österr. Z. Pilzkd. 18: 208 (2009) (Figs. 2A and 3A).

Classification: Basidiomycota, Agaricales, Hymenogastraceae, *Deconica*.

Pileus 6–8 mm wide, thin, firm, umbonate, alutaceous when dry, turns to reddish brown when moist. Stipe $15-20 \times 1-2$ mm, cylindrical, fibrillose, brownish, covered with white fibrils, annulus absent, turns into a flat disk that adheres to leaf at the base. Lamellae plane, broad, subdistant, brown, and white on the margin. Cheilocystidia $19.1-20.6-21.6 \times 6.3-7.2-8.1 \,\mu$ m. Pleurocystidia $13.6-15.9-20.1 \times 5.6-6.7-8.1 \,\mu$ m, fusoid, rhick walled towards apex. Caulocystidia not distinctive or absent. Basidia $17.5-19.9-23.8 \times 5.6-6.8-7.6 \,\mu$ m, 4-spored, clavate. Basidiospores $6.5-7.0-7.6 \times 4.5-5.0-5.5 \,\mu$ m, Q = 1.2-1.4-1.6, pale brown, subglobose or rhomboid, thick walled. Clamp connections present. Gregarious in leaf soil in woods.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Seonginbong, 37°30′09.7″ N 130°51′57.8″ E, on leaf soil of mixed forest, 14 Jul 2016, J. Y. Park, M. S. Park, SFC20160714-66 (GenBank accession No. MF437002).

Remarks: Deconica phyllogena is morphologically similar to *D. novae-zelandiae*. *D. novae-zelandiae* can be distinguished from *D. phyllogena* by larger basidiospores $(10-11 \times 6-7 \mu m)$ [47].

Mycena zephirus (Fr.) P. Kumm., Führer Pilzkud.: 110 (1871) (Figs. 2B and 3B).

Classification: Basidiomycota, Agaricales, Mycenaceae, *Mycena*.

Pileus 15-20 mm wide, parabolical to broadly conical, becoming plane in age, white to beige, turn to reddish brown when aged. Stipe $20-25 \times 1-2$ mm, silverly whitefloccose, grey flesh-color, grey lilac, reddish to wine-colored brown. Lamellae up to 4 mm, broad, whitish to pale brown with red-brown spots. Cheilocystidia $47.8-57.4-71.1 \times 7.9-$ 12.4-15.7 µm, fusiform, clavate, apically mucronate, with a simple or branched neck. Pleurocystidia present, 77.0-82.5- $89.4 \times 14.0-16.1-22.3 \,\mu$ m, fusiform, clavate, apically mucronate, with a simple or branched neck. Caulocystidia irregularly clavate, straight to curved, coarsely diverticulate. Pileipellis 2-10 µm long, smooth or with rare excrescences. Basidia 28.7-32.4-36.3 × 7.6-9.0-10.6 µm, clavate, 4-spored, sterigmata up to 7 μ m long. Basidiospores 8.5–9.3–10.4 × 5.3–5.9–6.6 μ m, Q = 1.4–1.6–1.8, elongate ellipsoid or cylindrical. Clamp connection present. Scattered or gregarious under conifers, but also in mixed woods.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, on the trunk of dead hardwood, 3 Sep 2015, J. Y. Park, N. K. Kim, H. J. Cho, SFC20150903-13 (GenBank accession No. MF437004); Korea, Gyeongsangbukdo, Ulleung-gun, Seonginbong, 37°30′09.7″ N 130°51′57.8″ E, on the trunk of dead hardwood, 15 Jun 2016, N. K. Kim, J. Y. Park, SFC20160615-06 (GenBank accession No. MF437003).

Remarks: *Mycena zephirus* is easily identified with its white pileus with red-brown spots and silvery white-floccose stipe [47]. Pileus color of *M. zephirus* is similar to those of *M. erminea* and *M. eburnean*, but red-brown spots in *M. zephirus* pileus distinguishes it from the other species. *M. zephirus* is similar to *M. algeriensis* and *M. valida*. Graybrown color in *M. algeriensis* and stipe color turning reddish brown to upward of *M. valida* are distinguishable characters [48].

Phaeomarasmius proximans (A. H. Sm. & Hesler) Singer, Fieldiana Bot. 21: 115 (1989) (Figs. 2C and 3C).

Classification: Basidiomycota, Agaricales, Inocybaceae, *Phaeomarasmius*.

Pileus 5–15 mm wide, plane to convex, surface dry and fibrillate, context thin, bright yellow brown, yellow, yellowish brown when mature. Stipe $7.0-15.0 \times 1.0-1.5$ mm, slightly fibrillose with rudimentary veil, becoming tubular, ochraceous overall when fresh, dark brown color when mature, but not darkening from base up on aging. Lamellae close, depressed-adnate, broad, and concolorous with pileus when



Fig. 2. Images of the 10 unrecorded species: A, Deconica phyllogena; B, Mycena zephirus; C, Phaeomarasmius proximans; D, Phlebia radiata; E, Pluteus semibulbosus; F, Postia alni; G, Resinicium pinicola; H, Scytinostroma portentosum; I, Tricholomopsis flammula; and J, Tyromyces kmetii (scale bars = 1 cm).

mature. Cheilocystidia 19.6–25.3–29.7 × 7.8–9.5–11.1 µm, narrowly clavate to nearly vesiculose, wall slightly thickened irregularly. Pleurocystidia absent. Basidia $20.1–22.7–26.9 \times 5.4-6.2-6.9 \mu$ m, 4-spored. Basidiospore 7.6–8.5–9.3 × 3.9–4.3–4.7 µm, Q = 1.8–2.0–2.3, elliptic to oblong, wall slightly thickened, minute apical pore, light brown to red brown. Clamp connections present. All hyphae inamyloid. Gregarious

on dead hardwood.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, 37°31′13.9″ N 130°52′01.7″ E, on dead hardwood, 3 Sep 2015, J. Y. Park, N. K. Kim, H. J. Cho, SFC20150903-34 (GenBank accession No. MF437005).

Remarks: Phaeomarasmius proximans shares similar cheilocystidia with Pholiota granulosa, but it is different



Fig. 3. Microscopic features of the 10 unrecorded species: A, *Deconica phyllogena*; B, *Mycena zephirus*; C, *Phaeomarasmius proximans*; D, *Phlebia radiata*; E, *Pluteus semibulbosus*; F, *Postia alni*; G, *Resinicium pinicola*; H, *Scytinostroma portentosum*; I, *Tricholomopsis flammula*; and J, *Tyromyces kmetii*. s, basidiospore; b, basidia; cc, cheilocystidia; pc, pleurocysidia; c, cystidia; gh, generative hyphae; d, dendrohyphidia.

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from *Pho. granulosa* in that the stipe did not darken from the base up. *Phae. curcuma* and *Phae. subechinatus* have similar pileus color to *Phae. proximans.* However, *Phae. curcuma* has a heavy veil in the stipe and *Phae. subechinatus* has much larger cheilocystidia, $26-40(50) \times 8-16 \mu m$ [49].

Phlebia radiata Fr., Syst. Mycol. (Lundae) 1: 427 (1821) (Figs. 2D and 3D).

Classification: Basidiomycota, Polyporales, Meruliaceae, *Phlebia.*

Basidiocarps resupinate, adnate, orbiculate-confluent. Hymenial radially and irregularly lamelliform or noduliferous, fimbrillate, surface purplish to whitish orange, margin white to reddish orange, In section subhyaline, membranaceous to cereous. Hyphal system monomitic; Generative hyphae with clamp connections. Cystidia $60.7-75.2-95.2 \times 7.2-8.8-11.5 \,\mu\text{m}$, clavate, smooth, thin-walled. Basidia $26.3-32.8-39.7 \times 3.9-4.6-4.9 \,\mu\text{m}$, narrowly clavate, with a basal clamp, 4-sterigmata, smooth, thin-walled. Basidiospores $4.7-5.0-5.4 \times 2.1-2.2-2.4 \,\mu\text{m}$, Q = 2.1-2.3-2.4, cylindrical to suballantoid, smooth, thin-walled.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, 37°30′45.9″ N, 130°51′58.3″ E, on dead hardwood, 20 Oct 2015, J. Y. Park, N. K. Kim & Y. W. Lim, SFC20151020-13 (GenBank accession No. MF437006).

Remarks: *Phlebia radiata* is morphologically similar to *Ph. rufa*, but it can be distinguished from *Ph. rufa* by purplish to whitish orange colors and a radially plicate hymenial surface [50].

Pluteus semibulbosus (Lasch) Quél., Mém. Soc. Émul. Montbéliard, Sér. 25: 543 (1875) (Figs. 2E and 3E).

Classification: Basidiomycota, Agaricales, Pluteaceae, *Pluteus*.

Pileus 10–25 mm, convex at first, becoming broadly convex with age, never umbonate, hygrophanous, radially striate toward margin, orange grey to brownish grey. Lamellae free, rather crowded, lamellulae present, white to cream, becoming pinkish with age. Stipe 15–30 × 2–4 mm, cylindrical, equal, with basal bulb, white to cream. Cheilocystidia 29.2–37.5–57.3 × 10.0–13.0–16.3 μ m, abundant, obovoid to utriform. Pleurocystidia 44.1–54.9–62.7 × 13.2–15.7–18.3 μ m, rare, utriform to broadly lageniform. Caulocystidia 24.3–37.1–48.3 × 9.2–11.6–14 μ m, clavate. Basidia 21.7–26.4–32.4 × 9.3–10.1–11.4 μ m, 4-spored, ovoid to utriform. Basidiospores 7.2–7.7–8.3 × 5.9–6.6–7.4 μ m, Q = 1.09–1.19–1.30 μ m, subglobose to broadly ellipsoidal. Clamp connections absent. Solitary on the dead stem of broad-leaved tree.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Nari basin, 37°31′25″ N, 130°51′44″ E, 3 Sep 2015, N. K. Kim, J. Y. Park, Y. W. Lim, SFC20150903-15 (GenBank accession No. MF437007).

Remarks: *Pluteus semibulbosus* is morphologically similar to *Pl. plautus* and *Pl. longistriatus*. It can be distinguished from *Pl. plautus* and *Pl. longistriatus* by its pale color and short stipe [51].

Postia alni Niemelä & Vampola, Karstenia 41: 7 (2001) (Figs. 2F and 3F).

Classification: Basidiomycota, Polyporales, Fomitopsidaceae, *Postia*.

Basidiocarps up to 20–30 mm long and 25–45 mm wide, annual, pileate, sessile, semiorbicular, effused-reflexed, soft and watery when fresh, hard when dry; upper surface slightly tomentose, pale yellow and white with blue-grey tint at the margin. Context up to 7 mm thick at the base, white. Pore 4–5 per mm, tube layer thick up to 10 mm at the base, pores circular, surface white or greyish. Hyphal system monomitic; generative hyphae with clamp connections, thin-walled and sometimes thicker-walled. Cystidia absent. Basidia 14.2–15.5–16.5 × 3.8–4.5–5.2 µm, clavate, 4-sterigmata with basal clamp. Basidiospores $4.8-5.1-5.4 \times 1.2-1.4-1.6$ µm, Q = 2.6-2.9-3.1, allantoid, thin-walled.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, 37°30′59.02″ N, 130°52′11.3″ E, on dead hardwood, 27 Sep 2016, M. S. Park, N. K. Kim & Y. W. Lim, SFC20160927-01 (GenBank accession No. MF437008). **Remarks:** *Postia alni* is morphologically similar to *Po. caesia*, but can be distinguished from *Po. caesia* by host; *Po. alni* grows on hardwoods, whereas *Po. caesia* occurs on conifers [52].

Resinicium pinicola (J. Erikss.) J. Erikss. & Hjortstam, in Eriksson, Hjortstam & Ryvarden, Cortic. N. Eur. (Oslo) 6: 1271 (1981) (Figs. 2G and 3G).

Classification: Basidiomycota, Hymenochaetales, Rickenellaceae, *Resinicium*.

Basidiocarps up to 1 mm long, resupinate, closely adnate, odontioid; aculei conical to cylindrical, yellowish in apical; whole fungus cereous, whitish in the edge. Hyphal system monomitic; thin-walled, hyphae with clamp connections. Cystidia (halocystidia) $33.2-34.7-37.5 \times 4.4-5.8-6.6 \,\mu$ m, halo $5.4-5.7-6.3 \,\mu$ m wide, thin-walled, filled with oily or grainy matter. Basidia $17.5-17.8-18.4 \times 4.8-5.5-6.1 \,\mu$ m, clavate, with a basal clamp, 4-sterigmata, smooth, thin-walled. Basidiospores $4.4-4.8-5.2 \times 1.5-2.1-2.5 \,\mu$ m, Q = 2.0-2.4-3.0, cylindrical, thin-walled, smooth, non-amyloid. **Specimen examined:** Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, $37^{\circ}30'45.8''$ N, $130^{\circ}51'58.5''$ E, on dead hardwood, 20 Oct 2016, J. Y. Park, N. K. Kim & Y. W. Lim, SFC20151020-15 (GenBank accession No. MF437009).

Remarks: *Resinicium pinicola* is morphologically similar to *R. chiricahuensis*. The latter species can be distinguished by lack of halocystidia and a grayish-white hymenial surface with very thin subiculum and cylindrical spores [53].

Scytinostroma portentosum (Berk. & M. A. Curtis) Donk, Fungus, Wageningen 26: 20 (1956) (Figs. 2H and 3H).

Classification: Basidiomycota, Russulales, Lachnocladiaceae, *Scytinostroma*.

Basidiocarps annual to perennial, resupinate, adnate, hard when dry; hymenial surface cream colored to luteous, smooth. Context in luteous, corky, brittle when dry, up to 3 mm thick. Hyphal system dimitic; generative hyphae rare, simple-septate, thin-walled, hyaline. Skeletal hyphae thick-walled. Dendrohyphidia in hymenial layers, thick-walled. Cystidia rare $35.9-45.0-51.2 \times 4.1-5.4-6.7 \mu$ m, more or less fusoid, thin-walled, hyaline. Basidia $30.7-36.8-43.6 \times 4.9-5.8-6.7 \mu$ m, more or less cylindrical, 4-sterigmata. Basidiospores $5.3-6.0-6.7 \times 5.2-6.1-6.8 \mu$ m, Q = 1.00-1.00-1.02, globose, thin-walled, hyaline, smooth.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, 37°30′40.8″ N, 130°51′50.5″ E, on dead hardwood, 14 Jul 2016, J. Y. Park, N. K. Kim & Y. W. Lim, SFC20160614-44 (GenBank accession No. MF437010).

Remarks: *Scytinostroma portentosum* is morphologically similar to *S. odoratum*. *S. odoratum* can be distinguished by lacking dendrohyphidia, a grayish white hymenial surface with very thin subiculum and cylindrical spores [54].

Tricholomopsis flammula Métrod ex Holec, J. Natl. Mus. (Prague) Nat. Hist. Ser. 178: 8 (2009) (Figs. 2I and 3I).

Classification: Basidiomycota, Agaricales, Tricholomataceae, *Tricholomopsis*.

Pileus 10–30 mm, convex at first, broadly convex to flat in age, pastel yellow to light yellow, with scattered red brown to purple scales. Lamellae adnate to subdecurrent, crowded, never branched, lamelluae abundant, cream to ochre. Stipe $15-45 \times 3-5$ mm, cylindrical, vertically fibrillose, tomentose with purple red color. Cheilocystidia $44.7-53.8-64 \times 15.8-18.5-22.2 \ \mu\text{m}$, pyriform, slightly thick-walled. Pleurocystidia very abundant, $39.9-44.3-50.7 \times 8.7-9.1-10.1 \ \mu\text{m}$, fusiform to clavate. Basidia $22.6-24.9-27.6 \times 5.1-6.1-6.7 \ \mu\text{m}$, clavate. Basidiospores $5.7-6.2-6.9 \times 3.5-3.9-4.3 \ \mu\text{m}$, Q = 1.5-1.6-1.8, ellipsoidal to oval. Clamp connections present. Solitary.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, 37°30'40.28" N, 130°51'38.34" E, on the trunk of dead hardwood, 20 Oct 2015, J. Y. Park, N. K. Kim, SFC20151020-25 (GenBank accession No. MF437012); Korea, Gyeongsangbuk-do, Ulleung-gun, Na-ri basin, 37°30'45.07" N, 130°51'58.30" E, on the trunk of dead pine tree, 27 Sep 2016, M. S. Park, N. K. Kim, SFC20160927-37 (GenBank accession No. MF437011).

Remarks: *Tricholomopsis flammula* is characterized by red brown to violet scales on the pileus and similar to *Tr. rutilans*. While basidiospores of *Tr. flammula* are ellipsoidal to oval with Q = 1.45-1.76, whereas basidiospores of *T. rutilans* are more round (Q = 1.3-1.4) [55].

Tyromyces kmetii (Bres.) Bondartsev & Singer (Figs. 2J and 3J).

Classification: Basidiomycota, Polyporales, Polyporaceae, *Tyromyces.*

Basidiocarps annual, pileate, sessile, applanate, semicircular, fleshy and watery when fresh, upper surface tomentose, shrinks with drying, becoming hard and brittle, apricot orange when fresh. Pore angular, thin-walled, 3–4 per mm, surface white when fresh, white to cream when dry.

Hyphal system monomitic; generative hyphae with clamp connections, hyaline, thin-walled. Cystidia absent. Cystidiols 13.8–16.4–18.8 × 3.9–4.3–4.9 μ m, fusiform, thin-walled. Basidia 13.3–14.9–16.9 × 4.1–4.8–5.7 μ m, clavate, 4-sterigmata. Basidiospores 3.7–4.3–5.0 × 2.1–2.5–3.0 μ m, Q = 1.5–1.7–2.0, broadly ellipsoid.

Specimen examined: Korea, Gyeongsangbuk-do, Ulleunggun, Na-ri basin, 37°30′43.8″ N, 130°51′54.5″ E, on dead hardwood, 2 Sep 2015, J. Y. Park, N. K. Kim, H. J. Cho & Y. W. Lim, SFC20150902-43 (GenBank accession No. MF437013).

Remarks: *Tyromyces kmetii* is easily distinguished from the other species of *Tyromyces* by apricot color, small size, mild taste, and broadly ellipsoid and small spores [45].

The published literature indicates that approximately 350 species have been detected from Ulleung Island [16-23]. This great diversity of fungi may be due to improved identification based on ITS sequences compared to traditional identification using solely morphological features. Our study found 10 unrecorded species in Korea and many new species candidates. Ulleung Island is a biodiversity hotspot in Korea. Regular surveys of the island's fungal diversity can provide valuable information that can inform the management and conservation of these ecosystems. Studies of fungal flora and new species on Ulleung Island are currently underway and will be presented in future studies.

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