

## RESEARCH NOTE

# Two Unrecorded Macrofungal Species from Sohwangbyeongsan in Korea

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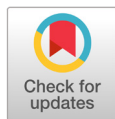
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## ABSTRACT

Indigenous fungi from Mount Sohwangbyeongsan, Odaesan National Park, Pyeongchang-gun, Gangwon-do, South Korea, were investigated between 2013 and 2016. Our survey identified a total of 137 macrofungi species. These species were systematically categorized into 2 phyla, 4 classes, 15 orders, 41 families, and 73 genera. We identified collected specimens to the species level based on their morphology and rDNA sequences. Two species-*Lentinellus flabelliformis* and *Tricholoma stans* were newly recorded as macromycota in Korea.

**Keywords:** Macrofungal flora, Odaesan National Park, Sohwangbyeongsan, Unrecorded species



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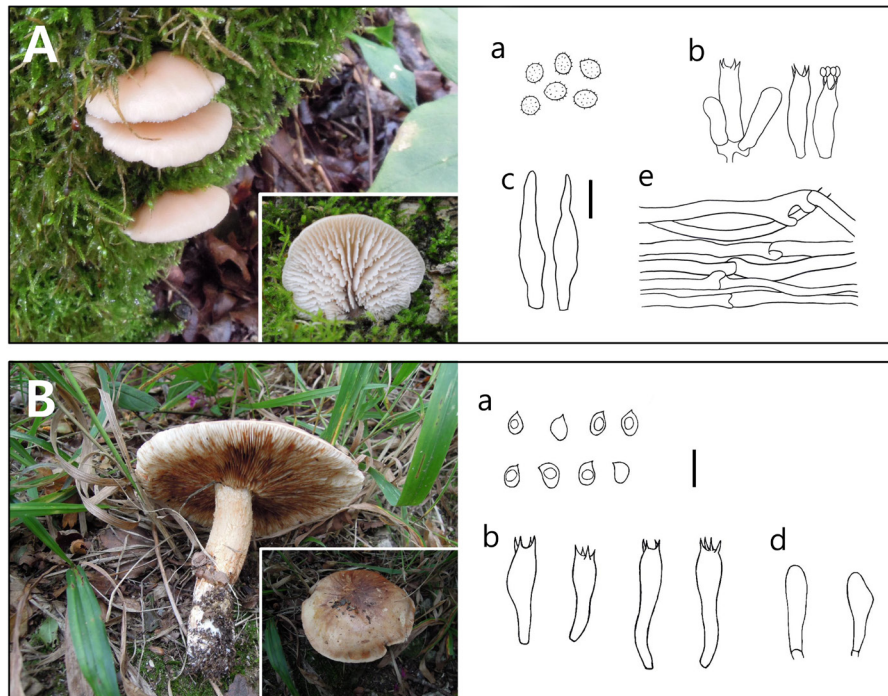
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Mount Sohwangbyeongsan, situated within the boundaries of Odaesan National Park in Pyeongchang-gun, Gangwon-do, was designated as an intensive investigation area from 2013 to 2016. This mountainous terrain includes both a military zone and an alpine meadow region. Portions of this area were designated as military protection zones, accessible exclusively with military authorization, resulting in reduced human interference and nature preservation. The higher altitudes of the mountain reveal vast grassy pastures with minimal forestation. Additionally, these high-altitude areas are frequently enveloped in fog, creating a consistently humid and distinctive environment conducive to mushroom growth. The military-restricted zones, with their limited public access and well-preserved natural conditions, presented an ideal opportunity for the discovery of new mushroom species. This research aimed to comprehensively assess the fungal diversity on Mt. Sohwangbyeongsan through a collection survey of native macrofungi. Through detailed taxonomic investigations of the specimens collected from the mountain, we sought to identify previously undocumented species. These newly recognized species have been included in the Korean National Species List [1], contributing to biodiversity research.

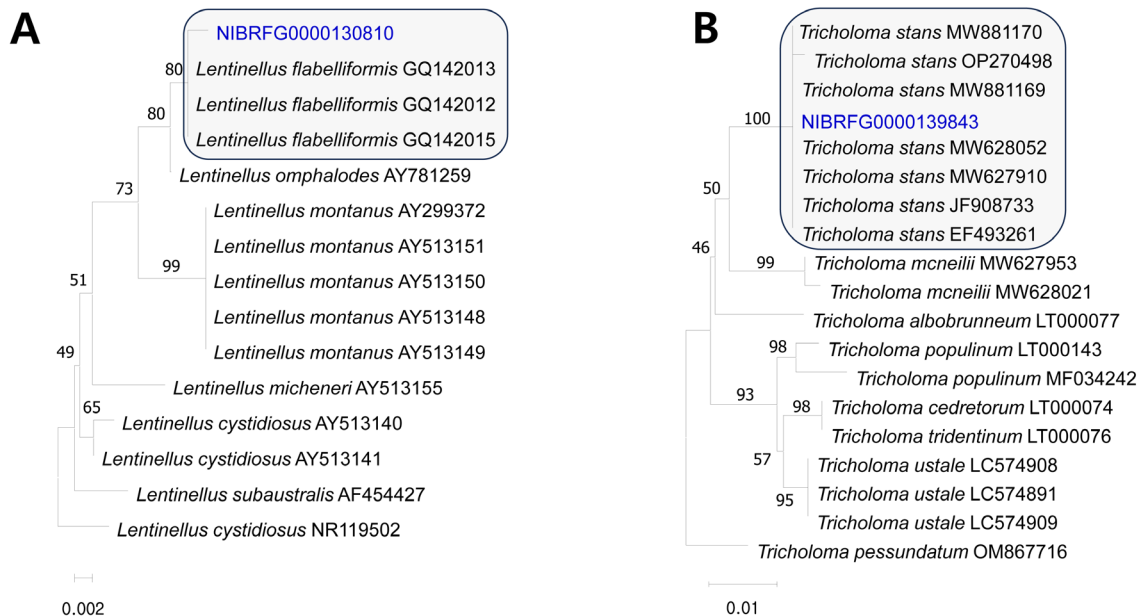
The Korean National Institute of Biological Resources conducted seven fungal collection surveys on Mt. Sohwangbyeongsan within Odaesan National Park between 2013 and 2016. During these surveys, a total of 214 mushroom specimens were obtained. Each specimen underwent preliminary identification based on its macroscopic morphology. When necessary, further identification was pursued through a detailed microstructure examination using a microscope. Measurements and drawings were conducted

employing a Nikon Eclipse 80i microscope (Nikon, Tokyo, Japan). In the process of identifying and describing two previously unrecorded species, twenty randomly selected mature basidiospores and basidia from each specimen were assessed and cross-referenced with published descriptions [2-7]. To facilitate genetic identification, total DNA was extracted from dried specimens using the AccuPrep Genomic DNA Extraction Kit (Bioneer, Daejeon, Korea). The internal transcribed spacer (ITS) region was then amplified using primers specifically designed for ITS1F and ITS4B [8]. DNA sequencing was performed at the DNA Synthesis and Sequencing Facility, Macrogen (Seoul, Korea) utilizing the primers mentioned above. The nucleotide sequences acquired were edited using MEGA 5 software [9] and subsequently deposited in GenBank. Species identities were verified by comparing the obtained nucleotide sequences with reference sequences from GenBank through BLASTn. A neighbor-joining phylogenetic analysis was executed within MEGA 5 software, incorporating Jukes–Cantor correction. The reliability of the inferred neighbor-joining topologies was assessed via 500 bootstrap replicates. Combining both morphological and phylogenetic analyses, all fungal taxa were enumerated and classified according to contemporary taxonomies. Taxonomic classification and nomenclature were assigned based on the Index Fungorum database (<http://www.indexfungorum.org/>).

The survey successfully identified a total of 137 macrofungi species in Mt. Sohwangbyeongsan within Odaesan National Park. These species were systematically categorized into 2 phyla, 4 classes, 15 orders, 41 families, and 73 genera (Appendix 1). Notably, this survey led to the discovery of two species—*Lentinellus flabelliformis* (Bolton) S. Ito 1959 and *Tricholoma stans* (Fr.) Sacc. 1887—marking their first recorded appearances in Korea. In this report, we provided photographic documentation of the fruiting bodies, detailed drawings of microscopic features (Fig. 1), comprehensive species descriptions, and insightful discussions. For scientific reference, the nucleotide sequences of these two species have been deposited in GenBank (accession numbers: OR701405 and OR976507). These sequences were compared to GenBank reference sequences and subsequently identified using ITS regions sequence analysis (Fig. 2). In particular, one specimen (NIBRFG0000130810) formed a distinct monophyletic clade with the reference sequence of *L. flabelliformis*, exhibiting a substantial bootstrap support of 90% and a sequence similarity of 99.7%. Likewise, another specimen (NIBRFG0000139843) established a monophyletic clade with the reference sequences of *T. stans*, marked by a robust bootstrap support of 100% and a sequence similarity of 100% (Fig. 2).



**Fig. 1.** Fruiting bodies and microscopic features of *Lentinellus flabelliformis* (A) and *Tricholoma stans* (B). a, basidiospores; b, basidia; c, pleurocystidia; d, basidioles; e, generative hyphae. Scale bar=10  $\mu$ m.



**Fig. 2.** Neighbor-joining tree of two 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. A, *Lentinellus flabelliformis*; B, *Tricholoma stans*.

A thorough examination of macrofungi species within Mt. Sohwangbyeongsan was conducted. A total of 214 collections were identified and classified down to the species level following contemporary classification systems, ultimately resulting in a comprehensive checklist comprising 137 species. These species, span across 7 families within the Ascomycota, including Helotiaceae, Sclerotiniaceae, Mollisiaceae, Leotiaceae, Helvellaceae, Pezizaceae, Cordycipitaceae, and Hypocreaceae. Additionally, we identified 128 species distributed among 34 families within the Basidiomycota, such as Agaricaceae, Amanitaceae, Amylocorticiaceae, Auriculariaceae, Auriscalpiaceae, Boletaceae, Clavulinaceae, Corticiaceae, Cortinariaceae, Crepidotaceae, Dacrybolaceae, Entolomataceae, Fomitopsidaceae, Ganodermataceae, Gomphaceae, Hydangiaceae, Hygrophoraceae, Hymenochaetaceae, Marasmiaceae, Meruliaceae, Mycenaceae, Omphalotaceae, Phallaceae, Physalacriaceae, Polyporaceae, Psathyrellaceae, Pterulaceae, Russulaceae, Schizophyllaceae, Sparassidaceae, Strophariaceae, Suillaceae, Tricholomataceae, and *Incertae sedis*. Among these, the families Amanitaceae, Boletaceae, Cortinariaceae, and Russulaceae emerge as dominant flora throughout the mountain (Appendix 1). Of notable interest, we confirmed the presence of two species, *L. flabelliformis* and *T. stans*, as new additions to the Korean fungal diversity. Although the number of fungal species may not be as extensive as those found in inland national parks, we uncovered a diverse spectrum of macrofungi within this area, highlighting the unique macrofungal flora of Mt. Sohwangbyeongsan. Given its location in the alpine region of the eastern Korean Peninsula and its remarkable array of previously undocumented fungal taxa, this mountain holds significant potential for phylogeographical research.

## Taxonomy

**Basidiomycota** R.T. Moore

**Agaricomycetes** Doweld

**Agaricales** Underw.

**Tricholomataceae** R. Heim ex Pouzar

***Tricholoma stans* (Fr.) Sacc.**, Sylloge Fungorum 5: 94 (1887)

**Korean name.** Gi-Dung-Song-I, nom. nov. (기둥송이),

Pileus 8 cm across, convex becoming almost planar, smooth, viscid, reddish brown to grey brown with a pale margin, very weakly striate. Gills white or cream to reddish brown, moderately crowded, emarginate. Stem initially white, becoming pale brown, cylindrical, smooth or finely longitudinally fibrillose, 7.5 cm long, 1.8 cm diameter, no stem ring. Flesh White, turning brownish when handled. Basidia clavate  $20.4\text{--}37.7 \times 5.2\text{--}7.5 \mu\text{m}$  with 4 sterigmata  $2.8\text{--}3.7 \mu\text{m}$  long. Basidiospores ellipsoidal, smooth,  $4.1\text{--}6.7 \times 3.1\text{--}5.0 \mu\text{m}$ . Spore print white. Odour/taste indistinct, farinaceous taste.

**Specimen examined:** NIBRFG0000139843 (37.76641N, 128.66808E; GenBank accession No. OR976507): habitat, soil, and solitary.

**Note:** *Tricholoma stans* is so rare that careful microscopic studies are required. *T. pesundatum* is a similar species; however, it differs in exhibiting a stronger farinaceous odor and taste, and its spores are significantly narrower.

**Russulales** Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David

**Auriscalpiaceae** Maas Geest.

***Lentinellus flabelliformis*** (Bolton) S. Ito 1959

**Korean name.** Pyeon-Sim-Teol-Neu-Ta-Ri, nom. nov. (편심털느타리),

Pileus 2.7 cm across, a thin, compact, hairy upper layer, and a thick, soft, white to light brown lower layer that is made of thin, thread-like filaments arranged, laterally stipitate. Stipe is similarly divided, with a thin, dark and hairy cortical layer covered by hairs, which encircles inner ochre-colored flesh.; Blades subdecurrent to decurrent, close to subspaced, with lamellae, whitish to pale brownish, with deeply toothed edges; Pleurocystidia fusoid to subclavate,  $27-48 \times 7.3-9.4 \mu\text{m}$ , hyaline with clamp connections; Basidia clavate  $27.7-30.5 \times 6.5-7.7 \mu\text{m}$  with 4 sterigmata  $2.1-3.3 \mu\text{m}$  long; Basidiospores subglobose to broadly ellipsoid, thin-walled, spinose with fine apicle, without germ pore, hyaline,  $5.6-7.0 \times 4.3-5.1 \mu\text{m}$ .

**Specimen examined:** NIBRFG0000130810 (37.76528N, 128.67183E; GenBank accession no. OR701405); habitat: dead hardwoods and conifers, solitary or gregarious.

**Note:** The species of *Lentinellus* is easy to identify because of their spinose and amyloid basidiospores. In particular, *L. flabelliformis* cannot be confused with any other taxon because it has laterally stipitated basidiomata and clamp connections.

## ACKNOWLEDGEMENTS

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## Appendix 1. List of macrofungi from Sohwangbyeongsan.

Scientific name	Specimen NIBR No.	Scientific name	Specimen NIBR No.
Ascomycota		<i>Amanita subjunquillea</i>	NIBRFG0000130726
Leotiomycetes		<i>Amanita vaginata</i>	NIBRFG0000130732 NIBRFG0000139703 NIBRFG0000139726
Helotiales		<i>Amanita virosa</i>	NIBRFG0000500896
Helotiaceae		<i>Amanita volvata</i>	NIBRFG0000130721
<i>Ascocoryne cylichnium</i>	NIBRFG0000139760	Cortinariaceae	
<i>Bisporella citrina</i>	NIBRFG0000139762	<i>Cortinarius anomalus</i>	NIBRFG0000130720
Mollisiaceae		<i>Cortinarius bolaris</i>	NIBRFG0000139766
<i>Tapesia fusca</i>	NIBRFG0000139761	<i>Cortinarius caperatus</i>	NIBRFG0000139765
Sclerotiniaceae		<i>Cortinarius hemitrichus</i>	NIBRFG0000139770 NIBRFG0000139782 NIBRFG0000139833 NIBRFG0000139837
<i>Sclerotinia sclerotiorum</i>	NIBRFG0000139826	<i>Cortinarius rubicundulus</i>	NIBRFG0000130823 NIBRFG0000139764 NIBRFG0000500902 NIBRFG0000500917 NIBRFG0000500897 NIBRFG0000500916
Leotiales		<i>Cortinarius tenuipes</i>	NIBRFG0000139758
Leotiaceae		<i>Cortinarius torvus</i>	NIBRFG0000139758
<i>Leotia lubrica</i>	NIBRFG0000130827	<i>Cortinarius violaceus</i>	NIBRFG0000130731
Pezizomycetes		<i>Thaxterogaster purpurascens</i>	NIBRFG0000130832
Pezizales		Crepidotaceae	
Helvellaceae		<i>Crepidotus applanatus</i>	NIBRFG0000139844
<i>Helvella ephippium</i>	NIBRFG0000139678	Entolomataceae	
<i>Helvella macropus</i>	NIBRFG0000139823	<i>Entocybe nitida</i>	NIBRFG0000139781
Sordariomycetes		Hydnangiaceae	
Hypocreales		<i>Laccaria laccata</i>	NIBRFG0000130814 NIBRFG0000139718
Cordycipitaceae		<i>Laccaria vinaceoavellanea</i>	NIBRFG0000139702
<i>Cordyceps kyusyuensis</i>	NIBRFG0000500908	Hygrophoraceae	
Hypocreaceae		<i>Hygrophorus eburneus</i>	NIBRFG0000130714
<i>Hypomyces luteovirens</i>	NIBRFG0000139701	Marasmiaceae	
Basidiomycota		<i>Marasmiellus candidus</i>	NIBRFG0000139683
Agaricomycetes		<i>Marasmius maximus</i>	NIBRFG0000130713
Agaricales		<i>Megacollybia marginata</i>	NIBRFG0000139776
Agaricaceae		<i>Mycetinis opacus</i>	NIBRFG0000139673
<i>Lycoperdon caudatum</i>	NIBRFG0000139724	<i>Rhodocollybia butyracea</i>	NIBRFG0000130812
<i>Lycoperdon perlatum</i>	NIBRFG0000139779 NIBRFG0000500920	Mycenaceae	
<i>Macrolepiota procera</i>	NIBRFG0000500906	<i>Mycena filipes</i>	NIBRFG0000139756
Amanitaceae		<i>Mycena polygramma</i>	NIBRFG0000139680
<i>Amanita fulva</i>	NIBRFG0000139736	<i>Panellus stipticus</i>	NIBRFG0000130816 NIBRFG0000500900
<i>Amanita punctata</i>	NIBRFG0000130813 NIBRFG0000130820 NIBRFG0000139730 NIBRFG0000139840 NIBRFG0000500905		
<i>Amanita rubrovolvata</i>			



Scientific name	Specimen NIBR No.	Scientific name	Specimen NIBR No.
Omphalotaceae		<i>Boletus ornatipes</i>	NIBRFG0000130712
<i>Gymnopus dryophilus</i>	NIBRFG0000500899	<i>Cyanoboletus pulverulentus</i>	NIBRFG0000139699
<i>Gymnopus erythropus</i>	NIBRFG0000139828	<i>Leccinum scabrum</i>	NIBRFG0000139769 NIBRFG0000500907
Physalacriaceae		<i>Leccinum versipelle</i>	NIBRFG0000139689 NIBRFG0000139695
<i>Armillaria gallica</i>	NIBRFG0000130821 NIBRFG0000139746	<i>Tylopilus eximius</i>	NIBRFG0000130727 NIBRFG0000139687
<i>Armillaria mellea</i>	NIBRFG0000139777	<i>Tylopilus vinosobrunneus</i>	NIBRFG0000130729
<i>Armillaria ostoyae</i>	NIBRFG0000139814	<i>Xerocomus chrysenteron</i>	NIBRFG0000130734
<i>Flammulina velutipes</i>	NIBRFG0000130824	Suillaceae	
<i>Hymenopellis raphanipes</i>	NIBRFG0000139700	<i>Suillus bovinus</i>	NIBRFG0000139706
<i>Oudemansiella venosolamellata</i>	NIBRFG0000500903	Cantharellales	
Psathyrellaceae		Clavulinaceae	
<i>Psathyrella candolleana</i>	NIBRFG0000139773	<i>Clavulina ornatipes</i>	NIBRFG0000139742 NIBRFG0000139780
<i>Psathyrella piluliformis</i>	NIBRFG0000139838	<i>Clavulina rugosa</i>	NIBRFG0000139754
Pterulaceae		Corticiales.	
<i>Radulomyces molaris</i>	NIBRFG0000500914	Corticaceae	
Schizophyllaceae		<i>Laeticorticium roseocarneum</i>	NIBRFG0000130833
<i>Schizophyllum commune</i>	NIBRFG0000500904	Gomphales	
Strophariaceae		Gomphaceae	
<i>Gymnopilus junonius</i>	NIBRFG0000139675	<i>Ramaria flava</i>	NIBRFG0000500898
<i>Hypholoma fasciculare</i>	NIBRFG0000139719	Hymenochaetales	
<i>Hypholoma sublateritium</i>	NIBRFG0000139830	Hymenochaetaceae	
<i>Pholiota lenta</i>	NIBRFG0000130826 NIBRFG0000139774	<i>Coltricia cinnamomea</i>	NIBRFG0000139771
<i>Pholiota lubrica</i>	NIBRFG0000139733 NIBRFG0000139763	<i>Coltricia perennis</i>	NIBRFG0000139723
<i>Pholiota squarrosa</i>	NIBRFG0000139734	<i>Hymenochaete intricata</i>	NIBRFG0000139721
Tricholomataceae		<i>Hymenochaete temuis</i>	NIBRFG0000139775
<i>Clitocybe gibba</i>	NIBRFG0000139735	<i>Inonotus mikadoi</i>	NIBRFG0000139690
<i>Lepista nuda</i>	NIBRFG0000130817 NIBRFG0000139819	<i>Inonotus nodulosus</i>	NIBRFG0000130811
<i>Tricholoma sejunctum</i>	NIBRFG0000500918	<i>Phellinus laevigatus</i>	NIBRFG0000139676
<i>Tricholoma stans</i>	NIBRFG0000139843	<i>Xanthoporia radiata</i>	NIBRFG0000130735
Incertae sedis		Phallales	
<i>Gloioxanthomyces nitidus</i>	NIBRFG0000139672	Phallaceae	
Amylocorticiales		<i>Pseudocolus schellenbergiae</i>	NIBRFG0000139674
Amylocorticaceae		Polyporales	
<i>Plicaturopsis crispa</i>	NIBRFG0000130818	Dacrybolaceae	
Auriculariales		<i>Postia caesia</i>	NIBRFG0000139834
Auriculariaceae		Fomitopsidaceae	
<i>Exidia recisa</i>	NIBRFG0000500921	<i>Laetiporus sulphureus</i>	NIBRFG0000139693
Boetales		Ganodermataceae	
Boletaceae		<i>Ganoderma applanatum</i>	NIBRFG0000139822



Scientific name	Specimen NIBR No.	Scientific name	Specimen NIBR No.
<b>Meruliaceae</b>		<i>Russula crustosa</i>	NIBRFG0000139752
<i>Crustodontia chrysocreas</i>	NIBRFG0000139684 NIBRFG0000130736	<i>Russula heterophylla</i>	NIBRFG0000130830
<i>Phlebia acerina</i>	NIBRFG0000139686	<i>Russula laccata</i>	NIBRFG0000139717
<i>Phlebia tremellosa</i>	NIBRFG0000130825	<i>Russula laurocerasi</i>	NIBRFG0000139720
<i>Stereopsis burtiana</i>	NIBRFG0000139751	<i>Russula lilacea</i>	NIBRFG0000139705 NIBRFG0000500901 NIBRFG0000130828 NIBRFG0000130831
<b>Polyporaceae</b>		<i>Russula mairei</i>	
	NIBRFG0000139750 NIBRFG0000139815 NIBRFG0000500919	<i>Russula omiensis</i>	NIBRFG0000500913
<i>Daedaleopsis confragosa</i>		<i>Russula puellaris</i>	NIBRFG0000139704
<i>Datronia mollis</i>	NIBRFG0000139816	<i>Russula sanguinea</i>	NIBRFG0000130722 NIBRFG0000139729
<i>Polyporus brevibasidiosus</i>	NIBRFG0000139696	<i>Russula senecis</i>	NIBRFG0000130716
<i>Polyporus brumalis</i>	NIBRFG0000139682	<i>Russula vesca</i>	NIBRFG0000130733 NIBRFG0000139697
<i>Trametes versicolor</i>	NIBRFG0000139818 NIBRFG0000146531	<i>Russula violeipes</i>	NIBRFG0000130822
<i>Tyromyces chioneus</i>	NIBRFG0000130815	<i>Russula virescens</i>	NIBRFG0000139740
<b>Sparassidaceae</b>		<i>Russula xerampelina</i>	NIBRFG0000139688
<i>Sparassis crispa</i>	NIBRFG0000130715		
<b>Russulales</b>			
<b>Auriscalpiaceae</b>			
<i>Artomyces pyxidatus</i>	NIBRFG0000130724 NIBRFG0000139692		
<i>Lentinellus flabelliformis</i>	NIBRFG0000130810		
<b>Russulaceae</b>			
<i>Lactarius auriolla</i>	NIBRFG0000139768		
<i>Lactarius cucurbitoides</i>	NIBRFG0000139685		
<i>Lactarius mitratus</i>	NIBRFG0000139725		
<i>Lactarius quietus</i>	NIBRFG0000130829 NIBRFG0000139738		
<i>Lactarius vietus</i>	NIBRFG0000500911		
<i>Lactarius volemus</i>	NIBRFG0000130723 NIBRFG0000139741 NIBRFG0000139842		
<i>Lactifluus glaucescens</i>	NIBRFG0000139744		
<i>Lactifluus koreamus</i>	NIBRFG0000139743		
<i>Lactifluus longistipes</i>	NIBRFG0000139745		
<i>Lactifluus orientivolemus</i>	NIBRFG0000500912		
<i>Lactifluus subquercicola</i>	NIBRFG0000500910 NIBRFG0000130718 NIBRFG0000130719 NIBRFG0000130725		
<i>Russula aeruginea</i>			
<i>Russula alboareolata</i>	NIBRFG0000139698		
<i>Russula albonigra</i>	NIBRFG0000139731 NIBRFG0000139732 NIBRFG0000130728 NIBRFG0000139694		
<i>Russula amoena</i>			
<i>Russula atropurpurea</i>	NIBRFG0000139708		
<i>Russula aurea</i>	NIBRFG0000139679		
<i>Russula brunneoviolacea</i>	NIBRFG0000139739		