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Unrecorded prokaryotic species belonging to the class *Actinobacteria* in Korea

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For the collection of indigenous prokaryotic species in Korea, 35 strains within the class *Actinobacteria* were isolated from various environmental samples (animals and clinical specimens) in 2017. Each strain showed high 16S rRNA gene sequence similarity (>98.8%) and formed a robust clade with recognized actinobacterial species. The isolates were assigned to 35 species, 22 genera, 15 families, and 8 orders of the class *Actinobacteria*. There are no official descriptions of these 35 bacterial species in Korea. Morphological properties, basic biochemical characteristics, isolation source, and strain IDs are included in the species descriptions.

Keywords: 16S rRNA sequence, *Actinobacteria*, unrecorded species

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Introduction

The class *Actinobacteria* is one of the dominant classes in the phylum *Actinobacteria*, which accommodates Gram-stain-positive bacteria with high G+C content in their DNA (Ventura *et al*., 2007). As of August 2018, the class *Actinobacteria* consisted of 18 orders, 48 families, and 379 genera (NCBI; https://www.ncbi.nlm.nih.gov/Taxonomy/). Also, 252 novel Korean indigenous species belonging to the class *Actinobacteria* were described and validated according to the List of Prokaryotic name with Standing in Nomenclature (LPSN) since February 2016 (Bae *et al*., 2016).

Members of the class *Actinobacteria* are abundantly distributed in terrestrial and aquatic environments (Servin *et al*., 2008) and are morphologically diverse, ranging from coccoid, fragmenting hyphal forms to those with a highly differentiated branched mycelium (Goodfellow and Williams, 1983). Many of these bacteria also produce external spores. Most actinobacterial species are saprophytic microorganisms but several genera are pathogenic to humans, animals, and plants. They are major producers of medically important antibiotics, particularly members of the genus *Streptomyces*, the most abundant group in this phylum (Barka *et al*., 2015). Also, members can have polymer-degradation activities and contribute to the biogeochemical cycling (Jendrossek *et al*., 1997).

In 2017, we isolated a great number of unrecorded prokaryotic species from diverse environmental samples, artificial sources, and clinical specimens in Korea. The present report focuses on the description 35 strains belonging to the class *Actinobacteria* which have not been previously isolated in Korea.

Materials and Methods

A total of 35 bacterial strains assigned to the class *Actinobacteria* were isolated from various environmental samples, animals and clinical specimens in 2017 (Table 1).

Table 1. The taxonomic affiliations of isolated strains belonging to the phylum *Actinobacteria*.

Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation		
						Source	Medium*	Incubation condition
Order *Actinomycetales*								
Actinomycetaceae	*Actinomyces*	CAU 1470	NIBRBAC000501230	*Actinomyces neuii* subsp. *anitratus*	99.9	Human urine	BHIA	37°C, 7d
Order *Corynebacteriales*								
Corynebacteriaceae	*Corynebacterium*	1_5_R2A	NIBRBAC000501001	*Corynebacterium freneyi*	99.0	Soil	R2A	30°C, 2d
		CAU 1475	NIBRBAC000501240	*Corynebacterium ureicelerivorans*	99.0	Human urine	BHIA	37°C, 3d
Dietziaceae	*Dietzia*	NA_1	NIBRBAC000500997	*Dietzia aerolata*	99.6	Soil	NA	30°C, 2d
		HC_48	NIBRBAC000501067	*Dietzia maris*	99.9	Soil	TSA	30°C, 3d
Mycobacteriaceae	*Mycobacterium*	D7-24	NIBRBAC000501036	*Mycobacterium brisbanense*	98.9	Mammal feces	NA	30°C, 12d
		GH1-18	NIBRBAC000501032	*Mycobacterium poriferae*	100	Tidal flat sediment	MA	30°C, 7d
		GH1-39	NIBRBAC000501045	*Mycobacterium pyrenivorans*	99.8	Tidal flat sediment	R2A	30°C, 10d
Nocardiaceae	*Nocardia*	Gsoil 1173	NIBRBAC000500993	*Nocardia rhamnosiphila*	99.4	Soil	R2A	30°C, 2d
Williamsiaceae	*Williamsia*	17J72-9	NIBRBAC000501341	*Williamsia phyllosphaerae*	99.7	Soil	R2A	25°C, 4d
Order *Micrococcales*								
Beutenbergiaceae	*Serinibacter*	IMCC34147	NIBRBAC000501099	*Serinibacter salmoneus*	99.9	Tidal flat sediment	R2A with seawater	25°C 3d
Cellulomonadaceae	*Cellulomonas*	17J27-1	NIBRBAC000501330	*Cellulomonas cellasea*	99.6	Soil	R2A	25°C, 4d
Intrasporangiaceae	*Knoellia*	17J28-11	NIBRBAC000501339	*Knoellia flava*	100	Soil	R2A	25°C, 4d
Microbacteriaceae	*Agromyces*	17J49-8	NIBRBAC000501344	*Agromyces salentinus*	99.7	Soil	R2A	25°C, 4d
		17J49-11	NIBRBAC000501345	*Agromyces ulmi*	98.8	Soil	R2A	25°C, 4d
	Leucobacter	Ibu_O_11	NIBRBAC000501082	*Leucobacter humi*	100	Soil	R2A	30°C, 2d
		Ibu_W2_3	NIBRBAC000501085	*Leucobacter margaritiformis*	99.4	Soil	R2A	30°C, 4d
	Microbacterium	AMX_O_4	NIBRBAC000501086	*Microbacterium resistens*	100	Soil	R2A	30°C, 1d
	Okibacterium	Ibu_O_21	NIBRBAC000501083	*Okibacterium fritillariae*	99.8	Soil	R2A	30°C, 2d
Micrococcaceae	*Arthrobacter*	LR2314	NIBRBAC000501176	*Arthrobacter gandavensis*	99.7	Chicken intestine	R2A	20°C, 7d
		MMS17-SY291	NIBRBAC000501212	*Arthrobacter halodurans*	99.7	Soil	NA	30°C, 3d
		LT2304	NIBRBAC000501177	*Arthrobacter luteolus*	99.8	Chicken intestine	TSA	20°C, 7d
		JMn2	NIBRBAC000501118	*Arthrobacter russicus*	100	Freshwater sediment	R2A	25°C, 3d
	Citricoccus	JMn10	NIBRBAC000501120	*Citricoccus nitrophenolicus*	99.9	Freshwater sediment	R2A	25°C, 3d
	Glutamicibacter	WD9	NIBRBAC000501125	*Glutamicibacter arilaitensis*	100	Seawater	MA	25°C, 2d
		LM3301	NIBRBAC000501182	*Glutamicibacter nicotianae*	99.7	Chicken intestine	MA	37°C, 7d
	Kocuria	KYW1377	NIBRBAC000501131	*Kocuria oceani*	99.8	Seawater	MA	25°C, 3d
		J1101	NIBRBAC000501337	*Kocuria salsicia*	100	Soil	R2A	25°C, 4d
	Micrococcus	ECSD18	NIBRBAC000501123	*Micrococcus flavus*	99.4	Seaweed	MA	25°C, 3d

Table 1. Continued.

Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation		
						Source	Medium*	Incubation condition
Order *Micromonosporales*								
Micromonosporaceae	*Dactylosporangium*	Gsoil 335	NIBRBAC000500984	*Dactylosporangium fulvum*	99.7	Soil	R2A	30°C, 2d
	Micromonospora	Gsoil 1175	NIBRBAC000500994	*Micromonospora endophytica*	99.7	Soil	R2A	30°C, 2d
		BE2-18	NIBRBAC000501034	*Micromonospora wenchangensis*	99.5	Tidal flat sediment	NA	30°C, 8d
Order *Propionibacteriales*								
Nocardioidaceae	*Nocardioides*	Gsoil 1130	NIBRBAC000500992	*Nocardioides aromaticivorans*	98.9	Soil	R2A	30°C, 2d
		17J48-16	NIBRBAC000501342	*Nocardioides exalbidus*	98.8	Soil	R2A	25°C, 4d
Order *Pseudonocardiales*								
Pseudonocardiaceae	*Amycolatopsis*	Gsoil 006	NIBRBAC000500982	*Amycolatopsis speibonae*	99.8	Soil	R2A	30°C, 2d
	Lentzea	Gsoil 262	NIBRBAC000501004	*Lentzea cavernae*	99.4	Soil	R2A	30°C, 2d
Order *Streptomycetales*								
Streptomycetaceae	*Streptomyces*	MMS17-SY284	NIBRBAC000501213	*Streptomyces caeruleatus*	99.4	Soil	NA	30°C, 5d
		MMS17-SY227	NIBRBAC000501209	*Streptomyces chartreusis*	99.3	Soil	NA	30°C, 3d
		MMS17-GJ001	NIBRBAC000500981	*Streptomyces mauvecolor*	99.9	Soil	ISP2, pH5	30°C, 5d
		Gsoil 961	NIBRBAC000500989	*Streptomyces scabrisporus*	100	Soil	R2A	30°C, 2d
		Gsoil 1526	NIBRBAC000500995	*Streptomyces seranimatus*	98.9	Soil	R2A	30°C, 2d
Order *Streptosporangiales*								
Streptosporangiaceae	*Microbispora*	Gsoil 554	NIBRBAC000500986	*Microbispora bryophytorum*	99.7	Soil	R2A	30°C, 2d

*Abbreviations: R2A, Reasoner's 2A; ISP2, international streptomyces project medium 2; BHIA, brain heart infusion; MA, marine agar; TSA, tryptic soy agar; NA, nutrient agar.

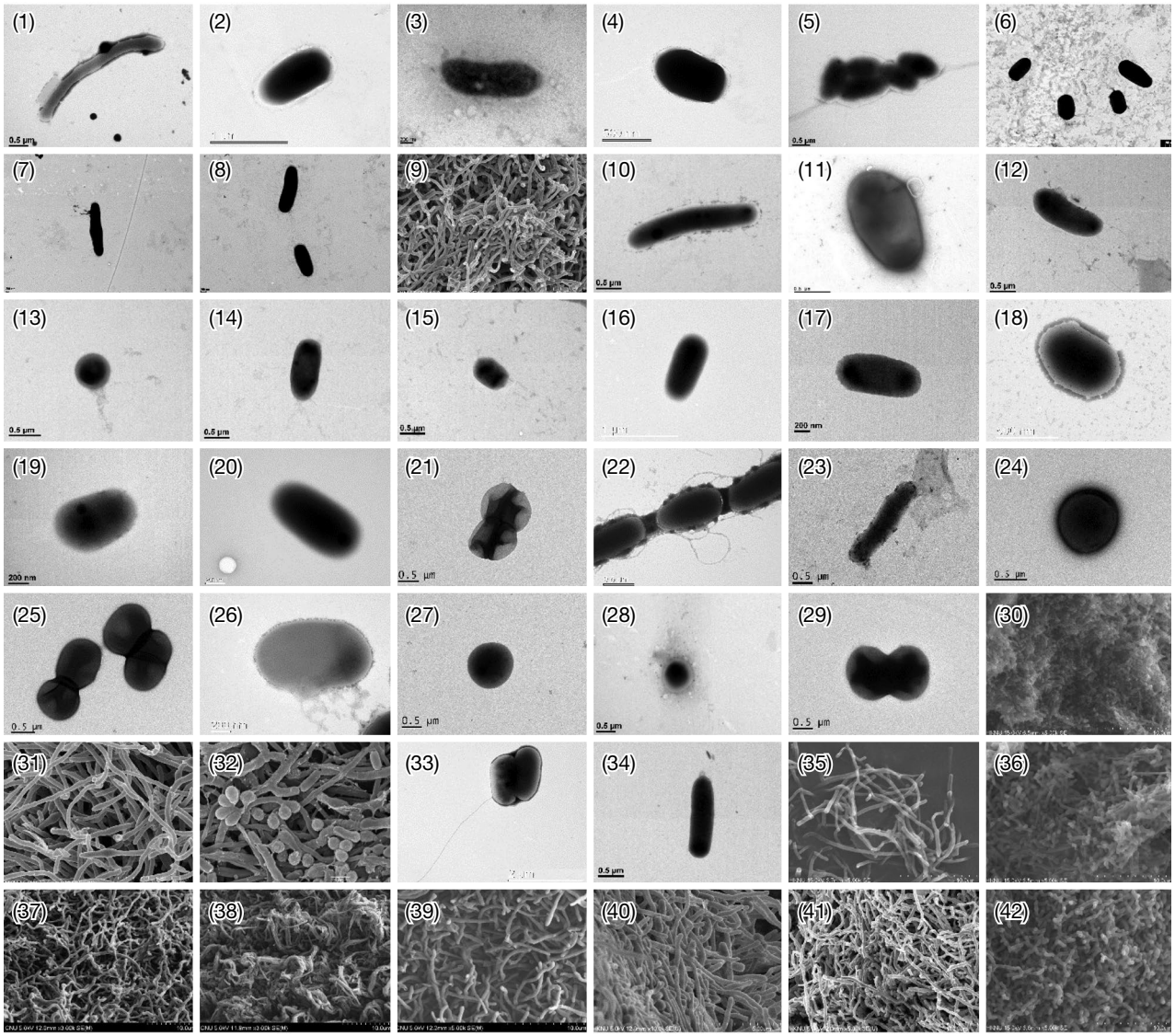

Fig. 1. Transmission electron micrographs or scanning electron micrographs of cells of the strains isolated in this study. Strains: 1, CAU 1470; 2, CAU 1475; 3, NA_1; 4, HC_48; 5, D7-24; 6, GH1-18; 7, GH1-39; 8, Gsoil 1173; 9, 17J72-9; 10, IMCC34147; 11, 17J28-11; 12, 17J49-8; 13, 17J49-11; 14, Ibu_O_11; 15, Ibu_O_21; 16, MMS17-SY291; 17, LT2304; 18, JMn2; 19, JMn10; 20, WD9; 21, LM3301; 22, KYW1377; 23, Gsoil 335; 24, Gsoil 1175; 25, BE2-18; 26, Gsoil 1130; 27, 17J48-16; 28, Gsoil 006; 29, Gsoil 262; 30, MMS17-SY284; 31, MMS17-SY227; 32, MMS17-GJ001; 33, Gsoil 961; 34, Gsoil 1526; 35, Gsoil 554.

Each sample was processed separately by spread onto a diverse culture agar media (Becton Dickinson) including Reasoner's 2A (R2A), international streptomyces project medium 2 (ISP2), brain heart infusion (BHIA), marine (MA), tryptic soy (TSA) and nutrient (NA) and incubated at 20-37°C for 1-12 days. All strains were purified as single colonies and stored as 10-20% glycerol suspension at −80°C as well as lyophilized ampoules.

Colony morphology of the strains was observed on agar plates with a magnifying glass after cells grew up to a stationary phase. Cellular morphology and cell size were examined by either transmission electron microscopy or scanning electron microscopy (Fig. 1). Biochemical characteristics were tested by using API 20NE galleries (bioMérieux) according to the manufacturer's instructions.

DNA extraction, PCR amplification, and 16S rRNA gene sequencing were carried out as described previously (Chun and Goodfellow, 1995). The 16S rRNA gene sequences of the strains assigned to the class *Actinobacteria* were compared with the sequences in GenBank by BLASTN and analyzed using the EzTaxon-e server (Kim *et al*., 2012). For phylogenetic analyses, multiple alignments were performed using Clustal_W (Thompson *et al*.,

1994) and gaps were edited in the BioEdit program (Hall, 1999). Evolutionary distances were calculated using the Jukes-Cantor model (Jukes and Cantor, 1969). Phylogenetic trees were constructed by using the neighbour-joining (Saitou and Nei, 1987), maximum-likelihood (Felsenstein, 1981), and maximum-parsimony (Fitch, 1971) methods in MEGA 6.0 (Tamura *et al*., 2013) with 1,000 bootstrap replicates (Felsenstein, 1985).

Results and Discussion

The 35 *Actinobacteria* strains are classified into 8 orders, 15 families, and 22 genera. The orders *Micrococcales* (13 strains) and *Corynebacteriales* (8 strains) were most common. The remaining orders are *Streptomycetales* (5 strains), *Micromonosporales* (3 strains), *Propionibacteriales* (2 strains), *Pseudonocardiales* (2 strains), *Actinomycetales* (1 strain), and *Streptosporangiales* (1 strain). Many isolates were affiliated with the families *Micrococcaceae* (7 strains) and *Microbacteriaceae* (4 strains) of the order *Micrococcales* and the family *Streptomycetaceae* (5 strains) of the order *Streptomycetales* (Table 1).

All the strains were isolated from diverse sources: 22 strains from soil, 4 strains from tidal flat sediment, 3 strains from animal intestine or feces, and 2 strains each from fresh water sediment, seawater, and clinical specimens. The geographic region where the strains were found is as follows: 14 strains from Gyeonggi Province, 6 strains from Jeju Province, 4 strains from Jeollannam Province, 3 strains each from Jeollabuk Province and Incheon City, 2 strains from Seoul City, and each one strain from Daejeon City, Busan City, and Gangwon Province.

These strains were Gram-stain-positive and chemoheterotrophic. Figure 2 shows phylogenetic assignment of the strains based on 16S rRNA gene sequences.

Here we report in detail about the 35 *Actinobacteria* species previously unrecorded in Korea.

Description of *Actinomyces neuii* subsp. *anitratus* CAU 1470

Cells are Gram-stain-positive, non-flagellated, and rod-shaped. Colonies are circular, convex, opaque, shiny, and cream colored after 7 days of incubation on BHIA at 37°C. Nitrate is reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of urease, gelatinase, β-galactosidase, and arginine dihydrolase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-mannitol, and D-maltose, whereas the strain does not utilize L-arabinose, D-mannose, *N*-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain CAU 1470 (=NIBRBAC000501230) was isolated from human urine, Kyunghee University Hospital, Korea.

Description of *Corynebacterium ureicelerivorans* CAU 1475

Cells are Gram-stain-positive, non-flagellated, and rod-shaped. Colonies are circular, flat, smooth, opaque, and cream colored after 3 days on BHIA at 37°C. Nitrate is not reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of gelatinase, β-galactosidase, and arginine dihydrolase, whereas the strain shows positive reaction for enzyme activity of urease. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, whereas the strain does not utilize L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain CAU 1475 (=NIBRBAC000501240) was isolated from human urine, Kyunghee University Hospital, Korea.

Description of *Dietzia aerolata* NA_1

Cells are Gram-stain-positive, non-flagellated, and oval shaped. Colonies are circular, convex, and pale-orange colored after 2 days on NA at 30°C. Nitrate is reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of urease, gelatinase, β-galactosidase, and arginine dihydrolase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, whereas the strain does not utilize L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain NA_1 (=NIBRBAC000500997) was isolated from a soil sample, Anseong, Gyeonggi Province, Korea.

Description of *Dietzia maris* HC_48

Cells are Gram-stain-positive, non-flagellated, and rod shaped. Colonies are circular and light-yellow colored after 3 days on TSA at 30°C. Nitrate is reduced and esculin is weakly hydrolyzed. The strain shows negative reactions for enzyme activities of oxidase, urease, β-galactosidase, and arginine dihydrolase, whereas the strain shows positive reaction for enzyme activity of gelatinase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, *N*-acetyl-glucosamine, D-maltose, and potassium gluconate, and weakly utilizes adipic acid and malic acid, whereas the strain does not utilize L-arabinose, D-mannose, D-mannitol, capric acid, trisodium citrate, and phenylacetic acid. Strain HC_48 (=NIBRBAC000501067) was isolated from a soil sample, Hwacheon, Gangwon Province, Korea.

Description of *Mycobacterium brisbanense* D7-24

Cells are Gram-stain-positive, non-flagellated, non-pig-

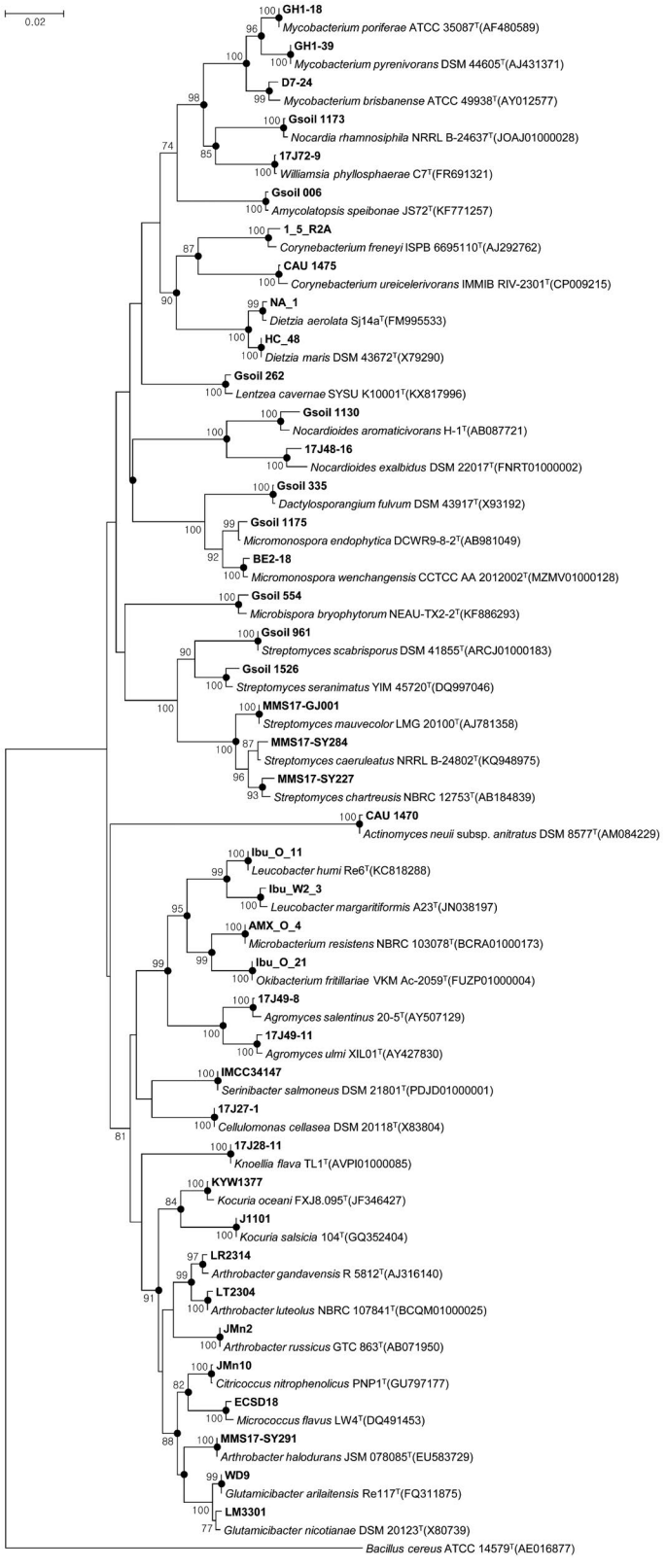

Fig. 2. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the class *Actinobacteria*. Bootstrap values (>70%) are shown above nodes. Filled circles indicate the nodes recovered by three other treeing methods including Maximum-likelihood, Maximum-parsimony and Neighbor-joining. Bar, 0.01 substitutions per nucleotide position.

mented, and rod-shaped. Colonies are punctiform, convex, entire, and cream colored after 12 days on NA at 30°C. Nitrate is reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of urease, gelatinase, β-galactosidase and arginine dihydrolase, whereas the strain shows positive reaction for enzyme activity of oxidase. Indole is not produced and glucose is not fermented. The strain utilizes *N*-acetyl-glucosamine, potassium gluconate and malic acid, and weakly utilizes D-mannitol, whereas the strain does not utilize L-arabinose, D-mannose, D-glucose, D-maltose, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain D7-24 (=NIBRBAC000501036) was isolated from mammal feces, Jeju, Korea.

Description of *Mycobacterium poriferae* GH1-18

Cells are Gram-stain-positive, non-flagellated, non-pigmented, and rod-shaped. Colonies are circular, convex, entire, and orange colored after 7 days on MA at 30°C. Nitrate is not reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of urease, gelatinase, β-galactosidase, and arginine dihydrolase, whereas the strain shows positive reaction for enzyme activity of oxidase. Indole is not produced and glucose is not fermented. The strain utilizes malic acid and weakly utilizes D-mannitol, whereas the strain does not utilize D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain GH1-18 (=NIBRBAC000501032) was isolated from tidal flat sediment, Incheon, Korea.

Description of *Mycobacterium pyrenivorans* GH1-39

Cells are Gram-stain-positive, non-flagellated, non-pigmented, and rod shaped. Colonies are circular, convex, entire, and pale-yellow colored after 10 days of incubation on R2A at 30°C. Nitrate is reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of urease, gelatinase, β-galactosidase and arginine dihydrolase, whereas the strain shows positive reaction for enzyme activity of oxidase. Indole is not produced and glucose is not fermented. The strain does not utilize D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine, D-maltose, D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain GH1-39 (=NIBRBAC000501045) was isolated from tidal flat sediment, Incheon, Korea.

Description of *Nocardia rhamnosiphila* Gsoil 1173

Cells are Gram-stain-positive, non-flagellated, and branched mycelium-forming. Colonies are filamentous, umbonate, and pale-orange colored after 2 days on R2A at 30°C. Nitrate is not reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of gelatinase and β-galactosidase, whereas the strain shows positive reactions for enzyme activities of urease, arginine dihydrolase, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, whereas the strain does not utilize D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine, D-maltose, D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain Gsoil 1173 (=NIBRBAC000500993) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Williamsia phyllosphaerae* 17J72-9

Cells are Gram-stain-positive, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and orange colored after 4 days on R2A at 25°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows negative reactions for enzyme activities of gelatinase and β-galactosidase, whereas the strain shows positive reactions for enzymes activities of urease and arginine dihydrolase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-maltose, D-mannitol, potassium gluconate, malic acid, and trisodium citrate, whereas the strain does not utilize L-arabinose, D-mannose, *N*-acetyl-glucosamine, capric acid, adipic acid, and phenylacetic acid. Strain 17J72-9 (=NIBRBAC000501341) was isolated from a soil sample, Jeju, Korea.

Description of *Serinibacter salmoneus* IMCC34147

Cells are Gram-stain-positive, non-flagellated, and rod-shaped. Colonies are circular, entire, raised, and cream beige-colored after 3 days incubation on R2A with seawater at 25°C. Nitrate is not reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of urease, gelatinase, and arginine dihydrolase, whereas the strain shows positives reactions for enzymes activities of β-galactosidase and oxidase. Indole is not produced and glucose is not fermented. The strain does not utilize D-glucose, L-arabinose, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, D-mannitol, D-mannose, malic acid, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain IMCC34147 (=NIBRBAC000501099) was isolated from tidal flat sediment, Incheon, Korea.

Description of *Knoellia flava* 17J28-11

Cells are Gram-stain-positive and cocci shaped. Colonies are circular, convex, smooth and yellow colored after 4 days on R2A at 25°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of urease, gelatinase, arginine dihydrolase, and β-galactosidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-mannose, and D-maltose, whereas the strain does not

utilize L-arabinose, D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, adipic acid, capric acid, malic acid, trisodium citrate, and phenylacetic acid. Strain 17J28-11 (=NIBRBAC000501339) was isolated from a soil sample, Jeju, Korea.

Description of *Agromyces salentinus* 17J49-8

Cells are Gram-stain-positive, non-flagellated, and rod shaped. Colonies are circular, convex, smooth, and pale-yellow colored after 4 days on R2A at 25°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of urease, arginine dihydrolase, and β-galactosidase, whereas the strain shows negative reaction for enzyme activity of gelatinase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, malic acid, and trisodium citrate, whereas the strain does not utilize adipic acid, capric acid, and phenylacetic acid. Strain 17J49-8 (=NIBRBAC000501344) was isolated from a soil sample, Jeju, Korea.

Description of *Agromyces ulmi* 17J49-11

Cells are Gram-stain-positive, non-flagellated, and rod shaped. Colonies are circular, convex, smooth, and yellow colored after 4 days on R2A at 25°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of urease and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase and gelatinase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, malic acid, and trisodium citrate, whereas the strain does not utilize capric acid and phenylacetic acid. Strain 17J49-11 (=NIBRBAC000501345) was isolated from a soil sample, Jeju, Korea.

Description of *Leucobacter humi* Ibu_O_11

Cells are Gram-stain-positive, non-flagellated, and rod shaped. Colonies are circular and white colored after 2 days on R2A at 30°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, urease, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-mannose, *N*-acetyl-glucosamine, D-maltose, malic acid, and trisodium citrate, whereas the strain does not utilize L-arabinose, D-mannitol, potassium gluconate, capric acid, adipic acid, and phenylacetic acid. Strain Ibu_O_11 (=NIBRBAC000501082) was isolated from a soil sample, Anseong, Gyeonggi Province, Korea.

Description of *Okibacterium fritillariae* Ibu_O_21

Cells are Gram-stain-positive, non-flagellated, and rod shaped. Colonies are circular, glistening, and pale yellow-colored after 2 days on R2A at 30°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of oxidase, gelatinase, and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase and urease. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, D-maltose, potassium gluconate, malic acid, and trisodium citrate, and weakly utilizes *N*-acetyl-glucosamine, whereas the strain does not utilize capric acid, phenylacetic acid, and adipic acid. Strain Ibu_O_21 (=NIBRBAC000501083) was isolated from a soil sample, Anseong, Gyeonggi Province, Korea.

Description of *Arthrobacter halodurans* MMS17-SY291

Cells are Gram-stain-positive and cocci-shaped. Colonies are circular, raised, opaque, glistening, and yellow colored after 3 days on NA at 30°C. Nitrate is not reduced and esculin is weakly hydrolyzed. The strain shows positive reactions for enzyme activities of oxidase and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, gelatinase, and urease. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-mannose, D-mannitol, D-maltose, potassium gluconate, malic acid, trisodium citrate, and phenylacetic acid, whereas the strain does not utilize L-arabinose, *N*-acetyl-glucosamine, capric acid and adipic acid. Strain MMS17-SY21 (=NIBRBAC000501212) was isolated from a soil sample, Sunyudo, Gunsan, Jeollabuk Province, Korea.

Description of *Arthrobacter luteolus* LT2304

Cells are Gram-stain-positive and coccus-ovoid-shaped. Colonies are circular, convex with entire margin, and beige colored after 7 days on TSA at 20°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reaction for enzyme activity of β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, gelatinase, urease, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, phenylacetic acid, and malic acid, whereas the strain does not utilize capric acid and trisodium citrate. Strain LT2304 (=NIBRBAC000501177) was isolated from a chicken intestine, Seoul Grand Park, Gyeonggi Province, Korea.

Description of *Arthrobacter russicus* JMn2

Cells are Gram-stain-positive, non-flagellated, non-pig-

mented, and rod shaped. Colonies are entire, smooth, circular, and cream colored after 3 days on R2A at 25°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, urease, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-mannose, D-maltose D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, malic acid, adipic acid, and trisodium citrate, whereas the strain does not utilize L-arabinose, phenylacetic acid and capric acid. Strain JMn2 (=NIBRBAC000501118) was isolated from freshwater sediment, Juam, Suncheon, Jeollanam Province, Korea.

Description of *Citricoccus nitrophenolicus* JMn10

Cells are Gram-stain-positive, non-flagellated, non-pigmented, and coccoid shaped. Colonies are circular, smooth, convex, entire, and pale-yellow colored after 3 days on R2A at 25°C. Nitrate is not reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities of arginine dihydrolase, gelatinase, β-galactosidase, urease, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, malic acid, and trisodium citrate, whereas the strain does not utilize L-arabinose, *N*-acetyl-glucosamine, D-maltose, D-mannose, D-mannitol, potassium gluconate, phenylacetic acid, capric acid, and adipic acid. Strain JMn10 (=NIBRBAC000501120) was isolated from freshwater sediment, Juam, Suncheon, Jeollanam Province, Korea.

Description of *Glutamicibacter arilaitensis* WD9

Cells are Gram-stain-positive, non-flagellated, non-pigmented, and rod-coccus shaped. Colonies are circular, smooth, convex, opaque, and pale-yellow colored after 2 days on MA at 25°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, urease, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-maltose, potassium gluconate, adipic acid, malic acid, trisodium citrate, and phenylacetic acid, whereas the strain does not utilize D-mannose, D-mannitol, *N*-acetyl-glucosamine, and capric acid. Strain WD9 (=NIBRBAC000501125) was isolated from seawater, Wando, Jeollanam Province, Korea.

Description of *Glutamicibacter nicotianae* LM3301

Cells are Gram-stain-positive, non-flagellated, and coccus shaped. Colonies are circular, convex with entire margin, and beige colored after 7 days on MA at 37°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reaction for enzyme activity of gelatinase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, β-galactosidase, urease, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-maltose, potassium gluconate, adipic acid, phenylacetic acid, malic acid, and trisodium citrate, whereas the strain does not utilize mannose, D-mannitol, *N*-acetyl-glucosamine, and capric acid. Strain LM3301 (=NIBRBAC000501182) was isolated from a chicken intestine, Seoul Grand Park, Gyeonggi Province, Korea.

Description of *Kocuria oceani* KYW1377

Cells are Gram-stain-positive, non-flagellated, non-pigmented, and coccoid shaped. Colonies are entire, circular, smooth, convex, and pale-orange colored after 3 days of incubation on MA at 25°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reaction for enzyme activity of β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, gelatinase, urease, and oxidase. Indole is produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannitol, D-maltose, potassium gluconate, adipic acid, and malic acid, whereas the strain does not utilize D-mannose, *N*-acetyl-glucosamine, capric acid, phenylacetic acid, and trisodium citrate. Strain KYW1377 (=NIBRBAC000501131) was isolated from seawater, Gwangyang, Jeollanam Province, Korea.

Description of *Dactylosporangium fulvum* Gsoil 335

Cells are Gram-stain-positive, non-flagellated, and mycelium-forming. Colonies are filamentous, umbonate and orange colored after 2 days on R2A at 30°C. Nitrate is reduced and esculin is not hydrolyzed. The strain shows positive reaction for enzyme activity of oxidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, gelatinase, urease, and β-galactosidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-maltose, adipic acid, and malic acid, whereas the strain does not utilize *N*-acetyl-glucosamine, D-mannitol, potassium gluconate, capric acid, trisodium citrate, and phenylacetic acid. Strain Gsoil 335 (=NIBRBAC000500984) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Micromonospora endophytica* Gsoil 1175

Cells are Gram-stain-positive, non-flagellated, and mycelium-forming with spore bearing. Colonies are circular, convex and orange colored after 2 days on R2A at 30°C. Nitrate is reduced and esculin is not hydrolyzed. The strain shows negative reactions for enzyme activities

of oxidase, arginine dihydrolase, gelatinase, urease, and β-galactosidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-maltose, and potassium gluconate, whereas the strain does not utilize D-mannitol, *N*-acetyl-glucosamine, malic acid, trisodium citrate, phenylacetic acid, capric acid, and adipic acid. Strain Gsoil 1175 (=NIBRBAC000500994) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Micromonospora wenchangensis* BE2-18

Cells are Gram-stain-positive, non-flagellated, non-pigmented, and mycelium-forming with spore bearing. Colonies are circular, entire, convex, and orange colored after 8 days on NA at 30°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase, oxidase, and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase and urease. Indole is not produced and glucose is not fermented. The strain utilizes L-arabinose, potassium gluconate, and weakly utilizes D-glucose and D-maltose, whereas the strain does not utilize D-mannose, D-mannitol, *N*-acetyl-glucosamine, capric acid, malic acid, trisodium citrate, adipic acid, and phenylacetic acid. Strain BE2-18 (=NIBRBAC000501034) was isolated from tidal flat sediment, Eulsukdo, Busan, Korea.

Description of *Nocardioidesa romaticivorans* Gsoil 1130

Cells are Gram-stain-positive, flagellated, and rod shaped. Colonies are circular, umbonate, and cream colored after 2 days on R2A at 30°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase, oxidase, and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase and urease. Indole is not produced and glucose is not fermented. The strain utilizes L-arabinose and potassium gluconate, and weakly utilizes D-glucose, L-arabinose, potassium gluconate, and malic acid, whereas the strain does not utilize *N*-acetyl-glucosamine, D-maltose, capric acid, trisodium citrate, D-mannose, D-mannitol, adipic acid, and phenylacetic acid. Strain Gsoil 1130 (=NIBRBAC000500992) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Nocardioides exalbidus* 17J48-16

Cells are Gram-stain-positive, non-flagellated, and rod shaped. Colonies are circular, convex, smooth, and cream colored after 4 days on R2A at 25°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of arginine dihydrolase, urease, gelatinase, and β-galactosidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-mannose, L-arabinose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, and malic acid, whereas the strain does not utilize adipic acid, capric acid, trisodium citrate, and phenylacetic acid. Strain 17J48-16 (=NIBRBAC000501342) was isolated from a soil sample, Jeju, Korea.

Description of *Amycolatopsis speibonae* Gsoil 006

Cells are Gram-stain-positive, non-flagellated, and branched mycelium-forming. Colonies are filamentous, umbonate, and cream colored after 2 days incubation on R2A at 30°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows negative reactions for enzyme activities of arginine dihydrolase, urease, gelatinase, β-galactosidase, and oxidase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, adipic acid, malic acid, and phenylacetic acid, whereas the strain does not utilize D-maltose, capric acid and trisodium citrate. Strain Gsoil 006 (=NIBRBAC000500982) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Lentzea cavernae* Gsoil 262

Cells are Gram-stain-positive, non-flagellated, and branched mycelium-forming. Colonies are filamentous, umbonate, and white colored after 2 days incubation on R2A at 30°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of oxidase and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase, gelatinase, and urease. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, and malic acid, whereas the strain does not utilize potassium gluconate, capric acid, trisodium citrate, adipic acid, and phenylacetic acid. Strain Gsoil 262 (=NIBRBAC000501004) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Streptomyces caeruleatus* MMS17-SY284

Cells are Gram-stain-positive, non-flagellated, and branched mycelium-forming. Colonies are circular, brittle, umbonate, opaque, and gray colored after 5 days incubation on NA at 30°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase, oxidase, and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase and urease. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol,

N-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, and malic acid, and weakly utilizes trisodium citrate and phenylacetic acid, whereas the strain does not utilize capric acid. Strain MMS17-SY284 (=NIBRBAC000501213) was isolated from a soil sample, Sunyudo, Gunsan, Jeollabuk Province, Korea.

Description of *Streptomyces chartreusis* MMS17-SY227

Cells are Gram-stain-positive, non-flagellated, non-pigmented, and branched mycelium-forming. Colonies are circular, convex, rough, entire and beige colored after 3 days of incubation on NA at 30°C. Nitrate is not reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase, oxidase and β-galactosidase, whereas the strain shows negative reactions for enzyme activities of arginine dihydrolase and urease. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, and malic acid, and weakly utilizes adipic acid, trisodium citrate and phenylacetic acid, whereas the strain does not utilize capric acid. Strain MMS17-SY227 (=NIBRBAC000501209) was isolated from soil, Gunsan, Jeollabuk Province, Korea.

Description of *Streptomyces mauvecolor* MMS17-GJ001

Cells are Gram-stain-positive, non-flagellated, pigmented, and branched mycelium-forming. Colonies are irregular, wrinkled, rough, and light-yellow colored after 5 days of incubation on ISP2 with pH 5 at 30°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of gelatinase, oxidase, urease, and β-galactosidase, whereas the strain shows negative reaction for enzyme activity of arginine dihydrolase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, *N*-acetyl-glucosamine and potassium gluconate, and weakly utilizes D-mannose, D-mannitol, and malic acid, whereas the strain does not utilize L-arabinose, D-maltose, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain MMS17-GJ001 (=NIBRBAC000500981) was isolated from a soil sample, Daejeon, Korea.

Description of *Streptomyces scabrisporus* Gsoil 961

Cells are Gram-stain-positive, non-flagellated, and branched mycelium-forming. Colonies are filamentous, umbonate, and pale-orange colored after 2 days of incubation on R2A at 30°C. Nitrate is not reduced and esculin is not hydrolyzed. The strain shows positive reaction for enzyme activity of oxidase, whereas the strain shows negative reactions for enzyme activities of gelatinase, urease, β-galactosidase, and arginine dihydrolase. Indole is not produced and glucose is not fermented. The strain utilizes potassium gluconate, adipic acid, and malic acid, whereas the strain does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, capric acid, trisodium citrate, and phenyl acetic acid. Strain Gsoil 961 (=NIBRBAC000500989) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Streptomyces seranimatus* Gsoil 1526

Cells are Gram-stain-positive, non-flagellated, and branched mycelium-forming. Colonies are circular, convex, and cream colored after 2 days of incubation on R2A at 30°C. Nitrate is reduced and esculin is not hydrolyzed. The strain shows positive reaction for enzyme activity of oxidase, whereas the strain shows negative reactions for enzyme activities of gelatinase, urease, β-galactosidase, and arginine dihydrolase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, D-mannose and *N*-acetyl-glucosamine, whereas the strain does not utilize L-arabinose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain Gsoil 1526 (=NIBRBAC000500995) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

Description of *Microbispora bryophytorum* Gsoil 554

Cells are Gram-stain-positive, non-flagellated, and mycelium-forming. Colonies are filamentous, umbonate, and brown colored after 2 days of incubation on R2A at 30°C. Nitrate is reduced and esculin is hydrolyzed. The strain shows positive reactions for enzyme activities of β-galactosidase and oxidase, whereas the strain shows negative reactions for enzyme activities of gelatinase, urease, and arginine dihydrolase. Indole is not produced and glucose is not fermented. The strain utilizes D-glucose, L-arabinose, *N*-acetyl-glucosamine, and potassium gluconate, whereas the strain does not utilize D-mannose, D-mannitol, D-maltose, capric acid, adipic acid, malic acid, trisodium citrate, and phenyl acetic acid. Strain Gsoil 554 (=NIBRBAC000500986) was isolated from a soil sample, Pocheon, Gyeonggi Province, Korea.

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