

Unrecorded bacterial species belonging to the phylum *Actinobacteria* originated from Republic of Korea

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As a subset study for the collection of Korean indigenous prokaryotic species, 62 bacterial strains belonging to the phylum *Actinobacteria* were isolated from various sources. Each strain showed higher 16S rRNA gene sequence similarity (>98.75%) and formed a robust phylogenetic clade with closest species of the phylum *Actinobacteria* which were defined with valid names, already. There is no official description on these 62 actinobacterial species in Korea. Consequently, unrecorded 62 species of 25 genera in the 14 families belonging to the order *Actinomycetales* of the phylum *Actinobacteria* were found in Korea. Morphological properties, basic biochemical characteristics, isolation source and strain IDs are described in the species descriptions.

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

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INTRODUCTION

During 2013 and 2014, the authors isolated a great number of unrecorded actinobacterial species from diverse environments in Korea. Natural environments which were used for the isolation sources were soils such as ginseng cultivating soil, biotite and natural cave, fresh water, seawater including tidal flat sediment, plant root and gut of birds and cattle. In addition, artificial environments such as fermented food and activated sludge were used for the actinobacterial isolation sources. The present report focuses on the description of unrecorded Korean indigenous species belonging to the phylum *Actinobacteria*.

The phylum *Actinobacteria* is one of the greatest groups in the domain Bacteria (Ludwig *et al.*, 2012). These bacteria are Gram-stain-positive microorganisms

with high G+C content in their DNA (Ventura *et al.*, 2007). Members of the phylum *Actinobacteria* are abundantly distributed in terrestrial or aquatic environments and are involving in the decomposition of the organic matter, and then in promoting crop production (Servin *et al.*, 2008). Most of the species which have medical or economic significance belong to the order *Actinomycetales* (Miao and Davies, 2010). Many actinobacterial species, especially members of the genus *Streptomyces* are recognized as the producers of many bioactive metabolites that are useful to humans in medicine, such as antibacterials, antifungals, antivirals, antithrombotics, immunomodifiers, anti-tumor drugs and enzyme inhibitors; and in agriculture, including insecticides, herbicides, fungicides and growth promoting substances for plants and animals (Bressan, 2003).

Until 2015, more than 250 Korean indigenous spe-

cies belonging to the phylum *Actinobacteria* have been isolated, described and validated according to the List of Prokaryotic name with Standing in Nomenclature (LPSN; <http://www.bacterio.net/>). As a part of results obtained from the research program supported by NIBR, the present report focuses on the description of bacterial species belonging to the phylum *Actinobacteria*, which have not been previously isolated in Korea. Here we report 62 unrecorded actinobacterial species in Korea.

MATERIALS AND METHODS

A total of 62 bacterial strains assigned to the phylum *Actinobacteria* were isolated from various environmental samples collected from soils such as ginseng cultivated soil, biotite and natural cave, fresh water, seawater including tidal flat sediment, plant root and gut of birds and cattle. In addition, artificial environments such as fermented food and activated sludge were used for the isolation sources (Table 1). Each sample was processed separately and spread onto diverse culture media (Becton Dickinson) including R2A, international streptomyces project medium 2 (ISP2), brain heart infusion (BHIA), 1/10 marine (1/10 MA), marine (MA), tryptic soy (TSA) and nutrient (NA) agars. Agar plates were incubated at 20-37°C for 1-16 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 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.

Bacterial DNA extraction, PCR amplification and 16S rRNA gene sequencing were performed using the standard procedures described elsewhere. The 16S rRNA gene sequences of the strains assigned to the phylum *Actinobacteria* were compared with the sequences held in GenBank by BLAST and also analyzed using the EzTaxon-e server (Kim *et al.*, 2012). For phylogenetic analyses, multiple alignments were performed using the Clustal_W program (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). The phylogenetic trees were constructed by using the neighbour-joining (Saitou and Nei, 1987), the maximum-likelihood (Felsenstein, 1981) and the maximum-parsimony (Fitch, 1971) methods with the MEGA 6.0 Program (Tamura *et al.*, 2013) with bootstrap values based on 1,000 replications (Felsenstein, 1985).

RESULTS AND DISCUSSION

All 62 strains belonged to order *Actinomycetales* and affiliated to 4 suborders and 15 families; 2 strains for *Cellulomonadaceae*, 1 strain for *Dermabacteraceae*, 1 strain for *Dermacoccaceae*, 3 strains for *Intrasporangiaceae*, 13 strains for *Microbacteriaceae*, 7 strains for *Micrococcaceae*, 2 strains for *Promicromonosporaceae* and 1 strain for *Sanguibacteraceae* (suborder *Micrococcineae*), 1 strain for *Pseudonocardiaceae* (suborder *Pseudonocardineae*), 2 strains for *Corynebacteriaceae*, 1 strain for *Dietziaceae*, 5 strains for *Mycobacteriaceae* and 6 strains for *Nocardiaceae* (suborder *Corynebacterineae*), and 17 strains for *Streptomyetaceae* (suborder *Streptomycineae*) (Table 1).

Isolation sources of the strains were as follows: 12 strains from ginseng cultivated soil, 11 strains from natural cave, 9 strains from soil, 8 strains from fresh water, 6 strains from sea water, 6 strains from gut of birds, each 2 strains from rhizosphere, black biotite, activated sludge and tidal flat sediment and each one strain from gut of Korean native cattle and Korean fermented food (jeotgal). Regional origins of the isolates were as follows: 21 strains from Gyeonggi, 11 strains from Jeju, 6 strains from Incheon, 5 strains from Chungbuk, 4 strains from Daejeon, each 3 strains from Busan, Jeonnam and Jeonbuk, each 2 strains from Gangwon and Chungnam and each one strain from Gyeongbuk and Seoul.

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

Here we report 62 unrecorded bacterial species in Korea belonging to the phylum *Actinobacteria*.

Description of *Cellulomonas denverensis* KHH20

Cells are Gram-staining-positive, non-flagellated and palisades shaped. Colonies are circular and yellow colored after 3 days on R2A at 25°C. Positive for esculin hydrolysis and β -galactosidase in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, L-arabinose, D-glucose, D-maltose, D-mannitol, D-mannose and potassium gluconate, but not utilize adipic acid, capric acid, malic acid, phenylacetic acid and trisodium citrate. Strain KHH20 (=NIBRBAC000497852) has been isolated from Gut of Japanese crested ibis (*Nipponia nippon*), Gyeonggi Province, Korea.

Description of *Cellulomonas soli* RDH8

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are glossy, watery, smooth and light yellow colored after 2 days on R2A at 3°C. Diffus-

Table 1. Taxonomic affiliation and isolation information of the isolates belonging to the phylum Actinobacteria.

| Suborder | Family | Genus | Strain ID | NIBR NO. | Most closely related species | Similarity (%) | Isolation | | Incubation condition |
|--------------------------|------------------------------|---------------------------|-------------------------------|--|--|-------------------------|--|-------------------|-----------------------------------|
| | | | | | | | Source | Medium | |
| <i>Micrococci</i> | <i>Cellulomonadaceae</i> | <i>Cellulomonas</i> | KHH20 | NIBRBAC000497852 | <i>Cellulomonas denverensis</i> W629 ^T | 99.64 | Gut of Japanese crested ibis | R2A | 25°C, 3d |
| | <i>Dermabacteraceae</i> | <i>Brachybacterium</i> | RDH8 Ho-10 | NIBRBAC000498079 NIBRBAC000498105 | <i>Cellulomonas soli</i> Kc1 ^T <i>Brachybacterium paraconglomeratum</i> LMG 19861 ^T | 99.64 99.93 | Fresh water Activated sludge | R2A R2A | 30°C, 2d 30°C, 2d |
| | <i>Dermabacteraceae</i> | <i>Dermacoccus</i> | KYW950 | NIBRBAC000497927 | <i>Dermacoccus barathri</i> MT2 ^T | 100.0 | Sea water | MA | 25°C, 3d |
| | <i>Intrasporangiaceae</i> | <i>Arsenicicoccus</i> | LPB0110 | NIBRBAC000497985 | <i>Arsenicicoccus bolidensis</i> CCUG 47306 ^T | 99.92 | Sea water | MA | 26°C, 1d |
| | | <i>Janibacter</i> | KYW1206 | NIBRBAC000497943 | <i>Janibacter indicus</i> 0704P10-1 ^T | 99.65 | Sea water | MA | 25°C, 4d |
| | | <i>Phycococcus</i> | HKS12 | NIBRBAC000498111 | <i>Phycococcus ochangensis</i> L1b-b9 ^T | 99.08 | Ginseng cultivated soil | R2A | 30°C, 2d |
| | <i>Microbacteriaceae</i> | <i>Agrococcus</i> | HKS25 | NIBRBAC000498117 | <i>Agrococcus lahaulensis</i> DSM 17612 ^T | 99.58 | Ginseng cultivated soil | R2A | 30°C, 2d |
| | | <i>Humibacter</i> | C4-1 | NIBRBAC000498029 | <i>Humibacter antri</i> D7-27 ^T | 99.72 | Natural cave | ISP2 | 30°C, 7d |
| | | <i>Lefsonia</i> | HKS09 | NIBRBAC000498109 | <i>Lefsonia lichena</i> 2Sb ^T | 98.75 | Ginseng cultivated soil | R2A | 30°C, 2d |
| | | <i>Microbacterium</i> | C7-7 C1-46 | NIBRBAC000498033 NIBRBAC000498021 | <i>Lefsonia soli</i> TG-S248 ^T <i>Microbacterium aoyamense</i> KV-492 ^T | 99.25 99.22 | Natural cave Natural cave | TSA TSA | 30°C, 4d 30°C, 7d |
| | | | HMF4427 | NIBRBAC000497916 | <i>Microbacterium arborescens</i> DSM 20754 ^T | 99.92 | Fermented food | MA | 30°C, 3d |
| | | | KHC15 | NIBRBAC000497842 | <i>Microbacterium esteraromaticum</i> DSM 8609 ^T | 99.79 | Gut of red-crowned crane | NA | 25°C, 3d |
| | | | IMCC25612 | NIBRBAC000498002 | <i>Microbacterium ketosireducens</i> DSM 12510 ^T | 100 | Fresh water | R2A | 20°C, 10d |
| | | | LPB0100 Ho-14 | NIBRBAC000497980 NIBRBAC000498106 | <i>Microbacterium marinum</i> H101 ^T <i>Microbacterium oleivorans</i> DSM 16091 ^T | 100.0 99.64 | Sea water Activated sludge | MA R2A | 26°C, 1d 30°C, 2d |
| | | | KHG7 | NIBRBAC000497857 | <i>Microbacterium paraoxydans</i> CF36 ^T | 99.57 | Gut of red-crowned crane | NA | 25°C, 3d |
| | | | DO214 | NIBRBAC000498052 | <i>Microbacterium schleiferi</i> IFO 15075 ^T | 99.69 | Fresh water | R2A | 25°C, 2d |
| | | <i>Mycetocola</i> | IMCC25611 | NIBRBAC000498001 | <i>Mycetocola miduensis</i> MD-T1-10-2 ^T | 99.50 | Fresh water | R2A | 20°C, 10d |
| | | <i>Arthrobacter</i> | HMF3875 KHK4 | NIBRBAC000497900 NIBRBAC000497856 | <i>Arthrobacter bergerei</i> CIP 108036 ^T <i>Arthrobacter nicotianae</i> DSM 20123 ^T | 99.93 99.78 | Soil Gut of red-crowned crane | R2A TSA | 30°C, 3d 25°C, 3d |
| | | <i>Kocuria</i> | IMCC25615 LPB0092 bT304 | NIBRBAC000498005 NIBRBAC000497975 NIBRBAC000497862 | <i>Kocuria marina</i> KMM 3905 ^T <i>Kocuria palustris</i> DSM 11925 ^T <i>Kocuria rhizophila</i> DSM 11926 ^T | 99.86 99.85 99.08 | Fresh water Soil Gut of Korean native cattle | R2A MA BHIA | 20°C, 10d 26°C, 2d 37°C, 3d |
| | | <i>Nesterenkonia</i> | UT 4-03 | NIBRBAC000498084 | <i>Nesterenkonia lacuskehoensis</i> IFAM EL-30 ^T | 100 | Plant root | TSA | 30°C, 5d |
| | | <i>Zhihengliuella</i> | LPB0101 | NIBRBAC000497981 | <i>Zhihengliuella flava</i> H85-3 ^T | 99.23 | Sea water | MA | 26°C, 2d |
| | <i>Promicromonosporaceae</i> | <i>Cellulosimicrobium</i> | KHC19 | NIBRBAC000497851 | <i>Cellulosimicrobium funkei</i> ATCC BAA-886 ^T | 99.86 | Gut of Japanese crested ibis | R2A | 25°C, 3d |
| | | <i>Promicromonospora</i> | C6-16 | NIBRBAC000498031 | <i>Promicromonospora flava</i> CC 0387 ^T | 99.16 | Natural cave | R2A | 30°C, 3d |
| | <i>Sanguibacteraceae</i> | <i>Sanguibacter</i> | IMCC25604 | NIBRBAC000497994 | <i>Sanguibacter suarezii</i> ST26 ^T | 99.86 | Fresh water | 1/10 MA | 20°C, 10d |
| <i>Pseudonocardineae</i> | <i>Pseudomonocardiaceae</i> | <i>Saccharopolyspora</i> | KYW998 | NIBRBAC000497925 | <i>Saccharopolyspora endophlytica</i> YIM 61095 ^T | 99.86 | Sea water | MA | 25°C, 3d |

Table 1. Continued.

| Suborder | Family | Genus | Strain ID | NIBR NO. | Most closely related species | Similarity (%) | Isolation | | |
|-------------------|--------------------|---|-----------|-------------------------|---|----------------|------------------------------|--------|----------------------|
| | | | | | | | Source | Medium | Incubation condition |
| Corynebacterineae | Corynebacteriaceae | <i>Corynebacterium</i> | HKS28 | NIBRBAC000498118 | <i>Corynebacterium freneyi</i> ISPB 6695110 ^T | 99.63 | Ginseng cultivated soil | R2A | 30°C, 2d |
| | | | Cip10 | NIBRBAC000498060 | <i>Corynebacterium marinum</i> 7015 ^T | 99.85 | Tidal flat | MA | 30°C, 2d |
| | | | IMCC25613 | NIBRBAC000498003 | <i>Dietzia timorensis</i> ID05-A0528 ^T | 99.50 | Fresh water | R2A | 20°C, 10d |
| | | | C3-50 | NIBRBAC000498028 | <i>Mycobacterium alvei</i> CIP 103464 ^T | 99.29 | Natural cave | TSA | 30°C, 10d |
| | | | HKS22 | NIBRBAC000498114 | <i>Mycobacterium hodleri</i> DSM 44183 ^T | 99.72 | Ginseng cultivated soil | R2A | 30°C, 2d |
| | | | C6-12 | NIBRBAC000498030 | <i>Mycobacterium obuense</i> ATCC 27023 ^T | 99.44 | Natural cave | ISP2 | 30°C, 3d |
| | | | C10-13 | NIBRBAC000498035 | <i>Mycobacterium senegalense</i> CIP 104941 ^T | 99.00 | Natural cave | agar | 30°C, 7d |
| | | | C6-18 | NIBRBAC000498032 | <i>Mycobacterium sphagni</i> DSM 44076 ^T | 99.30 | Natural cave | R2A | 30°C, 16d |
| | | | G1 | NIBRBAC000498066 | <i>Rhodococcus cerastii</i> C5 ^T | 99.48 | Tidal flat | R2A | 30°C, 2d |
| | | | KHO6 | NIBRBAC000497838 | <i>Rhodococcus fascians</i> LMG 3623 ^T | 99.00 | Gut of Japanese crested ibis | NA | 25°C, 3d |
| | | | C1-60 | NIBRBAC000498022 | <i>Rhodococcus kronopolitis</i> NEAU-ML12 ^T | 99.72 | Natural cave | TSA | 30°C, 3d |
| | | | C3-42 | NIBRBAC000498026 | <i>Rhodococcus wratislaviensis</i> NBRC 100605 ^T | 99.50 | Natural cave | ISP2 | 30°C, 5d |
| Streptomycineae | Streptomycetaceae | <i>Streptomyces</i> | C2-18 | NIBRBAC000498023 | <i>Williamsia maris</i> SJS0289-JS1 ^T | 99.71 | Natural cave | TSA | 30°C, 9d |
| | | | IMCC25607 | NIBRBAC000497997 | <i>Williamsia muralis</i> MA140/96 ^T | 100.00 | Fresh water | R2A | 20°C, 7d |
| | | | BK129 | NIBRBAC000498091 | <i>Streptomyces cockleensis</i> BK168 ^T | 98.96 | Plant root | ISP2 | 30°C |
| | | | MG3Y-3-1 | NIBRBA0000114269 | <i>Streptomyces coelicoflavus</i> NBRC 15399 ^T | 100 | Ginseng cultivated soil | MA | 30°C, 3d |
| | | | MG3Y-3-4 | NIBRBA0000114270 | <i>Streptomyces colombiensis</i> NRRL B-1990 ^T | 100 | Ginseng cultivated soil | MA | 30°C, 3d |
| | | | HKS20 | NIBRBAC000498113 | <i>Streptomyces crystallinus</i> NBRC 15401 ^T | 99.24 | Ginseng cultivated soil | R2A | 30°C, 1d |
| | | | TW1K13 | NIBRBAC000498097 | <i>Streptomyces cystabanicus</i> K04-0144 ^T | 99.56 | Soil | ISP2 | 30°C, 7d |
| | | | TW1K14 | NIBRBAC000498098 | <i>Streptomyces griseoplanus</i> NBRC 12779 ^T | 99.92 | Soil | ISP2 | 30°C, 7d |
| | | | BBT-4 | NIBRBA0000114215 | <i>Streptomyces kanamyceticus</i> NBRC 13414 ^T | 99.79 | Black biotite | R2A | 25°C, 2d |
| | | | Tri-200-1 | NIBRBAC000498080 | <i>Streptomyces laculatispora</i> BK166 ^T | 99.86 | Soil | R2A | 30°C, 2d |
| | | | TW1K20 | NIBRBAC000498099 | <i>Streptomyces lannensis</i> TA4-8 ^T | 100 | Soil | ISP2 | 30°C, 7d |
| | | | BBT-7 | NIBRBA0000114216 | <i>Streptomyces lienomycini</i> LMG 20091 ^T | 99.93 | Black biotite | R2A | 25°C, 2d |
| TW1M1 | NIBRBAC000498100 | <i>Streptomyces lucensis</i> NBRC 13056 ^T | 99.11 | Soil | ISP2 | 30°C, 7d | | | |
| TW1K17 | NIBRBAC000498101 | <i>Streptomyces mirabilis</i> NBRC 13450 ^T | 99.41 | Soil | ISP2 | 30°C, 7d | | | |
| HKS13 | NIBRBAC000498112 | <i>Streptomyces misakensis</i> NBRC 12891 ^T | 99.37 | Ginseng cultivated soil | R2A | 30°C, 1d | | | |
| MEC3Y-3-1 | NIBRBA0000114268 | <i>Streptomyces prunicolor</i> NBRC 13075 ^T | 99.71 | Ginseng cultivated soil | MA | 30°C, 3d | | | |
| TW1S1 | NIBRBAC000498102 | <i>Streptomyces puniscabiei</i> S77 ^T | 99.14 | Soil | ISP2 | 30°C, 7d | | | |
| MMD3Y-3-3 | NIBRBA0000114279 | <i>Streptomyces rishiriensis</i> NBRC 13407 ^T | 99.79 | Ginseng cultivated soil | MA | 30°C, 3d | | | |
| MK6Y-2-3 | NIBRBA0000114273 | <i>Streptomyces turgidiscabies</i> ATCC 700248 ^T | 99.16 | Ginseng cultivated soil | MA | 30°C, 3d | | | |

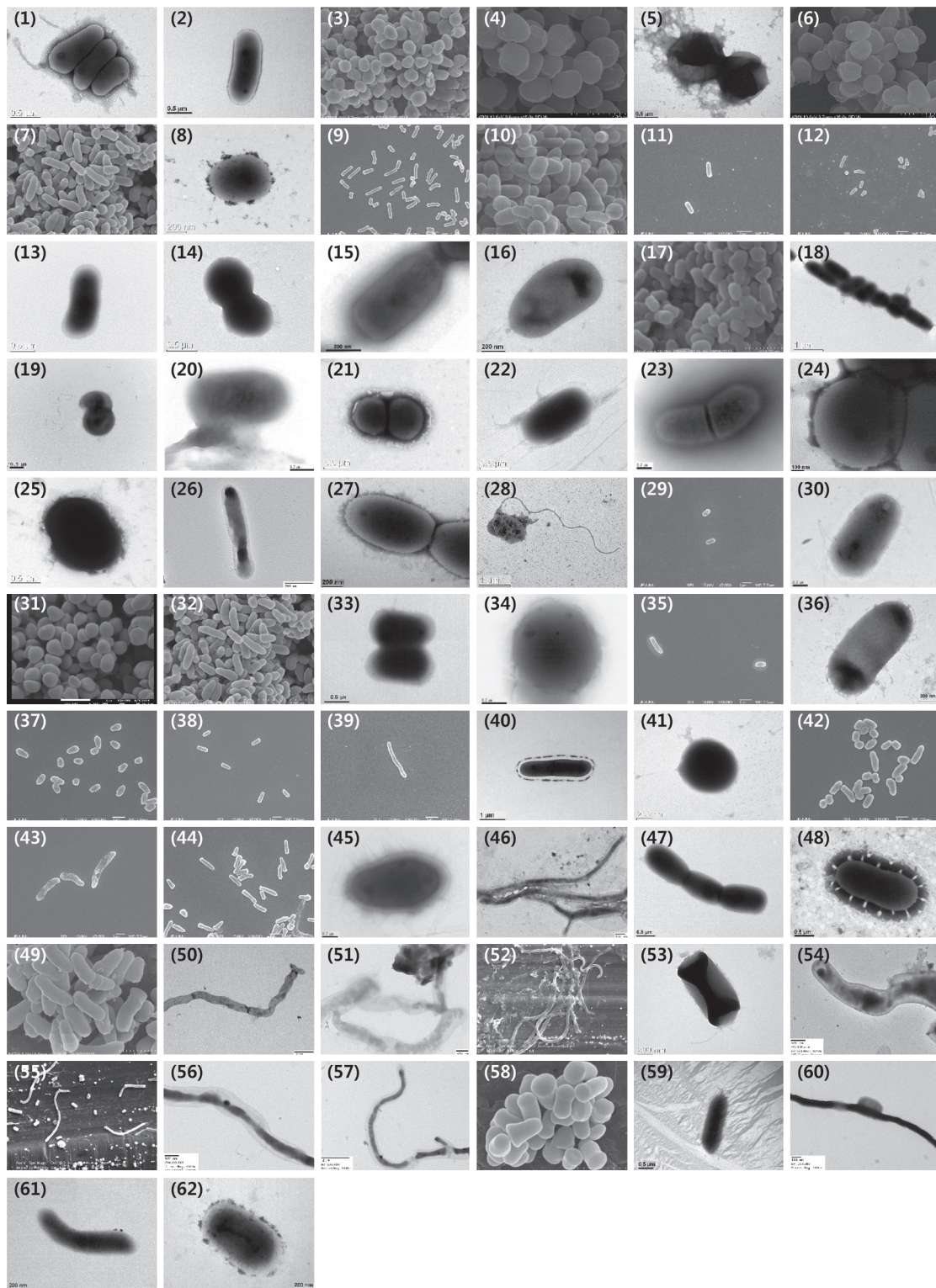


Fig. 1. Transmission electron micrographs or scanning electron micrographs of cells of the strains isolated in this study. Strains: 1, KHH20; 2, RDH8; 3, Ho-10; 4, KYW950; 5, LPB0110; 6, KYW1206; 7, HKS12; 8, HKS25; 9, C4-1; 10, HKS09; 11, C7-7; 12, C1-46; 13, HMF4427; 14, KHC15; 15, IMCC25612; 16, LPB0100; 17, Ho-14; 18, KHG7; 19, DO214; 20, IMCC25611; 21, HMF3875; 22, KHK4; 23, IMCC25615; 24, LPB0092; 25, bT304; 26, UT 4-03; 27, LPB0101; 28, KHC19; 29, C6-16; 30, IMCC25604; 31, KYW998; 32, HKS28; 33, Cip10; 34, IMCC25613; 35, C3-50; 36, HKS22; 37, C6-12; 38, C10-13; 39, C6-18; 40, G1; 41, KHO6; 42, C1-60; 43, C3-42; 44, C2-18; 45, IMCC25607; 46, BK1129; 47, MGS3Y-3-1; 48, MGS3Y-3-4; 49, HKS20; 50, TW1K13; 51, TW1K14; 52, BBT-4; 53, Tri-200-1; 54, TW1K20; 55, BBT-7; 56, TW1M1; 57, TW1K17; 58, HKS13; 59, MEC3Y-3-1; 60, TW1S1; 61, MMD3Y-3-3; 62, MK6Y-2-3.

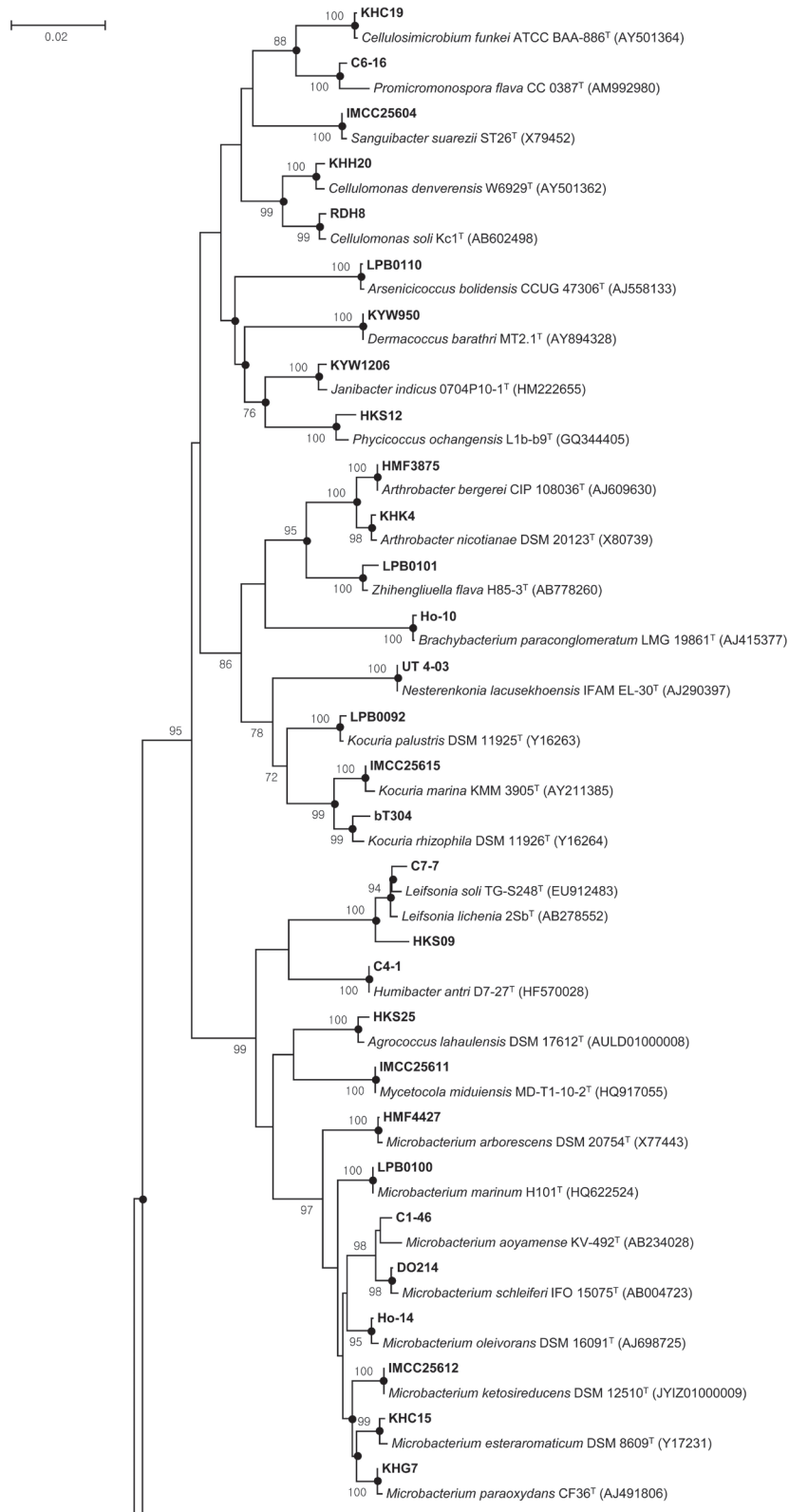


Fig. 2. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the phylum *Actinobacteria*. Bootstrap values (>70%) are shown above nodes. Filled circles indicate the nodes recovered by three other treeing methods including maximum likelihood, maximum parsimony, and neighbor joining. Bar, 0.02 substitutions per nucleotide position.

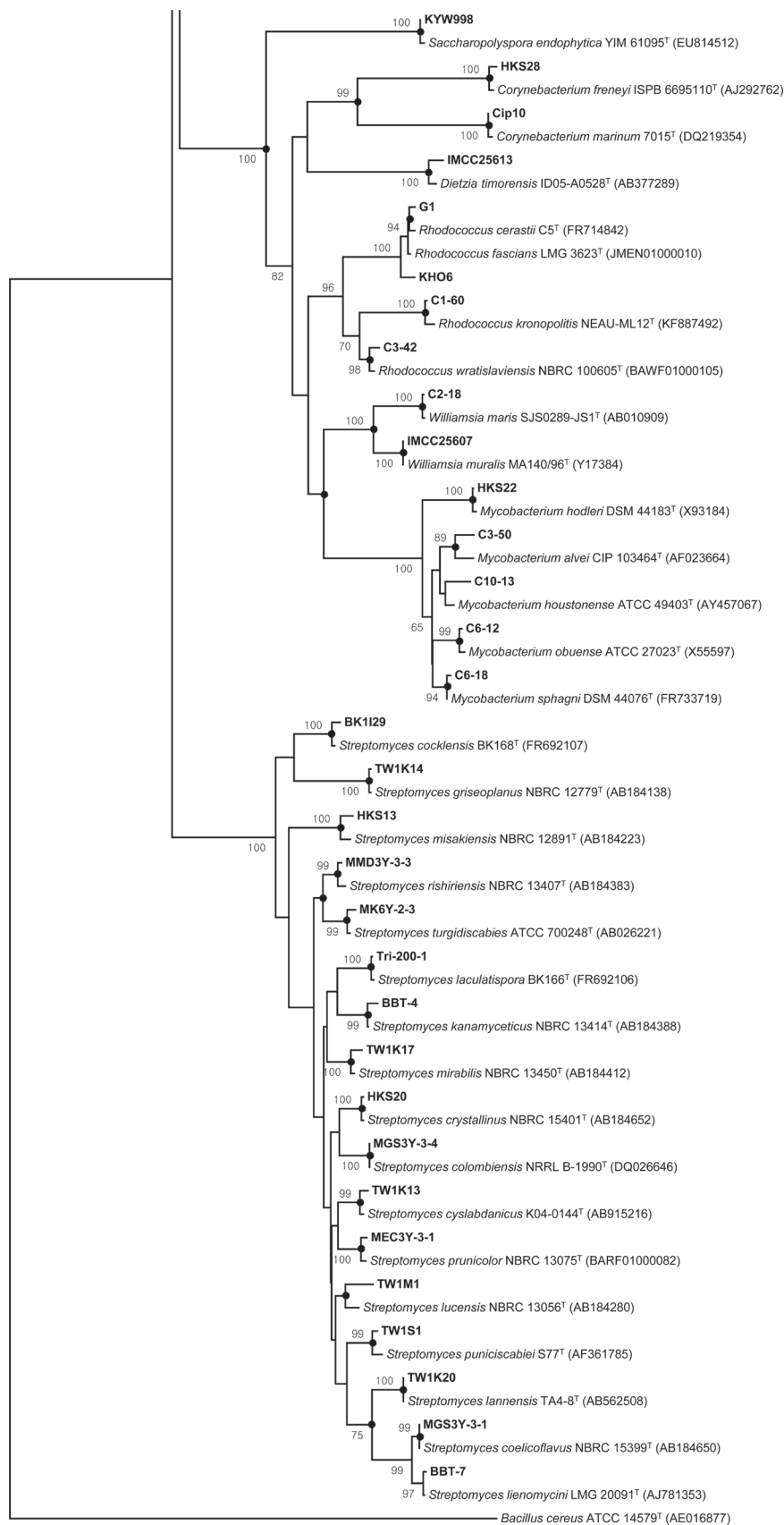


Fig. 2. Continued.

ible pigment is produced. Positive for esculin hydrolysis, β -galactosidase and nitrate reduction in API 20NE, but negative for arginine dihydrolase, glucose fermentation, gelatinase, indole production and urease. L-Arabinose, D-glucose, D-maltose, D-mannose are utilized. Does not utilize *N*-acetyl-glucosamine, adipic acid, capric acid, malic acid, D-mannitol, phenylacetic acid, potassium gluconate and trisodium citrate. Strain RDH8 (=NIBRBAC000498079) has been isolated from a fresh water lake at Chung-Ang University, Anseong, Gyeonggi Province, Korea.

Description of *Brachybacterium paraconglomeratum* Ho-10

Cells are Gram-staining-positive, non-flagellated and round or oval shaped. Colonies are circular, round, entire and light yellow colored after 2 days on R2A at 30°C. Positive for esculin hydrolysis, glucose fermentation and nitrate reduction in API 20NE, but negative for arginine dihydrolase, β -galactosidase, gelatinase, indole production and urease. D-Glucose, malic acid, D-maltose, D-mannitol and D-mannose are utilized. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, phenylacetic acid, potassium gluconate and trisodium citrate and are not utilized. Strain Ho-10 (=NIBRBAC000498105) has been isolated from activated sludge, Daejeon, Korea.

Description of *Dermacoccus barathri* KYW950

Cells are Gram-staining-positive, non-flagellated and coccoid-shaped. Colonies are circular, entire, convex and light yellow-colored after 3 days on MA at 25°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. D-Glucose, malic acid, D-maltose and potassium gluconate are utilized. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-mannitol, D-mannose, phenylacetic acid and trisodium citrate. Strain KYW950 (=NIBRBAC000497927) has been isolated from a sea water sample, Gwangyang Bay, Gwangyang, Jeonnam Province, Korea.

Description of *Arsenicococcus bolidensis* LPB0110

Cells are Gram-staining-positive, non-flagellated and coccus shaped. Colonies are circular and light yellow-colored after 1 day on MA at 26°C. Positive for esculin hydrolysis and nitrate reduction in API 20NE, but negative for arginine dihydrolase, β -galactosidase, gelatinase, glucose fermentation, indole production and urease. Does not utilize *N*-acetyl-glucosamine, adipic acid,

L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain LPB0110 (=NIBRBAC000497985) has been isolated from a sea water sample, Busan, Korea.

Description of *Janibacter indicus* KYW1206

Cells are Gram-staining-positive, non-flagellated, non-pigmented and coccoid-shaped. Colonies are circular, convex and light yellow-colored after 4 days on MA at 25°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, glucose fermentation, indole production, nitrate reduction and urease, but positive for gelatinase in API 20NE. D-Glucose, malic acid and potassium gluconate are utilized. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid and trisodium citrate. Strain KYW1206 (=NIBRBAC000497943) has been isolated from a sea water sample, Gwangyang Bay, Gwangyang, Jeonnam province, Korea.

Description of *Phycoccus ochangensis* HKS12

Cells are Gram-staining-positive and round or rod-shaped. Colonies are circular, round, entire and milky white colored after 2 days on R2A at 30°C. Negative for arginine dihydrolase, β -galactosidase, indole production, nitrate reduction and urease, but positive for esculin hydrolysis, gelatinase and glucose fermentation in API 20NE. Utilize *N*-acetyl-glucosamine, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate. Does not utilize adipic acid, L-arabinose, capric acid, phenylacetic acid and trisodium citrate. Strain HKS12 (=NIBRBAC000498111) has been isolated Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Agrococcus lahaulensis* HKS25

Cells are Gram-staining-positive, non-flagellated and coccus shaped. Colonies are wrinkled circular, convex, opaque and pale yellow colored after 2 days on R2A at 30°C. Positive for gelatinase and urease, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, glucose fermentation, indole production and nitrate reduction in API 20NE. *N*-Acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate are not utilized. Strain HKS25 (=NIBRBAC000498117) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Humibacter antri* C4-1

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, entire, convex and cream colored after 7 days on ISP2 agar at 30°C. Negative for arginine dihydrolase, β -galactosidase, gelatinase, glucose fermentation, indole production and urease, but weakly positive for esculin hydrolysis and nitrate reduction in API 20NE. *N*-Acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate are not utilized. Strain C4-1 (=NIBRBAC000498029) has been isolated from a natural cave, Jeju, Korea.

Description of *Leifsonia lichenia* HKS09

Cells are Gram-staining-positive, non-flagellated and rod or oval rod shaped. Colonies are circular, raised, entire and dark yellow colored after 2 days on R2A at 30°C. Positive for esculin hydrolysis and glucose fermentation, but negative for arginine dihydrolase, β -galactosidase, gelatinase, indole production, nitrate reduction and urease in API 20NE. Utilize *N*-acetyl-glucosamine, D-glucose, D-maltose, D-mannitol, D-mannose and potassium gluconate. Does not utilize adipic acid, L-arabinose, capric acid, malic acid, phenylacetic acid and trisodium citrate. Strain HKS09 (=NIBRBAC000498109) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Leifsonia soli* C7-7

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, entire, convex and cream colored after 4 days on TSA at 30°C. Positive for esculin hydrolysis and β -galactosidase, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain C7-7 (=NIBRBAC000498033) has been isolated from a natural cave, Jeju, Korea.

Description of *Microbacterium aoyamense* C1-46

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, entire, convex and light yellow colored after 7 days on TSA at 30°C. Positive for esculin hydrolysis and β -galactosidase, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. *N*-Acetyl-glucosamine, D-glucose, D-maltose, D-mannitol, D-mannose and potassium gluconate are utilized. Weakly utilize the L-arabinose. Does not utilize adipic acid, capric acid, malic acid, phenylacetic acid and trisodium citrate. Strain C1-46 (=NIBRBAC000498021) has been isolated from a natural cave, Jeju, Korea.

ose, D-mannitol, D-mannose and potassium gluconate are utilized. Weakly utilize the L-arabinose. Does not utilize adipic acid, capric acid, malic acid, phenylacetic acid and trisodium citrate. Strain C1-46 (=NIBRBAC000498021) has been isolated from a natural cave, Jeju, Korea.

Description of *Microbacterium arborescens* HMF4427

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, entire, convex and yellow colored after 3 days on MA at 30°C. Positive for esculin hydrolysis, β -galactosidase, gelatinase and glucose fermentation in API 20NE, but negative for arginine dihydrolase, indole production, nitrate reduction and urease. *N*-Acetyl-glucosamine, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, potassium gluconate and trisodium citrate are utilized. Does not utilize adipic acid, capric acid and phenylacetic acid. Strain HMF4427 (=NIBRBAC000497916) has been isolated from Korean fermented food (jeotgal), Jeonbuk Province, Korea.

Description of *Microbacterium esteraromaticum* KHC15

Cells are Gram-staining-positive, flagellated and coccibacillus. Colonies are circular and cream-colored after 3 days on NA at 25°C. Positive for esculin hydrolysis, β -galactosidase and nitrate reduction in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production and urease. Utilize *N*-acetyl-glucosamine, L-arabinose, D-glucose, D-maltose, D-mannitol, D-mannose and potassium gluconate, but not utilize adipic acid, capric acid, malic acid, phenylacetic acid and trisodium citrate. Strain KHC15 (=NIBRBAC000497842) has been isolated from Gut of Red-crowned Crane (*Grus japonensis*), Gyeonggi Province, Korea.

Description of *Microbacterium ketosireducens* IMCC25612

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, raised, entire and red colored after 10 days on R2A at 20°C. Positive for esculin hydrolysis, β -galactosidase, urease and oxidase, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production and nitrate reduction in API 20NE. *N*-Acetyl-glucosamine, L-arabinose, D-glucose, D-maltose, D-mannitol, D-mannose and potassium gluconate are utilized. Does not utilize adipic acid, capric acid, malic acid, phenylacetic acid and trisodium citrate. Strain IMCC25612 (=NIBRBAC000498002) has been isolated from a fresh water sample, Inkyong

lake, Incheon, Korea.

Description of *Microbacterium marinum* LPB0100

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular and light yellow colored after 1 day on MA at 26°C. Negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE, but positive for esculin hydrolysis and β -galactosidase. Positive for utilization of L-arabinose, D-glucose, D-maltose, D-mannitol and potassium gluconate. Does not utilize *N*-acetyl-glucosamine, adipic acid, capric acid, malic acid, D-mannose, phenylacetic acid and trisodium citrate. Strain LPB0100 (=NIBRBAC000497980) has been isolated from a sea water sample, Busan, Korea.

Description of *Microbacterium oleivorans* Ho-14

Cells are Gram-staining-positive, non-flagellated and irregular rod shaped. Colonies are circular, round, entire and yellow colored after 2 days on R2A at 30°C. Positive for esculin hydrolysis, but negative for arginine dihydrolase, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid and trisodium citrate, but utilize potassium gluconate. Strain Ho-14 (=NIBRBAC000498106) has been isolated from activated sludge, Daejeon, Korea.

Description of *Microbacterium paraoxydans* KHG7

Cells are Gram-staining-positive, non-flagellated and streptobacilli shaped. Colonies are circular and cream colored after 3 days on NA at 25°C. Positive for esculin hydrolysis, β -galactosidase and gelatinase in API 20NE, but negative for arginine dihydrolase, glucose fermentation, indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, D-glucose, D-maltose, D-mannitol, D-mannose, potassium gluconate and trisodium citrate, but not utilize L-arabinose, adipic acid, capric acid, malic acid and phenylacetic acid. Strain KHG7 (=NIBRBAC000497857) has been isolated from Gut of Red-crowned Crane (*Grus japonensis*), Gyeonggi Province, Korea.

Description of *Microbacterium schleiferi* DO214

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, convex and yellow colored after 2 days on R2A at 25°C. Positive for esculin hydrolysis, β -galactosidase and nitrate reduction in API 20NE, but negative for arginine dihydrolase, gelatinase,

glucose fermentation, indole production and urease. Utilize *N*-acetyl-glucosamine, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and trisodium citrate, but not utilize adipic acid, capric acid, phenylacetic acid and potassium gluconate. Strain DO214 (=NIBRBAC000498052) has been isolated from a fresh water sample, Jeonju, Jeonbuk Province, Korea.

Description of *Mycetocola miduiensis* IMCC25611

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, raised, entire and white colored after 10 days on R2A at 20°C. Positive for nitrate reduction and oxidase, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain IMCC25611 (=NIBRBAC000498001) has been isolated from a fresh water sample, Inkyong lake, Incheon, Korea.

Description of *Arthrobacter bergerei* HMF3875

Cells are Gram-staining-positive, non-flagellated and coccus-shaped. Colonies are circular, convex, entire and yellow colored after 3 days on R2A at 30°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Utilize L-arabinose, D-glucose, malic acid, D-maltose, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate, but not utilize *N*-acetyl-glucosamine, adipic acid, capric acid and D-mannitol. Strain HMF3875 (=NIBRBAC000497900) has been isolated from soil sample, Yongin, Gyeonggi Province, Korea.

Description of *Arthrobacter nicotianae* KHK4

Cells are Gram-staining-positive, non-flagellated and bacillus shaped. Colonies are circular, cream colored after 3 days on TSA at 25°C. Positive for gelatinase and nitrate reduction in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, glucose fermentation, indole production and urease. Utilizes adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, phenylacetic acid, potassium gluconate and trisodium citrate, but not utilize *N*-acetyl-glucosamine, capric acid, D-mannitol and D-mannose. Strain KHK4 (=NIBRBAC000497856) has been isolated from Gut of Red-crowned Crane (*Grus japonensis*), Gyeonggi Province, Korea.

Description of *Kocuria marina* IMCC25615

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, raised, entire and yellow colored after 10 days on R2A at 20°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatin hydrolysis, glucose fermentation, Indole production, nitrate reduction and urease in API 20NE. D-Glucose, D-maltose, D-mannitol, D-mannose and potassium gluconate are utilized. Does not utilize *N*-acetyl-glucosamine, L-arabinose, adipic acid, capric acid, malic acid, phenylacetic acid and trisodium citrate. Strain IMCC 25615 (=NIBRBAC000498005) has been isolated from a fresh water sample, Inkyong lake, Incheon, Korea.

Description of *Kocuria palustris* LPB0092

Cells are Gram-staining-positive, non-flagellated, non-pigmented and coccus-shaped. Colonies are circular and light yellow colored after 2 days on MA medium at 26°C. Positive for nitrate reduction and urease in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation and Indole production. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain LPB0092 (=NIBRBAC000497975) has been isolated from soil sample, Bukhan Mountain, Seoul, Korea.

Description of *Kocuria rhizophila* BT304

Cells are Gram-staining-positive, non-flagellated, non-pigmented and coccus-shaped. Colonies are circular and light yellow colored after 3 days on BHIA at 37°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Utilize *N*-acetyl-glucosamine, adipic acid, D-glucose, malic acid, D-maltose, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate are utilized. Does not utilize L-arabinose, capric acid and D-mannitol. Strain BT304 (=NIBRBAC000497862) has been isolated from Gut of Korean native cattle, Korea.

Description of *Nesterenkonia lacusekhoensis* UT 4-03

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are punctiform, flat, entire and white colored on TSA medium at 30°C. Positive for nitrate reduction and urease in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatin hydrolysis, glucose fermentation and Indole production. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic

acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain UT 4-03 (=NIBRBAC000498084) has been isolated from a plant root, Daejeon, Korea.

Description of *Zhihengliuella flava* LPB0101

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular and yellow colored after 2 days on R2A at 26°C. Positive for esculin hydrolysis, β -galactosidase and nitrate production in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production and urease. Does not utilize *N*-acetyl-glucosamine, L-arabinose, adipic acid and capric acid, but utilize D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain LPB0101 (=NIBRBAC000497981) has been isolated from a sea water sample, Busan, Korea.

Description of *Cellulosimicrobium funkei* KHC19

Cells are Gram-staining-positive, flagellated and coccibacillus shaped. Colonies are circular and yellow colored after 3 days on R2A at 25°C. Negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production and urease in API 20NE, but positive for esculin hydrolysis, β -galactosidase and nitrate reduction. Does not utilize *N*-acetyl-glucosamine, adipic acid, capric acid, malic acid, D-mannitol, phenylacetic acid and trisodium citrate, but utilize L-arabinose, D-glucose, D-mannose, D-maltose and potassium gluconate. Strain KHC19 (=NIBRBAC000497851) has been isolated from Gut of Japanese crested ibis (*Nipponia nippon*), Gyeonggi Province, Korea.

Description of *Promicromonospora flava* C6-16

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, convex, entire and white cream colored after 3 days on R2A at 30°C. Positive for esculin hydrolysis, β -galactosidase and oxidase, weakly positive for urease, but negative for arginine dihydrolase, gelatinase, glucose fermentation, Indole production and nitrate reduction. In API 20NE, positive assimilates for *N*-acetyl-glucosamine, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and trisodium citrate, but negative for adipic acid, capric acid, phenyl acetic acid and potassium gluconate. Strain C6-16 (=NIBRBAC000498031) has been isolated from a natural cave, Jeju, Korea.

Description of *Sanguibacter suarezii* IMCC25604

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire and yellow

low colored after 10 days on 1/10 MA at 20°C. Positive for esculin hydrolysis and β -galactosidase in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Utilize L-arabinose, D-glucose, D-maltose and D-mannose, but not utilize *N*-acetyl-glucosamine, adipic acid, capric acid, malic acid, D-mannitol, phenylacetic acid, potassium gluconate and trisodium citrate. Strain IMCC25604 (= NIBRBAC000497994) has been isolated from a fresh water sample, Chuncheon, Gangwon Province, Korea.

Description of *Saccharopolyspora endophytica* KYW998

Cells are Gram-staining-positive, non-flagellated. Colonies are circular, opaque and white colored after 3 days on MA at 25°C. Positive for esculin hydrolysis, gelatinase and urease, weakly positive for β -galactosidase, but negative for arginine dihydrolase, glucose fermentation, Indole production and nitrate reduction. In API 20NE, positive assimilates for D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate, weakly positive for *N*-acetyl-glucosamine and adipic acid, but negative for L-arabinose, capric acid, phenylacetic acid and trisodium citrate. Strain KYW998 (= NIBRBAC000497925) has been isolated from a sea water sample, Gwangyang Bay, Gwangyang, Jeonnam Province, Korea.

Description of *Corynebacterium freneyi* HKS28

Cells are Gram-staining-positive, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, round, entire and yellow colored after 2 days on R2A at 30°C. Positive for esculin hydrolysis, glucose fermentation and urease in API 20NE, but negative for arginine dihydrolase, β -galactosidase, gelatin hydrolysis, Indole production and nitrate reduction. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, malic acid, D-mannitol, phenylacetic acid and trisodium citrate, but utilize D-glucose, D-maltose, D-mannose and potassium gluconate. Strain HKS28 (= NIBRBAC000498118) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Corynebacterium marinum* Cip10

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, convex, erose and yellow colored after 2 days on MA at 30°C. Positive for nitrate reduction and urease in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation and indole production. Does not utilize *N*-acetyl-glucosamine, adipic

acid, L-arabinose, capric acid, D-glucose, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate, but utilize malic acid. Strain Cip10 (= NIBRBAC000498060) has been isolated from a tidal flat, Incheon, Korea.

Description of *Dietzia timorensis* IMCC25613

Cells are Gram-staining-positive, non-flagellated and cocci-shaped. Colonies are circular, entire, raised and red colored after 10 days on R2A at 20°C. Positive for gelatinase and urease in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, glucose fermentation, indole production and nitrate production. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain IMCC25613 (= NIBRBAC000498003) has been isolated from a fresh water sample, Inkyong lake, Incheon, Korea.

Description of *Mycobacterium alvei* C3-50

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, convex, entire and cream colored after 10 days on TSA at 30°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, phenylacetic acid, potassium gluconate and trisodium citrate. Weakly utilize the D-mannose. Strain C3-50 (= NIBRBAC000498028) has been isolated from a natural cave, Jeju, Korea.

Description of *Mycobacterium hodleri* HKS22

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are entire, circular, round and saffron yellow colored after 2 days on R2A at 30°C. Positive for arginine dihydrolase, esculin hydrolysis, glucose fermentation and urease in API 20NE, but negative for β -galactosidase, gelatinase, indole production and nitrate reduction. Utilize L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, potassium gluconate and trisodium citrate, but not utilize *N*-acetyl-glucosamine, adipic acid, capric acid and phenylacetic acid. Strain HKS22 (= NIBRBAC000498114) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Mycobacterium obuense* C6-12

Cells are Gram-staining-positive, non-flagellated and

rod-shaped. Colonies are entire, circular, convex and light orange colored after 3 days on ISP2 agar at 30°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid and trisodium citrate. Weakly utilize the potassium gluconate. Strain C6-12 (=NIBRBAC000498030) has been isolated from a natural cave, Jeju, Korea.

Description of *Mycobacterium senegalense* C10-13

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, convex, entire and cream colored after 7 days on R2A at 30°C. Positive for nitrate reduction in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production and urease. Utilize *N*-acetyl-glucosamine, D-mannitol, malic acid and potassium gluconate, but not utilize adipic acid, L-arabinose, capric acid, D-glucose, D-maltose, D-mannose, phenylacetic acid and trisodium citrate. Strain C10-13 (=NIBRBAC000498035) has been isolated from a natural cave, Jeju, Korea.

Description of *Mycobacterium sphagni* C6-18

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, convex, entire and cream colored after 16 days on R2A at 30°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain C6-18 (=NIBRBAC000498032) has been isolated from a natural cave, Jeju, Korea.

Description of *Rhodococcus cerastii* G1

Cells are Gram-staining-positive, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, convex and yellow colored after 2 days on R2A at 30°C. Positive for β -galactosidase and urease in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, gelatinase, glucose fermentation, indole production and nitrate reduction. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate, but not utilize capric

acid. Strain G1 (=NIBRBAC000498066) has been isolated from a tidal flat sample, Incheon, Korea.

Description of *Rhodococcus fascians* KHO6

Cells are Gram-staining-positive, non-flagellated and coccus-shaped. Colonies are circular and white colored after 3 days on NA at 25°C. Positive for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, nitrate reduction and urease in API 20NE, but negative for glucose fermentation and indole production. Utilize D-glucose, D-maltose and D-mannose, but not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, malic acid, D-mannitol, phenylacetic acid, potassium gluconate and trisodium citrate. Strain KHO6 (=NIBRBAC000497838) has been isolated from Gut of Japanese crested ibis (*Nipponia nippon*), Gyeonggi Province, Korea.

Description of *Rhodococcus kronopolitis* C1-60

Cells are Gram-staining-positive, non-flagellated, non-pigmented and rod- or coccoid-shaped. Colonies are circular, convex, entire and light pink-colored after 3 days on TSA at 30°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid and trisodium citrate. Weakly utilize the potassium gluconate. Strain C1-60 (=NIBRBAC000498022) has been isolated from a natural cave, Jeju, Korea.

Description of *Rhodococcus wratislaviensis* C3-42

Cells are Gram-staining-positive, non-flagellated, non-pigmented and rod shaped. Colonies are circular, convex, entire and light apricot-colored after 2 days on ISP2 agar at 30°C. Positive for β -galactosidase and nitrate reduction in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, gelatinase, glucose fermentation, indole production and urease. Utilize *N*-acetyl-glucosamine, adipic acid, D-glucose, malic acid, D-mannitol, phenylacetic acid, potassium gluconate and trisodium citrate, but not utilize L-arabinose, capric acid, D-maltose and D-mannose. Strain C3-42 (=NIBRBAC000498026) has been isolated from a natural cave, Jeju, Korea.

Description of *Williamsia maris* C2-18

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, convex, entire and light yellow colored after 9 days on TSA at 30°C. Positive for β -galactosidase in API 20NE, but negative for

arginine dihydrolase, esculin hydrolysis, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Weakly utilize the D-mannitol. Strain C2-18 (=NIBRBAC000498023) has been isolated from a natural cave, Jeju, Korea.

Description of *Williamsia muralis* IMCC25607

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, raised, entire and red-yellow colored after 7 days on R2A at 20°C. Positive for nitrate reduction, urease and oxidase in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation and indole production. Positive for utilization of L-arabinose, D-glucose, malic acid, D-mannitol, D-mannose and potassium gluconate, but negative for *N*-acetyl-glucosamine, adipic acid, capric acid, D-maltose, phenylacetic acid and trisodium citrate. Strain IMCC25607 (=NIBRBAC000497997) has been isolated from a fresh water sample, Chuncheon, Gangwon Province, Korea.

Description of *Streptomyces cocklensis* BK1129

Cells are Gram-staining-positive, non-flagellated and filamentous. Colonies are rhizoid, circular, aggregated and bright brown colored on ISP2 media at 30°C. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain BK1129 (=NIBRBAC000498091) has been isolated from a plant root, Naejang Mountain, Jeonbuk Province, Korea.

Description of *Streptomyces coelicoflavus* MGS3Y-3-1

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, entire, rough, raised and white colored after 3 days on MA at 30°C. Positive for esculin hydrolysis, β -galactosidase, nitrate reduction and urease in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation and indole production. *N*-Acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate are utilized, but capric acid, phenylacetic acid and trisodium citrate are not utilized. Strain MGS3Y-3-1 (=NIBRBA0000114269) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Streptomyces colombiensis* MGS3Y-3-4

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, entire, rough, raised and yellow colored after 3 days on MA at 30°C. Positive for esculin hydrolysis, β -galactosidase and gelatinase in API 20NE, but negative for arginine dihydrolase, glucose fermentation, indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate, but not utilize capric acid. Strain MGS3Y-3-4 (=NIBRBA0000114270) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Streptomyces crystallinus* HKS20

Cells are Gram-staining-positive, non-flagellated, non-pigmented and rod-shaped. Colonies are round, wrinkled circular, penet and white grey-colored after 1 day on R2A at 30°C. Positive for esculin hydrolysis, glucose fermentation and urease in API 20NE. Negative for arginine dihydrolase, β -galactosidase, gelatinase, indole production and nitrate reduction. Utilize adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate, but not utilize *N*-acetyl-glucosamine and capric acid. Strain HKS20 (=NIBRBAC000498113) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Streptomyces cyslabdanicus* TW1K13

Cells are Gram-staining-positive, non-flagellated and filamentous. Colonies are rhizoid, umbonate, curled and brown-colored after 7 days on ISP2 at 30°C. Diffusible pigment is produced. Negative for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate, but not utilize capric acid, phenylacetic acid and trisodium citrate. Strain TW1K13 (=NIBRBAC000498097) has been isolated from soil sample, Chungbuk Province, Korea.

Description of *Streptomyces griseoplanus* TW1K14

Cells are Gram-staining-positive, non-flagellated and filamentous. Colonies are rhizoid, umbonate, curled and greyish colored after 7 days on ISP2 at 30°C. Diffusible pigment is produced. Positive for esculin hydrolysis, β -galactosidase and oxidase in API 20NE, but negative

for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain TW1K14 (=NIBRBAC000498098) has been isolated from soil sample, Chungbuk Province, Korea.

Description of *Streptomyces kanamyceticus* BBT-4

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire and white-colored after 2 days on R2A at 25°C. Positive for esculin hydrolysis and β -galactosidase in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate. Does not utilize adipic acid, capric acid, phenylacetic acid and trisodium citrate. Strain BBT-4 (=NIBRBA0000114215) has been isolated from Black biotite, Chungnam Province, Korea.

Description of *Streptomyces laculatispora* Tri-200-1

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are circular, rough, dry and grayish-colored after 2 days on R2A at 30°C. Positive for arginine dihydrolase, esculin hydrolysis, β -galactosidase, gelatinase, nitrate reduction and urease in API 20NE, but negative for glucose fermentation and indole production. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, potassium gluconate and trisodium citrate, but not utilize capric acid and phenylacetic acid. Strain Tri-200-1 (=NIBRBAC000498080) has been isolated from soil sample, Anseong, Gyeonggi Province, Korea.

Description of *Streptomyces lannensis* TW1K20

Cells are Gram-staining-positive, non-flagellated, non-pigmented and filamentous. Colonies are rhizoid, umbonate, curled and brown colored after 7 days on ISP2 at 30°C. Positive for esculin hydrolysis, β -galactosidase, gelatinase and oxidase, but negative for arginine dihydrolase, glucose fermentation, indole production, nitrate reduction and urease in API 20NE. Positive for utilization of *N*-acetyl-glucosamine, L-arabinose, D-glucose, malic acid, D-mannitol, D-mannose and potassium gluconate, but negative for adipic acid, capric acid, D-maltose, phenylacetic acid and trisodium citrate. Strain TW1K20 (=NIBRBAC000498099) has been isolated from soil sample, Cheongju, Chungbuk Province, Korea.

Description of *Streptomyces lienomycini* BBT-7

Cells are Gram-staining-positive and rod-shaped. Colonies are circular, raised, convex and yellow colored after 2 days on R2A at 25°C. Positive for arginine dihydrolase, esculin hydrolysis, β -galactosidase, nitrate reduction and urease in API 20NE, but negative for gelatinase, glucose fermentation and indole production. Utilizes *N*-acetyl-glucosamine, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate, but not utilize adipic acid and capric acid. Strain BBT-7 (=NIBRBA0000114216) has been isolated from Black biotite, Chungnam Province, Korea.

Description of *Streptomyces lucensis* TW1M1

Cells are Gram-staining-positive, non-flagellated, non-pigmented and filamentous. Colonies are rhizoid, umbonate, curled and bright brown colored after 7 days on ISP2 at 30°C. Positive for esculin hydrolysis, β -galactosidase and oxidase in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Does not utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, capric acid, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, phenylacetic acid, potassium gluconate and trisodium citrate. Strain TW1M1 (=NIBRBAC000498100) has been isolated from soil sample, Cheongju, Chungbuk Province, Korea.

Description of *Streptomyces mirabilis* TW1K17

Cells are Gram-staining-positive, non-flagellated, non-pigmented and filamentous. Colonies are rhizoid, umbonate, curled and brown colored after 7 days on ISP2 at 30°C. Positive for esculin hydrolysis, β -galactosidase and oxidase in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate, but not utilize capric acid, phenylacetic acid and trisodium citrate. Strain TW1K17 (=NIBRBAC000498101) has been isolated from soil sample, Cheongju, Chungbuk Province, Korea.

Description of *Streptomyces misakiensis* HKS13

Cells are Gram-staining-positive, non-flagellated and rod or cocci rod shaped. Colonies are circular, round, penetrating, entire and white yellow colored after 1 days on R2A at 30°C. Positive for β -galactosidase, gelatinase and oxidase in API 20NE, but negative for arginine dihydrolase, esculin hydrolysis, glucose fermentation,

indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate, but not utilize capric acid, phenylacetic acid and trisodium citrate. Strain HKS13 (=NIBRBAC000498112) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Streptomyces prunicolor* MEC3Y-3-1

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, entire, dry, raised and orange colored after 3 days on MA at 30°C. Positive for esculin hydrolysis and β -galactosidase in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate, but not utilize capric acid, phenylacetic acid and trisodium citrate. Strain MEC3Y-3-1 (=NIBRBA0000114268) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

Description of *Streptomyces puniscabiei* TW1S1

Cells are Gram-staining-positive, non-flagellated and filamentous. Colonies are rhizoid, umbonate, curled and bright brown colored after 7 days on ISP2 at 30°C. Positive for esculin hydrolysis, β -galactosidase, gelatinase and oxidase in API 20NE, but negative for arginine dihydrolase, glucose fermentation, indole production, nitrate reduction and urease. Does not utilize capric acid, phenylacetic acid and trisodium citrate, but utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate. Strain TW1S1 (=NIBRBAC000498102) has been isolated from soil, Daejeon, Korea.

Description of *Streptomyces rishiriensis* MMD3Y-3-3

Cells are Gram-staining-positive, non-flagellated and rod shaped. Colonies are filamentous, undulate, rough, raised and pale yellow colored after 3 days on MA at 30°C. Positive for esculin hydrolysis, β -galactosidase and gelatinase in API 20NE, but negative for arginine dihydrolase, glucose fermentation, indole production, nitrate reduction and urease. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose, potassium gluconate and trisodium citrate, but not utilize capric acid and phenylacetic acid. Strain MMD3Y-3-3 (=NIBRBA0000114279) has been isolated from Ginseng cultivated

soil, Anseong, Gyeonggi Province, Korea.

Description of *Streptomyces turgidiscabies* MK6Y-2-3

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are irregular, undulate, rough, raised and white colored after 3 days on MA at 30°C. Positive for esculin hydrolysis, β -galactosidase and nitrate reduction in API 20NE, but negative for arginine dihydrolase, gelatinase, glucose fermentation, indole production and urease. Utilize *N*-acetyl-glucosamine, adipic acid, L-arabinose, D-glucose, malic acid, D-maltose, D-mannitol, D-mannose and potassium gluconate, but not utilize capric acid, phenylacetic acid and trisodium citrate. Strain MK6Y-2-3 (=NIBRBA0000114273) has been isolated from Ginseng cultivated soil, Anseong, Gyeonggi Province, Korea.

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REFERENCES

- Bressan, W. 2003. Biological control of maize seed pathogenic fungi by use of actinomycetes. *Biocontrol* 48(2): 233-240.
- Felsenstein, J. 1981. Evolutionary trees from DNA sequences: a maximum likelihood approach. *J. Mol. Evol.* 17(6): 368-376.
- Felsenstein, J. 1985. Confidence limit on phylogenies: an approach using the bootstrap. *Evolution* 39(4):783-791.
- Fitch, W.M. 1971. Toward defining the course of evolution: minimum change for a specific tree topology. *Syst. Zool.* 20(4):406-416.
- Hall, T.A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symp. Ser.* 41:95-98.
- Jukes, T.H. and C.R. Cantor. 1969. Evolution of protein molecules. In: H.N. Munro (ed.), *Mammalian Protein Metabolism*, Academic Press, New York. pp. 21-132.
- Kim, O.S., Y.J. Cho, K. Lee, S.H. Yoon, M. Kim, H. Na, S.C. Park, Y.S. Jeon, J.H. Lee, H. Yi, S. Won and J. Chun. 2012. Introducing EzTaxon-e: a prokaryotic 16S rRNA gene sequence database with phylotypes that represent uncultured species. *Int. J. Syst. Evol. Microbiol.* 62(3):716-721.
- Ludwig, W., J. Euzéby, P. Schumann, H.J. Busse, M.E. Trujillo, P. Kämpfer and W.B. Whiteman. 2012. Road map of the phylum *Actinobacteria*. In: M. Goodfellow, P.

- Kämpfer, H.J. Busse, M.E. Trujillo, K.I. Suzuki, W. Ludwig and W.B. Whitman (eds.), *Bergey's manual of systematic bacteriology*, vol 5, Springer-Verlag, New York. pp. 1-28.
- Miao, V. and J. Davies. 2010. *Actinobacteria*: the good, the bad and the ugly. *Antonie Van Leeuwenhoek* 98(2):143-150.
- Saitou, N. and M. Nei. 1987. The neighbor-joining method: a new method for reconstructing phylogenetic trees. *Mol. Biol. Evol.* 4(4):406-425.
- Servin, J.A., C.W. Herbold, R.G. Skophammer and J.A. Lake. 2008. Evidence excluding the root of the tree of life from the actinobacteria. *Mol. Biol. Evol.* 25(1):1-4.
- Tamura, K., G. Stecher, D. Peterson, A. Filipski, and S. Kumar. 2013. MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. *Mol. Biol. Evol.* 30(12):2725-2729.
- Thompson, J.D., D.G. Higgins and T.J. Gibson. 1994. CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. *Nucleic Acids Res.* 22(22): 4673-4680.
- Ventura, M., C. Canchaya, A. Tauch, G. Chandra, G.F. Fitzgerald, K.F. Chater and D. van Sinderen. 2007. Genomics of *Actinobacteria*: tracing the evolutionary history of an ancient phylum. *Microbiol. Mol. Biol. Rev.* 71(3): 495-548.

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