Journal of Species Research 8(4):351-364, 2019

Description of 42 unrecorded bacterial species in Korea, belonging to the class *Alphaproteobacteria*

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Here we describe indigenous prokaryotic species in Korea, a total of 42 bacterial strains affiliated to the class *Alphaproteobacteria* isolated from various environmental samples: fermented vinegar, sea water, beach sand, fresh water, salt flats, moss, algae, activated sludge, and soil. From the high 16S rRNA gene sequence similarity (>98.7%) and formation of a robust phylogenetic clade with the closest species, it was determined that each strain belonged to predefined bacterial species. There is no official report that these 42 species included in *Alphaproteobacteria* in Korea: 15 species of 6 genera in the order *Rhodospirillales*, 12 species of 10 genera in the order *Rhizobiales*, 10 species of 8 genera in the order *Rhodobacterales*, 4 species of 4 genera in the order *Sphingomonadales* and 1 species of 1 genus in the order *Caulobacterales*. Gram reaction, colony and cell morphology, basic biochemical characteristics, isolation source, and strain IDs are also described in the species description section.

Keywords: 16S rRNA, *Alphaproteobacteria*, bacterial diversity, indigenous prokaryotic species in Korea, unrecorded species

DOI:10.12651/JSR.2019.8.4.351

Introduction

In 2018, we isolated many novel and unrecorded bacterial species from various environmental samples collected in Korea. The identified bacterial species belongs to the classes/phyla *Alphaproteobacteria, Betaproteobacteria, Gammaproteobacteria, Deltaproteobacteria, Bacteroidetes, Firmicutes, Actinobacteria, Deinococci* and *Verrucomicrobia*. As a result, the present study described the unrecorded species belonging to the class *Alphaproteobacteria*.

In the phylum *Proteobacteria, Alphaproteobacteria* is composed of a variety of bacteria. The bacteria show different shapes as well as differences in metabolism. The majority of *Alphaproteobacteria* are phototrophic and oligotrophs and they can survive in environments with low nutrients. Affiliates of class *Alphaproteobacteria* are gram negative and some parasitic intracellular members lack peptidoglycan so they are gram variable (Brenner *et al*., 2006; Euzéby, 2011). Members of this class have stalked, stellate, and spiral morphology. *Monaibacterium* species could utilize a restricted number of complex substrates with a preference for yeast extract and tryptone, which is consistent with that peptides may serve as an important energy and carbon source for *Alphaproteobacteria* bacteria (Chernikova *et al*., 2017).

Alphaproteobacteria is also composed of C1-compound-metabolizing bacteria like *Methylobacterium* species (Williams *et al*., 2007; Matteo *et al*., 2013), plant symbionts like *Rhizobium* species, nitrifying bacteria like

Nitrobacter, animal and human pathogens like *Brucella* and *Ehrlichia*, and gas vacuoles and poly-b-hydroxybutyrate granules bacteria like *Roseobacter* (Buchan *et al*., 2005; Wagner-Döbler *et al*., 2006), *Gluconobacter* are used to synthesize acetic acid in industry. As a technological interest, *Agrobacterium* is used to transfer foreign DNA in plant genomes, so they also have many other biotechnological properties (Chilton *et al*., 1977).

Recently, evolution and genomics sequence have discovered well-maintained molecular markers in widely distributed proteins and whole proteins (*i.e*., signature proteins) which are the unique characteristics of either all *Alphaproteobacteria* or their different main orders. These evidence provide the assignment of new species into these groups, which suggests that *Alphaproteobacteria* has branched off later than most other phyla and classes of Bacteria with the exception of *Betaproteobacteria* and *Gammaproteobacteria* (Oren *et al*., 2014; Parte, 2014).

In 2018, we collected environmental samples from diverse habitats in Korea and isolated many novel and unrecorded bacterial species during a research program supported by NIBR of Korea. This report focused on the description of bacterial species in the phylum *Proteobacteria* that were not previously reported in Korea. Here we shortly describe 42 unrecorded bacterial species in the class *Alphaproteobacteria* belonging to 5 orders.

Materials and Methods

A total of 42 bacterial strains affiliated to the class *Alphaproteobacteria* were isolated from various environmental samples: fermented vinegar, sea water, beach sand, fresh water, salt flats, moss, algae, activated sludge, and soil (Table 1). Each environmental sample was processed separately, spread onto diverse culture media including HS, R2A, 1/5R2A, marine agar (MA) 2216, and incubated at 15, 20, 25, 28, 30 and 40°C for 2−5 days (Table 1). The designated strain IDs, sources, culture media, and incubation conditions are summarized in Table 1. All strains were purified as single colonies and stored as 20−25% (w/v) glycerol suspension −80°C as well as lyophilized ampoules.

The morphology was studied on agar plates for 2−5 days under their optimum temperature. Cell size and shape were examined either by transmission electron microscopy or scanning electron microscopy. Gram staining was performed using a Gram-staining kit of the standard procedures. Using API 20NE (bioMérieux) the biochemical characteristics were performed according to the manufacturer's instructions.

Bacterial DNA extraction, PCR amplification and 16S rRNA gene sequencing were performed using the standard procedures described by Lane (1991). The 16S rRNA gene sequences of the strains assigned to the *Alphaproteobacteria* were compared with the sequences held in GenBank by BLASTN and also analyzed using the EzBio Cloud blast (https://www.ezbiocloud.net) (Yoon *et al*., 2017). For phylogenetic analyses, multiple alignments were performed using the Clustal_X program (Thompson *et al*., 1997) and gaps were edited in the BioEdit program (Hall, 1999). Evolutionary distances were calculated using the Kimura two-parameter model (Kimura, 1983). The phylogenetic trees were constructed by using the neighbor-joining (Saitou and Nei, 1987) and the maximum-parsimony (Fitch, 1971) methods with the MEGA6 Program (Tamura *et al*., 2013) with bootstrap values based on 1,000 replications (Felsenstein, 1985).

Results and Discussion

The 42 strains were distributed in 5 orders of the *Alphaproteobacteria*; 15 strains for the order *Rhodospirillales*, 12 strains for the *Rhizobiales*, 10 strains for the *Rhodobacterales*, 4 strains for the *Sphingomonadales* and 1 strain for the *Caulobacterales* (Table 1). These strains were Gram-staining-negative or positive, chemoheterotrophic, rod, short-rod and coccoid shaped showing in Fig. 1.

The strains in the order *Caulobacterales* and *Rhizobiales* (Fig. 2) were found to belong to 7 families 11 separate genera: *Brevundimonas* (1 species), *Aurantimonas* (1 species), *Bosea* (1 species), *Devosia* (2 species), *Hyphomicrobium* (1 species), *Microvirga* (1 species), *Aminobacter* (1 species), *Mesorhizobium* (1 species), *Phyllobacterium* (1 species), *Rhizobium* (2 species) and *Shinella* (1 species).

Fig. 3 shows phylogenetic assignment of 14 strains of the orders *Rhodobacterales* and *Sphingomonadales* belong to 3 families 12 separate genera: *Haematobacter* (1 species), *Labrenzia* (2 species), *Lentibacter* (1 species), *Paenirhodobacter* (1 species), *Paracoccus* (1 species), *Roseicyclus* (2 species), *Roseivivax* (1 species), *Sinirhodobacter* (1 species), *Erythrobacter* (1 species), *Sphingobium* (1 species), *Sphingopyxis* (1 species) and *Sphingosinicella* (1 species).

15 strains were assigned to the order *Rhodospirillales*: 13 strains for the family *Acetobacteraceae*, 1 strain for the *Geminicoccaceae* and 1 strain for the *Rhodospirillaceae* (Fig. 4, Table 1).

Here we report 42 unrecorded bacterial species in Korea belonging to 13 families of 5 orders in the class *Alphaproteobacteria*.

Description of *Brevundimonas staleyi* CrO8

Cells are Gram-staining-negative, flagellated, and rod-shaped. Colonies are circular and apricot color after 3

Table 1. The taxonomic affiliations of isolated strains belong to the class *Alphaproteobacteria*.

Order	Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation source	Medium	Incubation conditions (°C, days)
Caulobacterales	*Caulobacteraceae*	*Brevundimonas*	CrO8	NIBRBAC000502483	*Brevundimonas staleyi*	99.3%	Freshwater algae	1/5 R2A	20–40°C, 3d
Rhizobiales	*Aurantimonadaceae*	*Aurantimonas*	KYW1510	NIBRBAC000502387	*Aurantimonas endophytica*	99.7%	Sea water	MA	25°C, 3d
	Bradyrhizobiaceae	*Bosea*	BT41	NIBRBAC000502350	*Bosea lupini*	99.4%	Soil	R2A	25°C, 4d
	Hyphomicrobiaceae	*Devosia*	BO184	NIBRBAC000502412	*Devosia neptuniae*	99.8%	Plantation soil	R2A	25°C, 3d
		Devosia	Wi-122	NIBRBAC000502444	*Devosia lucknowensis*	98.9%	Sludge	R2A	30°C, 2d
		Hyphomicrobium	Wi-69	NIBRBAC000502443	*Hyphomicrobium denitrificans*	99.5%	Sludge	R2A	30°C, 2d
	Methylobacteriaceae	*Microvirga*	CAU 1493	NIBRBAC000502366	*Microvirga makkahensis*	98.7%	Coal mine soil	MA	30°C, 2–3d
	Phyllobacteriaceae	*Aminobacter*	Hyper-3	NIBRBAC000502460	*Aminobacter niigataensis*	99.9%	Sludge	R2A	30°C, 2d
		Mesorhizobium	BT148	NIBRBAC000502334	*Mesorhizobium huakuii*	99.9%	Soil	R2A	25°C, 4d
		Phyllobacterium	HMF7144	NIBRBAC000502512	*Phyllobacterium brassicacearum*	99.9%	Leaves and stems of moss	R2A	30°C, 3d
	Rhizobiaceae	*Rhizobium*	MMS18-CY061	NIBRBAC000502554	*Rhizobium altiplani*	99.1%	Soil	R2A	30°C, 3d
		Rhizobium	GA017	NIBRBAC000502565	*Rhizobium mesoamericanum*	99.8%	Soil	R2A	30°C, 3d
		Shinella	Wi-125	NIBRBAC000502445	*Shinella curvata*	99.6%	Sludge	R2A	30°C, 2d
Rhodobacterales	*Rhodobacteraceae*	*Haematobacter*	18JY13-8	NIBRBAC000502347	*Haematobacter massiliensis*	100.0%	Soil	R2A	25°C, 4d
		Labrenzia	Gri211	NIBRBAC000502486	*Labrenzia alba*	99.2%	Seaweed	MA	30°C, 3d
		Labrenzia	CAU 1498	NIBRBAC000502364	*Labrenzia alexandrii*	99.2%	Sea sand	MA	30°C, 5d
		Lentibacter	KYW1484	NIBRBAC000502385	*Lentibacter algarum*	100.0%	Sea water	MA	25°C, 3d
		Paenirhodobacter	Wi-144	NIBRBAC000502446	*Paenirhodobacter enshiensis*	99.9%	Sludge	R2A	30°C, 2d
		Paracoccus	dNF-2	NIBRBAC000502458	*Paracoccus denitrificans*	99.9%	Sludge	R2A	30°C, 2d
		Roseicyclus	Ast32	NIBRBAC000502475	*Roseovarius indicus*	100.0%	Seaweed	MA	20°C, 3d
		Roseicyclus	JBTF-M28	NIBRBAC000502327	*Roseicyclus marinus*	100.0%	Salt flats	MA	30°C, 5d
		Roseivivax	CAU 1505	NIBRBAC000502378	*Roseivivax halodurans*	99.7%	Soil	MA	30°C, 1–2d
		Sinirhodobacter	BO-81	NIBRBAC000502467	*Sinirhodobacter ferrireducens*	98.9%	Sludge	R2A	30°C, 2d
Rhodospirillales	*Acetobacteraceae*	*Acetobacter*	CHM 34	NIBRBAC000502314	*Acetobacter ghanensis*	99.9%	Fermented vinegar	HS	28°C, 3d
		Acetobacter	SGG 2	NIBRBAC000502315	*Acetobacter pasteurianus* subsp. *pasteurianus*	99.9%	Fermented vinegar	HS	28°C, 3d
		Acetobacter	SG3.K22	NIBRBAC000502316	*Acetobacter tropicalis*	99.9%	Fermented vinegar	HS	28°C, 3d
		Gluconacetobacter	YA.S	NIBRBAC000502317	*Gluconacetobacter entanii*	99.9%	Fermented vinegar	HS	28°C, 3d
		Gluconobacter	KO.BC1	NIBRBAC000502318	*Gluconobacter oxydans*	99.9%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	CLH 2	NIBRBAC000502319	*Komagataeibacter europaeus*	100.0%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	SG2.K2	NIBRBAC000502320	*Komagataeibacter hansenii*	99.8%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	DW.G5	NIBRBAC000502321	*Komagataeibacter intermedius*	99.9%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	CDK1.9	NIBRBAC000502322	*Komagataeibacter kakiaceti*	99.9%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	YA.W2	NIBRBAC000502323	*Komagataeibacter nataicola*	99.8%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	SG3.K31	NIBRBAC000502324	*Komagataeibacter rhaeticus*	99.9%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	MGO 2	NIBRBAC000502325	*Komagataeibacter saccharivorans*	99.9%	Fermented vinegar	HS	28°C, 3d
		Komagataeibacter	SG.K 4	NIBRBAC000502326	*Komagataeibacter xylinus*	99.8%	Fermented vinegar	HS	28°C, 3d

Table 1. Continued.

Order	Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation source	Medium	Incubation conditions (°C, days)
Rhodospirillales	*Geminicoccaceae*	*Geminicoccus*	HMF9221	NIBRBAC000502524	*Geminicoccus roseus*	99.7%	Beach sand	MA	30°C, 3d
	Rhodospirillaceae	*Ferrovibrio*	H-1	NIBRBAC000502468	*Ferrovibrio xuzhouensis*	100.0%	Sludge	R2A	30°C, 2d
Sphingomonadales	*Erythrobacteraceae*	*Erythrobacter*	HMF9223	NIBRBAC000502525	*Erythrobacter pelagi*	98.9%	Beach sand	MA	30°C, 3d
	Sphingomonadaceae	*Sphingobium*	MMS18-GA122	NIBRBAC000502563	*Sphingobium czechense*	99.9%	Soil	R2A	30°C, 3d
		Sphingopyxis	HMF9218	NIBRBAC000502523	*Sphingopyxis flava*	99.2%	Beach sand	MA	30°C, 3d
		Sphingosinicella	LA-50	NIBRBAC000502450	*Sphingosinicella xenopeptidilytica*	99.9%	Sludge	R2A	30°C, 2d

days on 1/5 R2A at 20−40°C. In API 20NE, positive for nitrate reduction, urease, esculin hydrolysis, gelatinase, β-galactosidase, but negative for glucose fermentation, indole production, arginine dihydrolase. Utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, and potassium gluconate capric acid. Does not utilize adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain CrO8 (=NIBRBAC 000502483) has been isolated from a freshwater algae sample, Nakdonggang River, Korea.

Description of *Aurantimonas endophytica* KYW1510

Cells are Gram-staining-negative, non-flagellated, and short rod-shaped. Colonies are circular, smooth, convex, opaque and yellow color after 3 days on MA at 25°C. In API 20NE, positive for glucose fermentation, urease, negative for nitrate reduction, indole production, esculin hydrolysis, arginine dihydrolase, β-galactosidase and gelatinase. Does not utilize, D-glucose, 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 KYW1510 (=NIBRBAC000502387) has been isolated from sea water, Gwangyang Bay, Korea.

Description of *Bosea lupini* BT41

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and yellow color after 4 days on R2A at 25°C. Positive for nitrate reduction, while negative for arginine dihydrolase, indole production, urease, glucose fermentation, β-galactosidase, and esculin hydrolysis in API 20NE. Utilizes potassium gluconate, malic acid, and trisodium citrate. Does not utilize D-glucose, L-arabinose, D-mannose, D-maltose, D-mannitol, *N*-acetyl-glucosamine, adipic acid, capric acid, and phenylacetic acid. Strain BT41 (=NIBR BAC000502350) has been isolated from soil, Samcheok, Korea.

Description of *Devosia neptuniae* BO184

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, smooth, convex, and white color after 3 days on R2A at 25°C. In API 20NE, positive for urease, esculin hydrolysis, β-galactosidase, negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, and gelatinase. Does not utilize, D-glucose, 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 BO184 (=NIBRBAC 000502412) has been isolated from plantation soil, Suncheon, Korea.

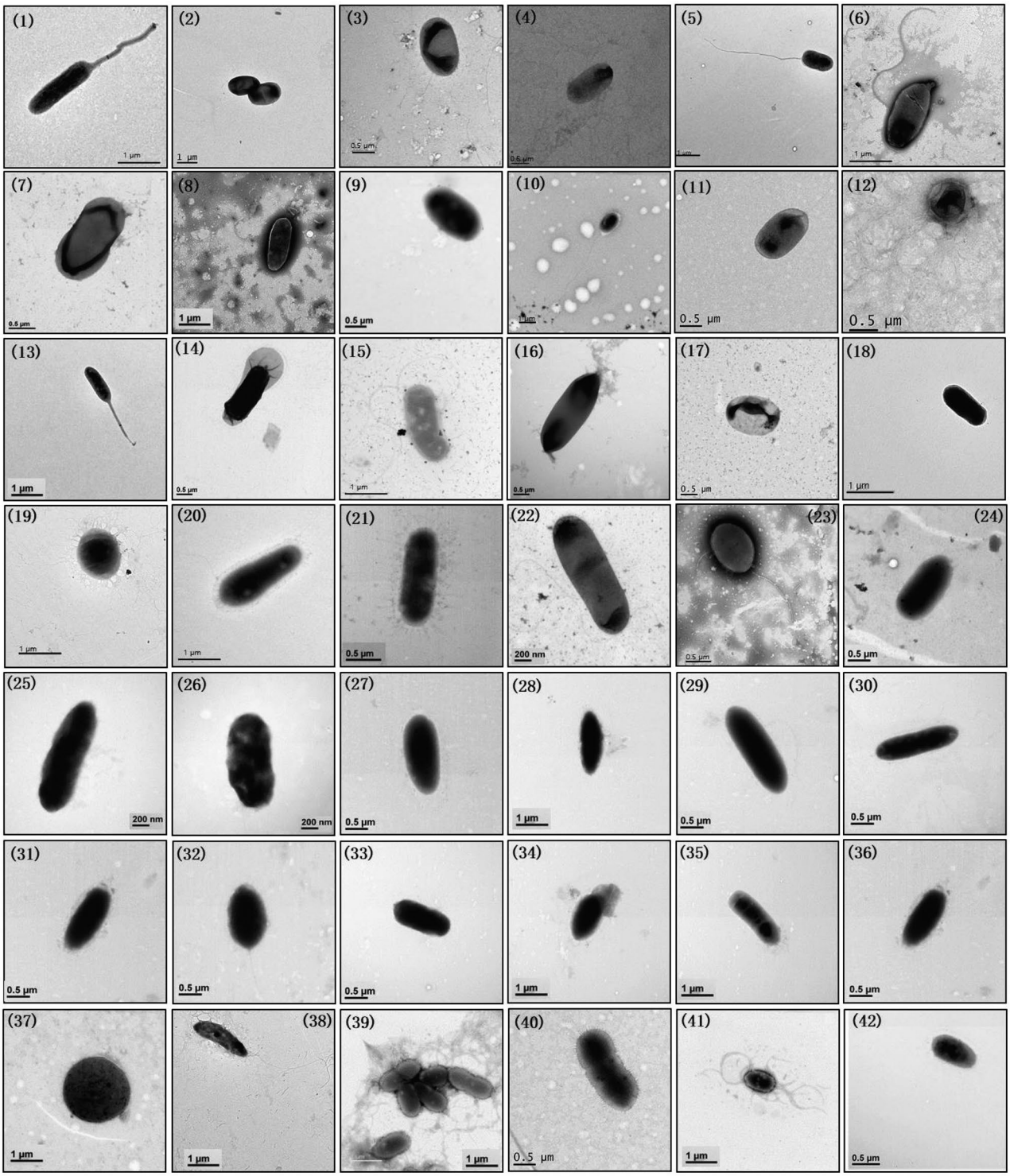

Fig. 1. Transmission and scanning electron micrographs of cells of the strains isolated in this study. Strains: 1, CrO8; 2, KYW1510; 3, BT41; 4, BO184; 5, Wi-122; 6, Wi-69; 7, CAU 1493; 8, Hyper-3; 9, BT148; 10, HMF7144; 11, MMS18-CY061; 12, GA017; 13, Wi-125; 14, 18JY13-8; 15, Gri211; 16, CAU 1498; 17, KYW1484; 18, Wi-144; 19, dNF-2; 20, Ast32; 21, JBTF-M28; 22, CAU 1505; 23, BO-81; 24, CHM 34; 25, SGG 2; 26, SG3.K22; 27, YA.S; 28, KO.BC1; 29, CLH 2; 30, SG2.K2; 31, DW.G5; 32, CDK1.9; 33, YA.W2; 34, SG3.K31; 35, MGO 2; 36, SG.K 4; 37, HMF9221; 38, H-1; 39, HMF9223; 40, MMS18-GA122; 41, HMF9218; 42, LA-50.

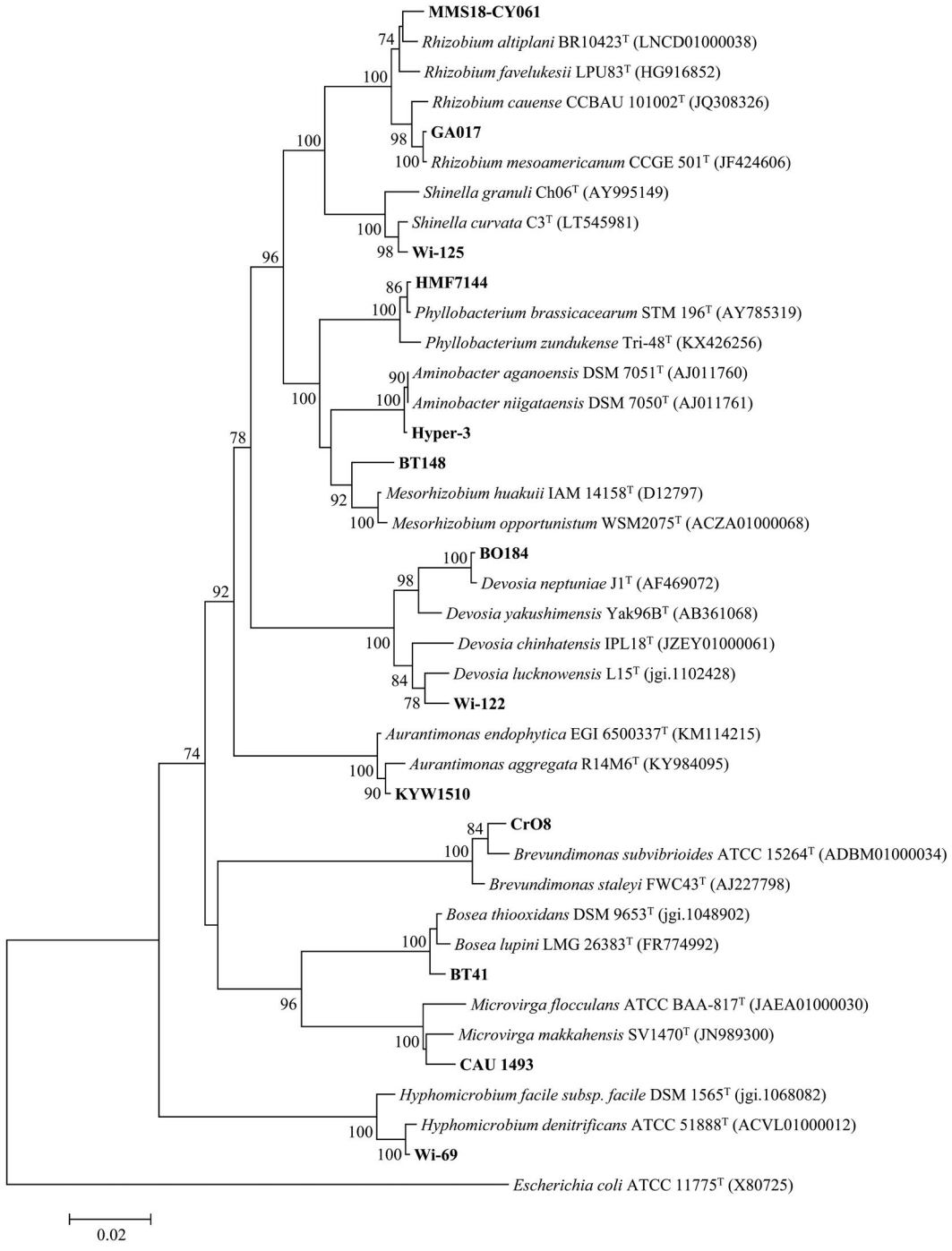

Fig. 2. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the order *Caulobacterales* and *Rhizobiales* in the class *Alphaproteobacteria*. Bootstrap values (>70%) are shown in the neighbor-joining method. Bar, 0.02 substitutions per nucleotide position. The strain *Escherichia coli* ATCC 11775^T is used as an outgroup.

Description of *Devosia lucknowensis* Wi-122

Cells are Gram-staining-negative, flagellated, and rod-shaped. Colonies are circular, convex, and white color after 2 days on R2A at 30°C. Positive for urease, esculin hydrolysis and β-galactosidase in API 20NE, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, and gelatinase. D-glucose, L-arabinose, D-mannitol, *N*-acetyl-glucosamine, and D-maltose are utilized. Does not utilize D-mannose,

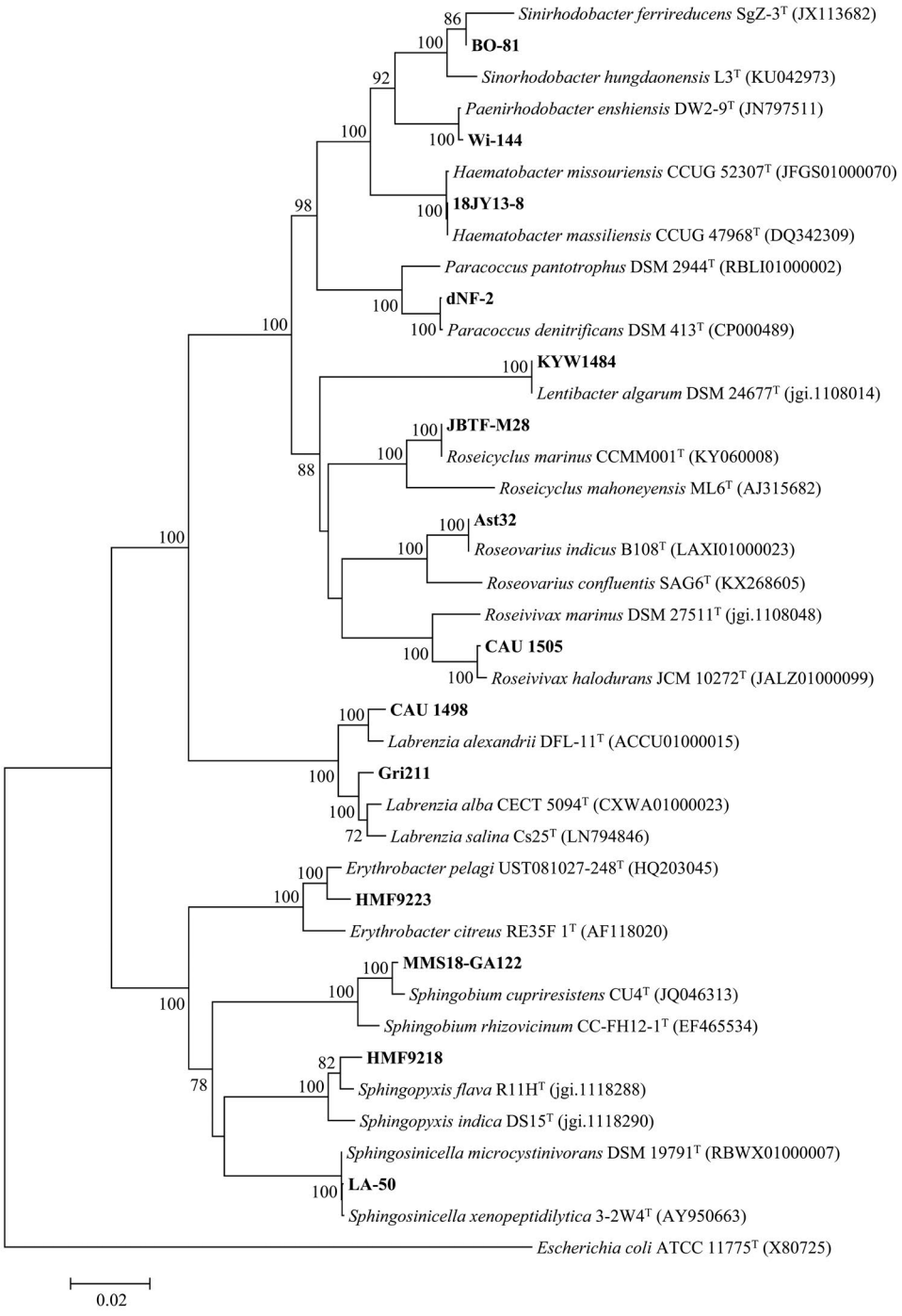

Fig. 3. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the order *Rhodobacterales* and *Sphingomonadales* in the class *Alphaproteobacteria*. Bootstrap values are greater than 70% are shown the neighbor-joining tree method. Bar, 0.02 substitutions per nucleotide position. The strain *Escherichia coli* ATCC 11775^T is used as an outgroup.

adipic acid, malic acid, potassium gluconate, trisodium citrate, phenylacetic acid, and capric acid. Strain Wi-122 (=NIBRBAC000502444) has been isolated from sludge, Seoul Tancheon Recreation Center, Korea.

Description of *Hyphomicrobium denitrificans* Wi-69

Cells are Gram-staining-negative, flagellated, and rod shaped. Colonies are circular and light, convex, and smooth cream color after 2 days on R2A at 30°C. In API

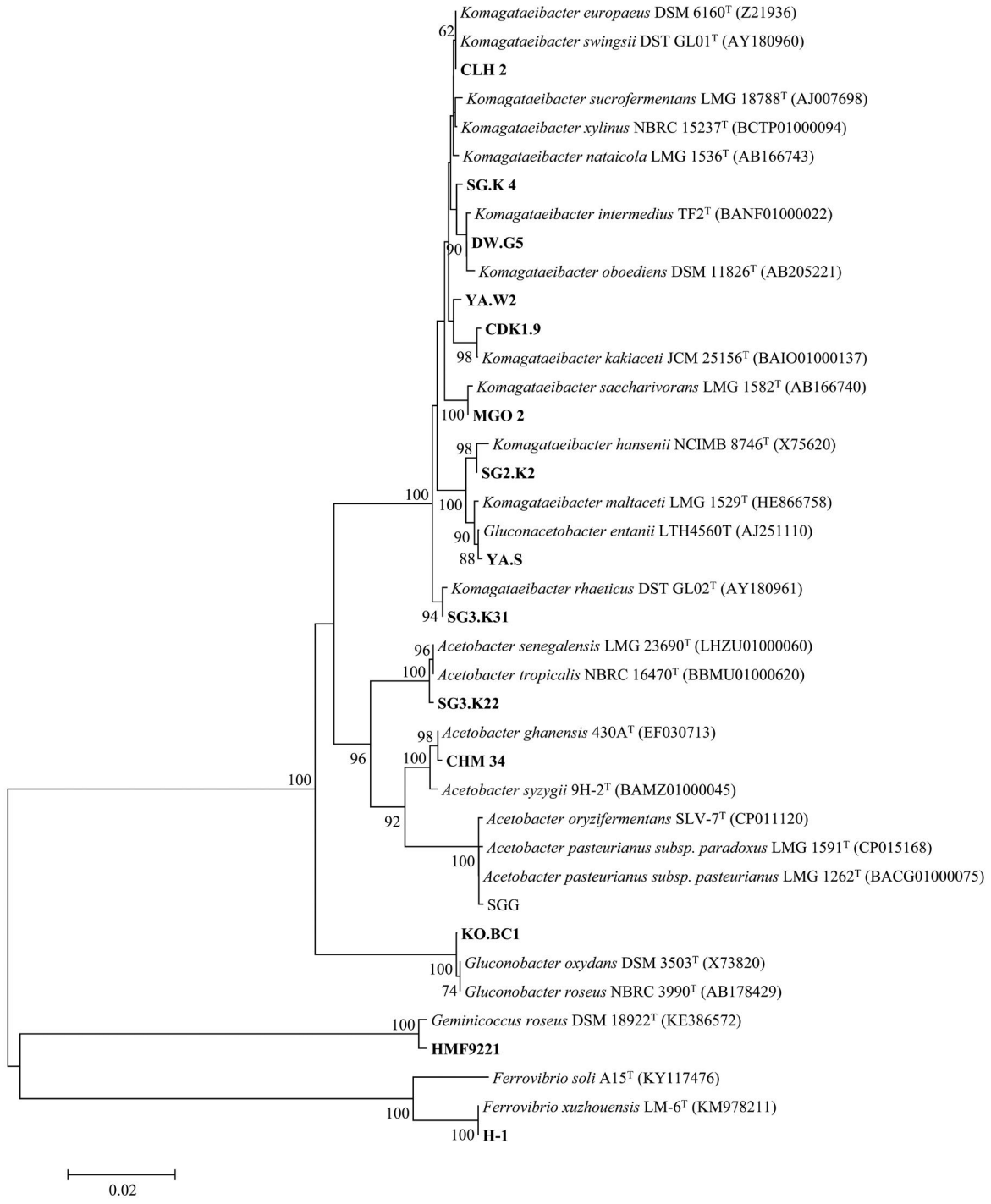

Fig. 4. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the order *Rhodospirillales* in the class *Alphaproteobacteria*. Bootstrap values >70% are shown in the neighbor-joining tree. Bar, 0.02 substitutions per nucleotide position.

20NE, negative for nitrate reduction, indole production, urease, esculin hydrolysis, β-galactosidase, glucose fermentation, arginine dihydrolase, and gelatinase. Does not utilize D-glucose, D-mannitol, D-mannose, L-arabinose, adipic acid, *N*-acetyl-glucosamine, malic acid, D-maltose, potassium gluconate, phenylacetic acid, and capric acid. Strain Wi-69 (=NIBRBAC000502443) has been isolated from sludge, Seoul Tancheon Recreation Center, Korea.

Description of *Microvirga makkahensis* CAU 1493

Cells are Gram-staining-negative, non-flagellated, and short rod-shaped. Colonies are circular, convex, entire smooth, shiny, opaque, and pink color after 2−3 days of incubation on MA at 30°C. In API 20NE, positive for gelatinase, negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, and β-galactosidase. D-glucose and D-mannose are utilized. Does not utilize L-arabinose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain CAU 1493 (=NIBRBAC000502366) has been isolated from coal mine soil, Hongcheon-gun, Korea.

Description of *Aminobacter niigataensis* Hyper-3

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and cream color after 2 days on R2A at 30°C. In API 20NE, positive for nitrate reduction and urease, and negative for esculin hydrolysis, β-galactosidase, arginine dihydrolase, indole production, glucose fermentation, and gelatinase. L-arabinose, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, malic acid, and trisodium citrate are utilized. Does not utilize D-glucose, D-mannose, D-mannitol, capric acid, and phenylacetic acid. Strain Hyper-3 (=NIBRBAC000502460) has been isolated from sludge, Suwon, Korea.

Description of *Mesorhizobium huakuii* BT148

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and yellow color after 4 days on R2A at 25°C. Positive for nitrate reduction and esculin hydrolysis, while negative for arginine dihydrolase, indole production, urease, glucose fermentation, and β-galactosidase in API 20NE. Utilizes D-glucose, L-arabinose, D-mannose, D-maltose, *N*-acetyl-glucosamine, D-mannitol, and potassium gluconate. Does not utilize, adipic acid, capric acid, malic acid, trisodium citrate, and phenylacetic acid. Strain BT148 (=NIBRBAC000502334) has been isolated from soil, Jeju, Korea.

Description of *Phyllobacterium brassicacearum* HMF7144

Cells are Gram-staining-negative, flagellated, and rod-shaped. Colonies are circular, convex, mucoid and white color after 3 days on R2A at 30°C. In API 20NE, positive for nitrate reduction, but negative for glucose fermentation, indole production, arginine dihydrolase, urease, esculin hydrolysis, β-galactosidase, and gelatinase. D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, and malic acid are utilized. Does not utilize D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain HMF7144 (=NIBRBAC000502512) has been isolated from leaves and stems of moss, Yongin, Korea.

Description of *Rhizobium altiplani* MMS18-CY061

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and cream color after 3 days on R2A at 30°C. Positive for urease and β-galactosidase, and negative for nitrate reduction, gelatinase, esculin hydrolysis, arginine dihydrolase, indole production, and glucose fermentation in API 20NE. D-glucose, D-mannose, D-maltose, potassium gluconate, L-arabinose, D-mannitol, and malic acid are utilized. Does not utilize *N*-acetyl-glucosamine, capric acid, adipic acid, trisodium citrate and phenylacetic acid. Strain MMS18-CY061 (=NIBRBAC000502554) has been isolated from soil, Cheongyang-gun, Korea.

Description of *Rhizobium mesoamericanum* GA017

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, smooth, glistening, and cream color after 3 days on R2A at 30°C. Positive for nitrate reduction, urease, and β-galactosidase, and negative for esculin hydrolysis, arginine dihydrolase, indole production, and glucose fermentation in API 20NE. Utilizes D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, malic acid, and phenylacetic acid. But potassium gluconate, adipic acid, Capric acid and trisodium citrate are not utilized. Strain GA017 (=NIBRBAC000502565) has been isolated from soil, Daejeon, Korea.

Description of *Shinella curvata* Wi-125

Cells are Gram-staining-negative, flagellated, and rod-shaped. Colonies are circular, convex, smooth, and cream color after 2 days on R2A at 30°C. In API 20NE, positive for urease, esculin hydrolysis, and β-galactosidase. Negative for nitrate reduction, glucose fermentation, indole production, arginine dihydrolase, and gelatinase. D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, and trisodium citrate are utilized. Does not utilize adipic acid, malic acid, D-maltose, capric acid, and phenylacetic acid. Strain Wi-125 (=NIBRBAC000502445) has been isolated from sludge, Seoul Tancheon Recreation Center, Korea.

Description of *Haematobacter massiliensis* 18JY13-8

Cells are Gram-staining-negative, flagellated, and rod-

shaped. Colonies are circular, convex, smooth, and yellow color after 4 days on R2A at 25°C. Positive for arginine dihydrolase, urease, and esculin hydrolysis, while negative for nitrate reduction, indole production, glucose fermentation, and β-galactosidase in API 20NE. Utilizes D-glucose, D-mannose, D-maltose, capric acid, adipic acid, and phenylacetic acid. Does not utilize L-arabinose, potassium gluconate, D-mannitol, *N*-acetyl-glucosamine, malic acid, and trisodium citrate. Strain 18JY13-8 (=NIBR BAC000502347) has been isolated from soil, Jeju, Korea.

Description of *Labrenzia alba* Gri211

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and white color after 3 days on MA at 30°C. In API 20NE, positive for arginine dihydrolase, urease, esculin hydrolysis, β-galactosidase, but negative for nitrate reduction, glucose fermentation, indole production, and gelatinase. D-mannose, D-mannitol, *N*-acetyl-glucosamine, and D-maltose are utilized. Does not utilize D-glucose, L-arabinose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain Gri211 (=NIBRBAC000502486) has been isolated from a seaweed sample, Taean, Korea.

Description of *Labrenzia alexandrii* CAU 1498

Cells are Gram-staining-negative, non-flagellated, and rod shaped. Colonies are Circular, smooth, shiny, opaque, and pale pink color after 5 days on MA at 30°C. Positive for gelatinase in API 20NE, but negative for nitrate reduction, glucose fermentation, esculin hydrolysis, urease, indole production, arginine dihydrolase, and β-galactosidase. D-glucose is utilized. L-arabinose, D-mannitol, phenylacetic acid Capric acid, malic acid, trisodium citrate, D-mannose, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, and adipic acid are not assimilated. Strain CAU 1498 (=NIBRBAC000502364) has been isolated from sea sand, Seogwipo, Korea.

Description of *Lentibacter algarum* KYW1484

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, entire, and beige color after 3 days on MA at 25°C. In API 20NE, negative for nitrate reduction, glucose fermentation, indole production, urease, esculin hydrolysis, arginine dihydrolase, β-galactosidase, and gelatinase. Does not utilize, D-glucose, 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 KYW1484 (=NIBRBAC 000502385) has been isolated from sea water, Gwangyang Bay, Korea.

Description of *Paenirhodobacter enshiensis* Wi-144

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, entire, smooth, glistening, and cream color after 2 days on R2A at 30°C. In API 20NE, positive for glucose fermentation, arginine dihydrolase, and urease, but negative for nitrate reduction, indole production, gelatinase, esculin hydrolysis, and β-galactosidase. D-glucose, L-arabinose, D-maltose, malic acid, and trisodium citrate are utilized. Does not utilize D-mannose, D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, adipic acid, capric acid, and phenylacetic acid. Strain Wi-144 (=NIBRBAC000502446) has been isolated from sludge, Seoul Tancheon Recreation Center, Korea.

Description of *Paracoccus denitrificans* dNF-2

Cells are Gram-staining-negative, non-flagellated, and coccus shaped. Colonies are circular, convex, smooth, and cream color after 2 days on R2A at 30°C. In API 20NE, positive for nitrate reduction and negative for esculin hydrolysis, β-galactosidase arginine dihydrolase, urease, indole production glucose fermentation, and gelatinase. D-glucose, L-arabinose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, malic acid, and phenylacetic acid are utilized. Do not utilize D-mannose, capric acid, adipic acid and trisodium citrate. Strain dNF-2 (=NIBRBAC000502458) has been isolated from sludge, Suwon, Korea.

Description of *Roseovarius indicus* Ast32

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and white color after 3 days on MA at 20°C. In API 20NE, positive for nitrate reduction, arginine dihydrolase and urease but negative for glucose fermentation, indole production, esculin hydrolysis, β-galactosidase, and gelatinase. Does not utilize D-glucose, 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 Ast32 (=NIBRBAC000502475) has been isolated from a seaweed sample, Taean, Korea.

Description of *Roseicyclus marinus* JBTF-M28

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and cream color after 5 days on MA at 30°C. In API 20NE, positive for nitrate reduction, urease, esculin hydrolysis, and β-galactosidase, but negative for glucose fermentation, indole production, arginine dihydrolase, and gelatinase. Does not utilize D-glucose, 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 JBTF-M28 (=NIBRBAC000502327) has been isolated from a salt flat sample, Jebudo, Korea.

Description of *Roseivivax halodurans* CAU 1505

Cells are Gram-staining-negative, non-flagellated, and short-rod. Colonies are circular, convex, smooth, and pink orange color after 1−2 days on MA at 30°C. Positive for nitrate reduction and indole production in API 20NE, but negative for urease, esculin hydrolysis, β-galactosidase, glucose fermentation, arginine dihydrolase, and gelatinase. Does not utilize D-mannitol, D-mannose, L-arabinose, adipic acid, *N*-acetyl-glucosamine, malic acid, D-maltose, potassium gluconate, phenylacetic acid, and capric acid. D-glucose and trisodium citrate are utilized. Strain CAU 1505 (=NIBRBAC000502378) has been isolated from a soil sample, Incheon, Korea.

Description of *Sinirhodobacter ferrireducens* BO-81

Cells are Gram-staining-negative, flagellated, and oval-rod shaped. Colonies are circular, convex, smooth, glistening, and cream color after 2 days on R2A at 30°C. Positive for nitrate reduction, arginine dihydrolase, urease, and esculin hydrolysis In API 20NE. Negative for β-galactosidase, indole production, glucose fermentation, and gelatinase. Utilizes D-maltose and phenylacetic acid. Does not utilize D-glucose, D-mannose, potassium gluconate, L-arabinose, D-mannitol, *N*-acetyl-glucosamine, malic acid, capric acid, adipic acid, and trisodium citrate. Strain BO-81 (=NIBRBAC000502467) has been isolated from sludge, Suwon, Korea.

Description of *Acetobacter ghanensis* CHM 34

Cells are Gram-staining-negative, non-flagellated, and rod shaped. Colonies are circular, convex, smooth, glistening and yellowish-white color after 3 days of incubation on HS at 28°C. Positive for nitrate reduction, glucose fermentation, and esculin hydrolysis in API 20NE, but negative for indole production, arginine dihydrolase, urease, gelatinase, and β-galactosidase. D-glucose is utilized. 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 CHM 34 (=NIBR BAC000502314) has been isolated from fermented vinegar, Cheongdo, Korea.

Description of *Acetobacter pasteurianus* subsp. *pasteurianus* SGG 2

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction, glucose fermentation, and esculin hydrolysis, but negative for indole production, arginine dihydrolase, urease, gelatinase, and β-galactosidase. Does not utilize D-glucose, 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 SGG 2 (=NIBRBAC000502315) has been isolated from fermented vinegar, Sangju, Korea.

Description of *Acetobacter tropicalis* SG3.K22

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction, glucose fermentation, esculin hydrolysis, but negative for indole production, arginine dihydrolase, urease, gelatinase and β-galactosidase. Does not utilize D-glucose, 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 SG3.K22 (=NIBRBAC000502316) has been isolated from fermented vinegar, Seoul, Korea.

Description of *Gluconacetobacter entanii* YA.S

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction, esculin hydrolysis, but negative for glucose fermentation, urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. D-glucose is utilized. 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 YA.S (=NIBRBAC000502317) has been isolated from fermented vinegar, Yeongam, Korea.

Description of *Gluconobacter oxydans* KO.BC1

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for esculin hydrolysis, but negative for nitrate reduction, glucose fermentation, urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. Does not utilize D-glucose, 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 KO.BC1 (=NIBRBAC000502318) has been isolated from fermented vinegar, Boryeong, Korea.

Description of *Komagataeibacter europaeus* CLH 2

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction and esculin hydrolysis, but negative for glucose fermentation, urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. Does not utilize D-glucose, 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 CLH 2 (=NIBRBAC000502319) has been isolated from fermented vinegar, Cheongju, Korea.

Description of *Komagataeibacter hansenii* SG2.K2

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction, glucose fermentation, and esculin hydrolysis, but negative for urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. Does not utilize D-glucose, 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 SG2.K2 (=NIBRBAC000502320) has been isolated from fermented vinegar, Seoul, Korea.

Description of *Komagataeibacter intermedius* DW.G5

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and yellowish-white color after 3 days on HS at 28°C. Positive for nitrate reduction, glucose fermentation, and esculin hydrolysis in API 20NE, but negative for indole production, arginine dihydrolase, urease, gelatinase, and β-galactosidase. D-glucose is utilized. 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 DW.G5 (=NIBRBAC000502321) has been isolated from fermented vinegar, Wanju, Korea.

Description of *Komagataeibacter kakiaceti* CDK1.9

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction and esculin hydrolysis, but negative for glucose fermentation, urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. Does not utilize D-glucose, 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 CDK1.9 (=NIBRBAC000502322) has been isolated from fermented vinegar, Cheongdo, Korea.

Description of *Komagataeibacter nataicola* YA.W2

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for esculin hydrolysis, but negative for nitrate reduction, glucose fermentation, urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. D-glucose is utilized. 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 YA.W2 (=NIBRBAC000502323) has been isolated from fermented vinegar, Yeongam, Korea.

Description of *Komagataeibacter rhaeticus* SG3.K31

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction and esculin hydrolysis, but negative for glucose fermentation, urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. Does not utilize D-glucose, 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 SG3.K31 (=NIBRBAC000502324) has been isolated from fermented vinegar, Seoul, Korea.

Description of *Komagataeibacter saccharivorans* MGO 2

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for nitrate reduction, glucose fermentation, urease, esculin hydrolysis, but negative for indole production, arginine dihydrolase, gelatinase, and β-galactosidase. D-glucose and potassium gluconate are utilized. Does not utilize L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain MGO 2 (=NIBRBAC000502 325) has been isolated from fermented vinegar, Jecheon, Korea.

Description of *Komagataeibacter xylinus* SG.K 4

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

rod-shaped. Colonies are circular, convex, smooth, glistening, and yellowish-white color after 3 days on HS at 28°C. In API 20NE, positive for esculin hydrolysis, but negative for nitrate reduction, glucose fermentation, urease, indole production, arginine dihydrolase, gelatinase, and β-galactosidase. Does not utilize D-glucose, 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 SG.K 4 (=NIBRBAC000502326) has been isolated fermented vinegar, Seoul, Korea.

Description of *Geminicoccus roseus* HMF9221

Cells are Gram-staining-negative, non-flagellated, and coccus-shaped. Colonies are circular, convex, smooth, and pale pink color after 3 days on MA at 30°C. In API 20NE, positive for urease, but negative for nitrate reduction, glucose fermentation, indole production, arginine dihydrolase, esculin hydrolysis, β-galactosidase, and gelatinase. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, malic acid, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Does not utilize adipic acid and trisodium citrate. Strain HMF9221 (=NIBRBAC 000502524) has been isolated from beach sand, Pohang, Korea.

Description of *Ferrovibrio xuzhouensis* H-1

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and cream color after 2 days on R2A at 30°C. In API 20NE, positive for nitrate reduction, arginine dihydrolase, and urease, and negative for indole production, glucose fermentation, gelatinase, esculin hydrolysis, and β-galactosidase. D-glucose, L-arabinose, *N*-acetyl-glucosamine, adipic acid, and malic acid are utilized. Does not utilize D-mannose, D-mannitol, potassium gluconate, D-maltose, capric acid, trisodium citrate, and phenylacetic acid. Strain H-1 (=NIBRBAC000502468) has been isolated from sludge, Suwon, Korea.

Description of *Erythrobacter pelagi* HMF9223

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and orange color after 3 days on MA at 30°C. In API 20NE, positive for esculin hydrolysis, but negative for nitrate reduction, glucose fermentation, indole production, urease, arginine dihydrolase, β-galactosidase, and gelatinase. D-glucose and malic acid are utilized. Does not utilize L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain HMF9223 (=NIBRBAC000502525) has been isolated from beach sand, Pohang, Korea.

Description of *Sphingobium czechense* MMS18-GA122

Cells are Gram-staining-positive, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and yellow color after 3 days on R2A at 30°C. Positive for β-galactosidase and esculin hydrolysis, while negative for nitrate reduction, arginine dihydrolase, indole production, urease, and glucose fermentation in API 20NE. Utilizes D-glucose, L-arabinose, and D-maltose. Does not utilize D-mannose, potassium gluconate, D-mannitol, *N*-acetyl-glucosamine, adipic acid, capric acid, malic acid, trisodium citrate, and phenylacetic acid. Strain MMS18-GA122 (=NIBRBAC000502563) has been isolated from soil, Daejeon, Korea.

Description of *Sphingopyxis flava* HMF9218

Cells are Gram-staining-negative, flagellated, and rod-shaped. Colonies are circular, convex, smooth, and yellow color after 3 days on MA at 30°C. In API 20NE, positive for nitrate reduction, esculin hydrolysis, and β-galactosidase, but negative for glucose fermentation, indole production, arginine dihydrolase, urease, and gelatinase. Malic acid is utilized. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain HMF9218 (=NIBRBAC000502523) has been isolated from beach sand, Pohang, Korea.

Description of *Sphingosinicella xenopeptidilytica* LA-50

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and yellow color after 2 days on R2A at 30°C. Positive for nitrate reduction and gelatinase, but negative for indole production, arginine dihydrolase, urease, esculin hydrolysis, glucose fermentation, and β-galactosidase in API 20NE. Trisodium citrate is utilized. D-glucose, D-mannose, *N*-acetyl-glucosamine, malic acid, D-mannitol, L-arabinose, potassium gluconate, D-maltose, capric acid, adipic acid, and phenylacetic acid are not utilized. Strain LA-50 (=NIBRBAC000502450) has been isolated from sludge, Seoul Tancheon Recreation Center, Korea.

Acknowledgements

This study was supported by the research grant "The Survey of Korean Indigenous Species" from the Nation-

al Institute of Biological Resources of the Ministry of Environment in Korea.

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Submitted: September 21, 2019
Revised: October 19, 2019
Accepted: October 21, 2019