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Report of 39 unrecorded bacterial species in Korea belonging to Gammaproteobacteria

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During a series of extensive surveys of prokaryotic species diversity in Korea, bacterial strains belonging to Gammaproteobacteria were isolated from various sources of aquatic and terrestrial environments. A total of 39 isolates were obtained, which represented 39 unrecorded species in Korea belonging to 20 genera in 12 families. *Enterobacteriaceae* was the largest family, as eight species were assigned, which was followed by *Moraxellaceae* (6 species) and *Pseudomonadaceae* (5 species). At the genus level, *Marinobacter* (6 species), and *Pseudomonas* (5 species) were the main genera, and at least two species were obtained for *Acinetobacter* (3 species), *Psychrobacter* (3 species), *Shewanella* (2 species), *Dickeya* (2 species), *Salinivibrio* (2 species), *Vibrio* (2 species) and *Rhodanobacter* (2 species). The detailed description of each unrecorded species is provided.

Keywords: 16S rRNA, *Enterobacteriaceae*, Gammaproteobacteria, *Marinobacter*, unrecorded species

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Introduction

The phylum Proteobacteria is currently the largest known bacterial group, and among the classes of Proteobacteria, Gammaproteobacteria is comprised of the broadest groups of proteobacteria, including 21 orders, 60 families and 394 genera as of August 2017 (Euzéby, 2017).

Gammaproteobacteria encompasses anoxygenic phototrophs, various chemolithotrophs and fermenters as well as aerobic or anaerobic respiratory heterotrophs, thus exhibiting virtually all types of metabolism found among prokaryotes (Brenner *et al*., 2005). Their habitats are also diverse, including terrestrial and aquatic environments, environments with extreme physicochemical conditions, and animal and plant hosts.

The diverse environments of Korea have contributed to the biodiversity of Gammaproteobacteria, as a number of unrecorded gammaproteobacterial species have already been reported in previous studies (Kim *et al*., 2011; Choi *et al*., 2015; Jung *et al*., 2016; Lim *et al*., 2016). Members of the families *Moraxellaceae*, *Pseudomonadaceae*, and *Enterobacteriaceae* were consistently recovered in all studies, and *Xanthomonadaceae*, *Alteromonadaceae*, *Pseudoalteromonadaceae*, *Vibrionaceae* were also frequently recovered constituents in those studies.

In the following series of extensive surveys on the prokaryotic diversity in Korea, novel strains belonging to the class Gammaproteobacteria of the phylum Proteobacteria were isolated from various environmental sources, and their taxonomic properties were analyzed. As a result, a total of 39 unrecorded species of Gammaproteobacteria were identified, and their taxonomic properties are presented.

Materials and Methods

A total of 39 bacterial strains assigned to the class Gammaproteobacteria were isolated from diverse environmental samples collected from sediment, tidal flats, soil, seawater, freshwater, brown alga, mealworm, solar saltern, plants and sewage treatment plants (Table 1). The samples were processed or treated separately, diluted and spread onto diverse culture media R2A, marine agar (MA), tryptic soy agar (TSA) or nutrient agar (NA) (BD), and incubated at 25-30°C for 2-5 days. The designated strain IDs, sources of isolation, culture media, and incubation conditions are provided in the description and Table 1. All strains were purified as single colonies and stored as 10-20% glycerol suspension at −80°C as well as lyophilized ampoules.

Colony characteristics of the isolates were observed on the same agar media for cultivation. Cellular morphology and cell size were examined using either a transmission electron microscope or a scanning electron microscope. Gram staining was performed using the standard procedures. Biochemical characteristics were tested by using API 20NE galleries (bioMérieux) according to the manufacturer's instructions.

The extraction of genomic DNA, PCR amplification of 16S rRNA gene and sequencing were performed using the procedures as described previously (Choi *et al*., 2015; Jung *et al*., 2016; Um *et al*., 2016). The 16S rRNA gene sequences of the strains were compared with the reference strains using the EzBioCloud (Kim *et al*., 2012), and their 16S rRNA sequences were aligned using EzEditor2 (Jeon *et al*., 2014). Phylogenetic trees were generated by Jukes-Cantor distance model (Jukes and Cantor, 1969) and neighbor-joining method (Saitou and Nei, 1987) using MEGA 7.0 (Kumar *et al*., 2016). The phylogenetic trees were evaluated using the bootstrap analysis (Felsenstein, 1985) based on 1,000 resampled dataset.

Results and Discussion

A total of 39 bacterial strains belonging to the class Gammaproteobacteria were isolated (Table 1). The strains represented 39 unrecorded species in Korea belonging to 20 genera of 12 families. *Enterobacteriaceae* was the largest family, as eight species were assigned, which was followed by *Moraxellaceae* (6 species), *Pseudomonadaceae* (5 species) and *Vibrionaceae* (4 species). One or two species were recovered for the remaining nine families (Table 1). At the genus level, *Marinobacter* (6 species), and *Pseudomonas* (5 species) were the main genera, and at least two species were obtained for *Acinetobacter* (3 species), *Psychrobacter* (3 species), *Shewanella* (2 species), *Dickeya* (2 species), *Salinivibrio* (2 species), *Vibrio* (2 species) and *Rhodanobacter* (2 species). Single species were recovered for the remaining 11 genera (Table 1). The electron microscopic images of the isolates are provided in Fig. 1, and the phylogenetic relationship between the isolates and closely related species are presented in Figs. 2-5. The detailed description of each unrecorded species is provided below.

Description of *Acinetobacter gandensis* 4003

Cells are Gram-stain-negative, non-flagellated, non-pigmented and coccoid-shaped. Colonies are irregular, entire, smooth, raised and white colored after incubation for 3 days on R2A at 30°C. Positive for nitrate reduction, indole production, glucose fermentation, urease, esculin hydrolysis and β-galactosidase, but negative for arginine dihydrolase and gelatin hydrolysis in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, malic acid, trisodium citrate and phenylacetic acid are utilized as sole carbon sources, but not adipic acid. Strain 4003 (=NIBRBAC000498564) was isolated from a sediment sample, Seoul, Korea.

Description of *Raoultella electrica* 4231

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, entire, smooth, flat and white colored after incubation for 2 days on R2A at 30°C. Positive for nitrate reduction, glucose fermentation, urease, esculin hydrolysis and β-galactosidase, but negative for indole production, arginine dihydrolase and gelatin hydrolysis in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, malic acid and trisodium citrate are utilized as sole carbon sources, but not capric acid and phenylacetic acid. Strain 4231 (=NIBRBAC000498567) was isolated from a sediment sample, Seoul, Korea.

Description of *Dickeya zeae* 7026

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, entire,

Table 1. Summary of strains isolated belonging to the class Gammaproteobacteria and their taxonomic affiliations

Phylum	Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation source	Medium	Incubation conditions
Gammaproteobacteria	*Aeromonadaceae*	*Aeromonas*	KB012	NIBRBAC000498636	*Aeromonas allosaccharophila*	100	Freshwater	R2A	25°C, 4 days
		Haemophilus	UL222	NIBRBAC000498616	*Haemophilus piscium*	99.6	Sea water	TSA with ASW	25°C, 3 days
	Alteromonadaceae	*Marinobacter*	IMCC25643	NIBRBAC000498542	*Marinobacter hydrocarbonoclasticus*	99.9	Tidal flat	MA	20°C, 3 days
			LPB0132	NIBRBAC000498520	*Marinobacter oulmenensis*	99.4	*Urechis unicinctus*	MA	25°C, 1 day
			LPB0156	NIBRBAC000498527	*Marinobacter sediminum*	98.9	Tidal flat	MA	25°C, 1 day
			LPB0159	NIBRBAC000498530	*Marinobacter guineae*	100	Tidal flat	MA	25°C, 1 day
			CAU 1046	NIBRBAC000498497	*Microbulbifer taiwanensis*	99.1	Soil	MA	30°C, 2 days
			IMCC25642	NIBRBAC000498541	*Microbulbifer mangrovi*	99.7	Tidal flat	MA	20°C, 3 days
	Pseudoalteromonadaceae	*Pseudoalteromonas*	EC2D12	NIBRBAC000498484	*Pseudoalteromonas lipolytica*	100	*Ecklonia cava*	MA	25°C, 3 days
	Shewanellaceae	*Shewanella*	IMCC25635	NIBRBAC000498534	*Shewanella algae*	99.9	Tidal flat	MA	20°C, 3 days
			LPB0153	NIBRBAC000498525	*Shewanella algidipiscicola*	100	Tidal flat	MA	25°C, 1 day
	Arenicellaceae	*Arenicella*	ZOD21	NIBRBAC000498478	*Arenicella chitinivorans*	100	*Zostera marina*	MA	25°C, 5 days
	Enterobacteriaceae	*Dickeya*	7026	NIBRBAC000498574	*Dickeya zeae*	99.2	Sediment	R2A	30°C, 2 days
			9023	NIBRBAC000498576	*Dickeya chrysanthemi*	99.9	Sediment	R2A	30°C, 2 days
		Erwinia	HMF7415	NIBRBAC000498453	*Erwinia billingiae*	99.9	Tree	R2A	25°C, 3 days
		Escherichia	BE6-1	NIBRBAC000498660	*Escherichia fergusonii*	100	Tidal flat	TSA	30°C, 4 days
		Pantoea	SN10	NIBRBAC000498426	*Pantoea stewartii* subsp. *indologenes*	99.4	Sewage treatment plant	MA	30°C, 2 days
		Raoultella	4231	NIBRBAC000498567	*Raoultella electrica*	99.7	Sediment	R2A	30°C, 2 days
		Serratia	GM22	NIBRBAC000498486	*Serratia quinivorans*	99.2	*Tenebrio molitor*	LB	25°C, 1 day
		Yokenella	7034	NIBRBAC000498575	*Yokenella regensburgei*	99.2	Sediment	R2A	30°C, 2 days
	Oceanospirillaceae	*Marinobacterium*	IMCC25639	NIBRBAC000498538	*Marinobacterium nitratireducens*	100	Tidal flat	MA	25°C, 1 day
	Moraxellaceae	*Acinetobacter*	4003	NIBRBAC000498564	*Acinetobacter gandensis*	98.7	Sediment	R2A	30°C, 2 days
			DS041	NIBRBAC000498630	*Acinetobacter junii*	98.5	Freshwater	R2A	25°C, 4 days
			IMCC25647	NIBRBAC000498546	*Acinetobacter radioresistens*	99.9	Plant root	MA	20°C, 3 days
		Psychrobacter	LGGG06	NIBRBAC000498632	*Psychrobacter marincola*	99.6	Sea water	R2A	25°C, 3 days
			POB9	NIBRBAC000498473	*Psychrobacter faecalis*	99.8	Wastewater	R2A	25°C, 2 days
			UL158	NIBRBAC000498615	*Psychrobacter piscatorii*	99.9	Sea water	TSA with ASW	25°C, 3 days
	Pseudomonadaceae	*Pseudomonas*	CAU 1335	NIBRBAC000498504	*Pseudomonas punonensis*	98.7	Sea water	MA (pH 8)	30°C, 2 days
			IMCC25652	NIBRBAC000498551	*Pseudomonas alcaliphila*	98.8	Plant root	MA	20°C, 3 days
			UL498-1	NIBRBAC000498618	*Pseudomonas guineae*	98.8	Sea water	TSA (pH 9)	25°C, 2 days
			UL506	NIBRBAC000498619	*Pseudomonas salina*	99.7	Sea water	TSA	30°C, 3 days
			YC7-24	NIBRBAC000498655	*Pseudomonas cuatrocienegasensis*	99.0	Cave	TSA	30°C, 2 days
	Vibrionaceae	*Salinivibrio*	HMF8002	NIBRBAC000498456	*Salinivibrio costicola* subsp. *vallismortis*	99.3	Saltern	MA	37°C, 2 days
			HMF8044	NIBRBAC000498458	*Salinivibrio sharmensis*	99.5	Saltern	MA	37°C, 2 days
		Vibrio	HMF8004	NIBRBAC000498457	*Vibrio ruber*	99.3	Saltern	MA	37°C, 2 days
			SFD22	NIBRBAC000498472	*Vibrio fortis*	99.9	*Sargassum fulvellum*	MA	25°C, 3 days
	Rhodanobacteraceae	*Rhodanobacter*	Gsoil 3009	NIBRBAC000498590	*Rhodanobacter spathiphylli*	99.1	Ginseng field	R2A	25°C, 3 days
			YHY1	NIBRBAC000498406	*Rhodanobacter glycinis*	99.7	Sewage treatment plant	R2A	25°C, 2 days
	Xanthomonadaceae	*Xanthomonas*	SN5	NIBRBAC000498425	*Xanthomonas sacchari*	99.2	Sewage treatment plant	MA	30°C, 2 days

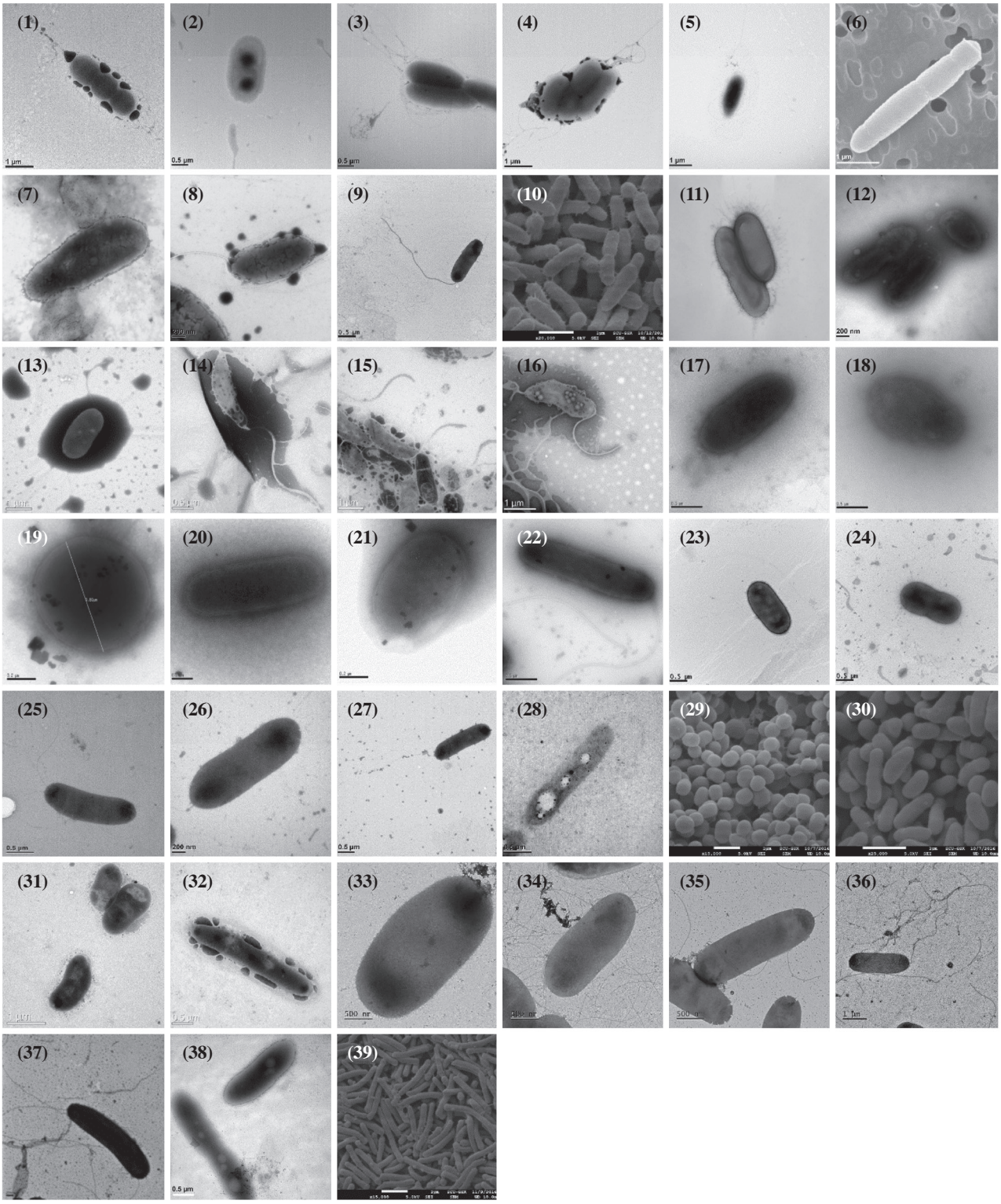


Fig. 1. Transmission electron micrographs or scanning electron micrographs of cells of the strains isolated in the study. Strains: 1, 4003; 2, 4231; 3, 7026; 4, 7034; 5, 9023; 6, BE6-1; 7, CAU 1046; 8, CAU 1335; 9, DS041; 10, EC2D12; 11, GM22; 12, Gsoil 3009; 13, HMF7415; 14, HMF8002; 15, HMF8004; 16, HMF8044; 17, IMCC25635; 18, IMCC25639; 19, IMCC25642; 20, IMCC25643; 21, IMCC25647; 22, IMCC25652; 23, KB012; 24, LGGG06; 25, LPB0132; 26, LPB0153; 27, LPB0156; 28, LPB0159; 29, POB9; 30, SFD22; 31, SN5; 32, SN10; 33, UL158; 34, UL222; 35, UL498-1; 36, UL506; 37, YC7-24; 38, YHY1; 39, ZOD21.

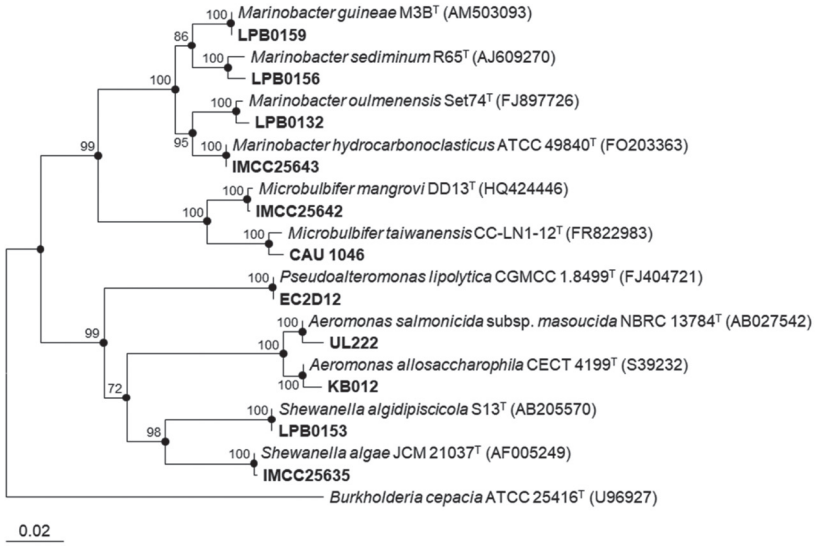


Fig. 2. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationships between the strains isolated in this study and their relatives of the order *Aeromonadales* and *Alteromonadales* in the class Gammaproteobacteria. Bootstrap values (>50%) are shown at branching points. Filled circles indicate that the corresponding nodes were also recovered in the trees generated with the maximum-likelihood and maximum-parsimony algorithms, while open circles indicate that the corresponding nodes were also recovered in the tree generated with one of these algorithms. Bar, 0.02 substitutions per nucleotide position.

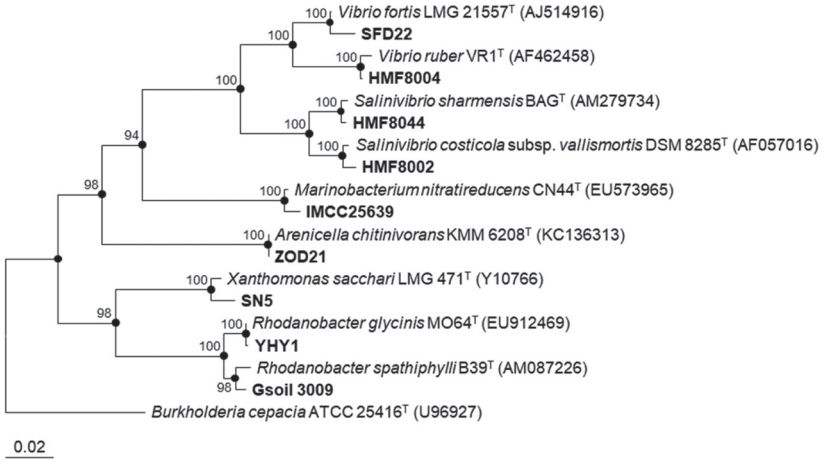


Fig. 3. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationships between the strains isolated in this study and their relatives of the order *Arenicellales*, *Vibrionales* and *Xanthomonadales* in the class Gammaproteobacteria. Bootstrap values (>50%) are shown at branching points. Filled circles indicate that the corresponding nodes were also recovered in the trees generated with the maximum-likelihood and maximum-parsimony algorithms, while open circles indicate that the corresponding nodes were also recovered in the tree generated with one of these algorithms. Bar, 0.02 substitutions per nucleotide position.

smooth, raised and white colored after incubation for 2 days on R2A at 30°C. Positive for nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, potassium gluconate, malic acid and trisodium citrate are utilized as sole carbon sources, but not D-maltose, capric acid, adipic acid and phenylacetic acid. Strain 7026 (=NIBRBAC000498574) was isolated from a sediment sample, Seoul, Korea.

Description of *Yokenella regensburgei* 7034

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, entire,

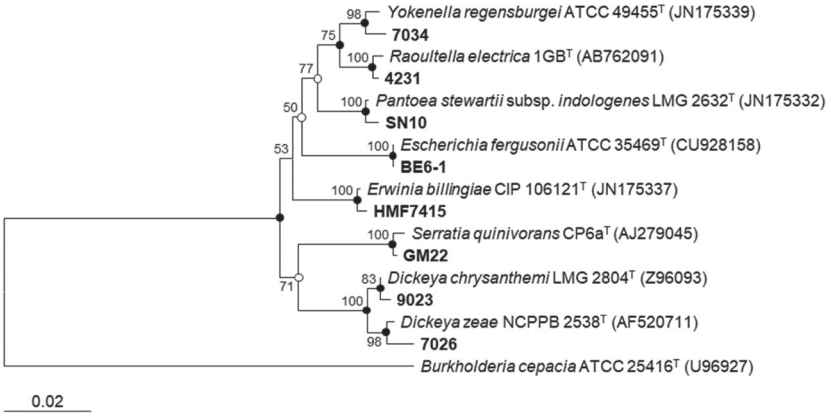


Fig. 4. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationships between the strains isolated in this study and their relatives of the order *Enterobacteriales* in the class Gammaproteobacteria. Bootstrap values (>50%) are shown at branching points. Filled circles indicate that the corresponding nodes were also recovered in the trees generated with the maximum-likelihood and maximum-parsimony algorithms, while open circles indicate that the corresponding nodes were also recovered in the tree generated with one of these algorithms. Bar, 0.02 substitutions per nucleotide position.

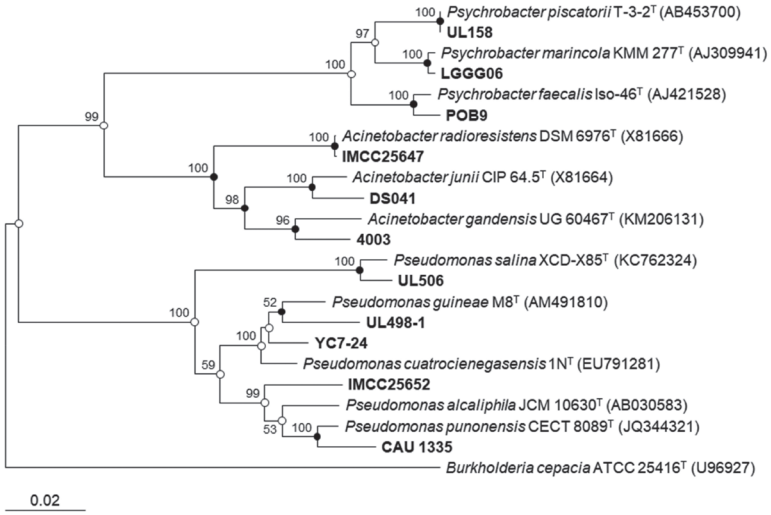


Fig. 5. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationships between the strains isolated in this study and their relatives of the order *Pseudomonadales* in the class Gammaproteobacteria. Bootstrap values (>50%) are shown at branching points. Filled circles indicate that the corresponding nodes were also recovered in the trees generated with the maximum-likelihood and maximum-parsimony algorithms, while open circles indicate that the corresponding nodes were also recovered in the tree generated with one of these algorithms. Bar, 0.02 substitutions per nucleotide position.

smooth, raised and white colored after incubation for 2 days on R2A at 30°C. Positive for nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, potassium gluconate, malic acid and trisodium citrate are utilized as sole carbon sources, but not D-maltose, capric acid, adipic acid and phenylacetic acid. Strain 7034 (=NIBRBAC000498575) was isolated from a sediment sample, Seoul, Korea.

Description of *Dickeya chrysanthemi* 9023

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are irregular, undulate, glistening and white colored after incubation for 2 days on R2A at 30°C. Positive for nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate,

malic acid and trisodium citrate are utilized as sole carbon sources, but not capric acid, adipic acid and phenylacetic acid. Strain 9023 (=NIBRBAC000498576) was isolated from a sediment sample, Seoul, Korea.

Description of *Escherichia fergusonii* BE6-1

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, convex, entire and cream colored after incubation for 4 days on TSA at 30°C. Positive for nitrate reduction, glucose fermentation, esculin hydrolysis and β-galactosidase, but negative for indole production, arginine dihydrolase, urease and gelatin hydrolysis in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, malic acid and phenylacetic acid are utilized as sole carbon sources, but not capric acid, adipic acid and trisodium citrate. Strain BE6-1 (=NIBRBAC000498660) was isolated from a tidal flat sample, Eulsuk Island, Korea.

Description of *Microbulbifer taiwanensis* CAU 1046

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, glistening, convex and pale yellow colored after incubation for 3 days on MA at 30°C. Positive for esculin hydrolysis and gelatin hydrolysis, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and β-galactosidase in API 20NE. L-Arabinose and D-maltose are utilized as sole carbon sources, but not D-glucose, D-mannose, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid. Strain CAU 1046 (=NIBRBAC000498497) was isolated from a soil sample, Jeju Island, Korea.

Description of *Pseudomonas punonensis* CAU 1335

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are small circular, convex and cream colored after incubation for 3 days on pH 8 MA at 30°C. Positive for nitrate reduction, glucose fermentation, arginine dihydrolase, urease and esculin hydrolysis, but negative for indole production, gelatin hydrolysis and β-galactosidase in API 20NE. D-Glucose, L-arabinose, N-acetylglucosamine, D-maltose, capric acid, malic acid and trisodium citrate are utilized as sole carbon sources, but not D-mannose, D-mannitol, potassium gluconate, adipic acid and phenylacetic acid. Strain CAU 1335 (=NIBRBAC000498504) was isolated from a seawater sample, Jeju Island, Korea.

Description of *Acinetobacter junii* DS041

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, convex and pale yellow colored after 4 days of incubation on R2A at 25°C. Positive for nitrate reduction, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. D-Glucose, L-arabinose, capric acid, malic acid and trisodium citrate are utilized as sole carbon sources, but not D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid and phenylacetic acid. Strain DS041 (=NIBRBAC000498630) was isolated from a freshwater sample, Seoul, Korea.

Description of *Pseudoalteromonas lipolytica* EC2D12

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, transparent, smooth, umbonate and cream colored after incubation for 3 days on MA at 25°C. Positive for nitrate reduction, esculin hydrolysis and gelatin hydrolysis, but negative for indole production, glucose fermentation, arginine dihydrolase, urease and β-galactosidase in API 20NE. 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 EC2D12 (=NIBRBAC000498484) was isolated from an *Ecklonia cava* sample, Yeosu, Korea.

Description of *Serratia quinivorans* GM22

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, opaque, smooth, convex and cream colored after incubation for 1 day on LB at 25°C. Positive for nitrate reduction, glucose fermentation, esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for indole production, arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, malic acid and trisodium citrate are utilized as sole carbon sources, but not adipic acid and phenylacetic acid. Strain GM22 (=NIBRBAC000498486) was isolated from a *Tenebrio molitor* sample, Gokseong, Korea.

Description of *Rhodanobacter spathiphylli* Gsoil 3009

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, convex, glistening and yellow colored after incubation for 3 days on R2A at 25°C. Positive for nitrate reduction and esculin hydrolysis, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, gelatin hydrolysis and β-galactosidase in API 20NE. D-Glu-

cose, D-mannose, N-acetyl-glucosamine and D-maltose are utilized as sole carbon sources, but not L-arabinose, D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid. Strain Gsoil 3009 (=NIBRBAC000498590) was isolated from a ginseng field soil sample, Anseong, Korea.

Description of *Erwinia billingiae* HMF7415

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod to oval-shaped. Colonies are circular, convex, entire and beige colored after incubation for 3 days on R2A at 25°C. Positive for nitrate reduction, glucose fermentation, esculin hydrolysis and β-galactosidase, but negative for indole production, arginine dihydrolase, urease and gelatin hydrolysis in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate and malic acid are utilized as sole carbon sources, but not capric acid, adipic acid, trisodium citrate and phenylacetic acid. Strain HMF7415 (=NIBRBAC000498453) was isolated from a tree sample, Yongin, Korea.

Description of *Salinivibrio costicola* subsp. *vallismortis* HMF8002

Cells are Gram-stain-negative, non-flagellated, non-pigmented and curved-rod-shaped. Colonies are circular, convex, entire and red colored after incubation for 2 days on MA at 37°C. Positive for glucose fermentation, arginine dihydrolase and gelatin hydrolysis, but negative for nitrate reduction, indole production, urease, esculin hydrolysis and β-galactosidase in API 20NE. D-Glucose, D-mannose, N-acetyl-glucosamine, potassium gluconate and malic acid are utilized as sole carbon sources, but not L-arabinose, D-mannitol, D-maltose, capric acid, adipic acid, trisodium citrate and phenylacetic acid. Strain HMF8002 (=NIBRBAC000498456) was isolated from a saltern sample, Sinan, Korea.

Description of *Vibrio ruber* HMF8004

Cells are Gram-stain-negative, non-flagellated, non-pigmented and curved-rod-shaped. Colonies are circular, convex, entire and red colored after incubation for 2 days on MA at 30°C. Positive for nitrate reduction, glucose fermentation, esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for indole production, arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol and D-maltose are utilized as sole carbon sources, but not N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid. Strain HMF8004 (=NIBRBAC000498457) was isolated from a saltern sample, Sinan, Korea.

Description of *Salinivibrio sharmensis* HMF8044

Cells are Gram-stain-negative, non-flagellated, non-pigmented and curved-rod-shaped. Colonies are circular, convex, entire and beige colored after incubation for 2 days on MA at 37°C. Positive for esculin hydrolysis, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, gelatin hydrolysis and β-galactosidase in API 20NE. Dose 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 HMF8044 (=NIBRBAC000498458) was isolated from a saltern sample, Sinan, Korea.

Description of *Shewanella algae* IMCC25635

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, entire, convex and orange colored after incubation for 3 days on MA at 20°C. Positive for indole production, gelatin hydrolysis and β-galactosidase, but negative for nitrate reduction, glucose fermentation, arginine dihydrolase, urease and esculin hydrolysis in API 20NE. D-Maltose and trisodium citrate are utilized as sole carbon sources, but not D-glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid and phenylacetic acid. Strain IMCC25635 (=NIBRBAC000498534) was isolated from a tidal flat sample, Mo Island, Korea.

Description of *Marinobacterium nitratireducens* IMCC25639

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, entire, convex and yellow colored after incubation for 3 days on MA at 20°C. Negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. 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 IMCC25639 (=NIBRBAC000498538) was isolated from a tidal flat sample, Mo Island, Korea.

Description of *Microbulbifer mangrove* IMCC25642

Cells are Gram-stain-negative, non-flagellated, non-pigmented and coccoid-shaped. Colonies are circular, convex, entire and yellow colored after incubation for 3 days on MA at 20°C. Positive for nitrate reduction, gelatin hydrolysis and β-galactosidase, but negative for indole production, glucose fermentation, arginine dihydrolase, urease and esculin hydrolysis in API 20NE.

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 IMCC25642 (=NIBRBAC000498541) was isolated from a tidal flat sample, Mo Island, Korea.

Description of *Marinobacter hydrocarbonoclasticus* IMCC25643

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, convex, entire and white colored after incubation for 3 days on MA at 20°C. Positive for nitrate reduction, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. 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 IMCC25643 (=NIBR BAC000498542) was isolated from a tidal flat sample, Mo Island, Korea.

Description of *Acinetobacter radioresistens* IMCC25647

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, convex, entire and white colored after incubation for 3 days on MA at 20°C. Negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. L-Arabinose, adipic acid and malic acid are utilized as sole carbon sources, but not D-glucose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, trisodium citrate and phenylacetic acid. Strain IMCC25647 (=NIBRBAC000498546) was isolated from a plant root sample, Jo Island, Korea.

Description of *Pseudomonas alcaliphila* IMCC25652

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, convex, entire and white colored after incubation for 3 days on MA at 20°C. Positive for esculin hydrolysis, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, gelatin hydrolysis and β-galactosidase in API 20NE. L-Arabinose, N-acetyl-glucosamine, capric acid, adipic acid, trisodium citrate and phenylacetic acid are utilized as sole carbon sources, but not D-glucose, D-mannose, D-mannitol, D-maltose, potassium gluconate and malic acid. Strain IMCC25652 (=NIBRBAC000498551) was isolated from a plant root sample, Jo Island, Korea.

Description of *Aeromonas allosaccharophila* KB012

Cells are Gram-stain-negative, non-flagellated, non-pigmented and oval-shaped. Colonies are circular, convex, smooth, opaque and white colored after incubation for 4 days on R2A at 25°C. Positive for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for urease in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, malic acid and trisodium citrate are utilized as sole carbon sources, but not adipic acid and phenylacetic acid. Strain KB012 (=NIBRBAC000498636) was isolated from a freshwater sample, Gunsan, Korea

Description of *Psychrobacter marincola* LGGG06

Cells are Gram-stain-negative, non-flagellated, non-pigmented and oval-shaped. Colonies are circular, slightly convex and pale yellow colored after incubation for 3 days on R2A at 25°C. Positive for nitrate reduction and glucose fermentation, but negative for indole production, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. 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 LGGG06 (=NIBRBAC000498632) was isolated from a seawater sample, Jeju Island, Korea.

Description of *Marinobacter oulmenensis* LPB0132

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, entire, convex and beige colored after incubation for 1 day on MA at 25°C. Positive for nitrate reduction and gelatin hydrolysis, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis and β-galactosidase in API 20NE. N-Acetyl-glucosamine and malic acid are utilized as sole carbon sources, but not D-glucose, L-arabinose, D-mannose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate and phenylacetic acid. Strain LPB0132 (=NIBRBAC000498520) was isolated from an *Urechis unicinctus* sample, Jumunjin, Korea.

Description of *Shewanella algidipiscicola* LPB0153

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, entire, convex and beige colored after incubation for 1 day on MA at 25°C. Positive for nitrate reduction and esculin

hydrolysis, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, gelatin hydrolysis and β-galactosidase in API 20NE. N-Acetyl-glucosamine and malic acid are utilized as sole carbon sources, but not D-glucose, L-arabinose, D-mannose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate and phenylacetic acid. Strain LPB0153 (=NIBRBAC000498525) was isolated from a tidal flat sample, Jebu Island, Korea.

Description of *Marinobacter sediminum* LPB0156

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, entire, convex and yellow colored after 1 day of incubation on MA at 25°C. Positive for nitrate reduction, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. 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 LPB0156 (=NIBR BAC000498527) was isolated from a tidal flat sample, Jebu Island, Korea.

Description of *Marinobacter guineae* LPB0159

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, entire, convex and beige colored after 1 day of incubation on MA at 25°C. Positive for nitrate reduction, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. 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 LPB0159 (=NIBR BAC000498530) was isolated from a tidal flat sample, Jebu Island, Korea.

Description of *Psychrobacter faecalis* POB9

Cells are Gram-stain-negative, non-flagellated, non-pigmented and coccobacilli-shaped. Colonies are opaque, circular, smooth, convex and cream colored after incubation for 2 days on R2A at 25°C. Positive for nitrate reduction and glucose fermentation, but negative for indole production, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. Dose 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 POB9 (=NIBRBAC000498473) was isolated from a wastewater sample, Gwangyang, Korea.

Description of *Vibrio fortis* SFD22

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are opaque, smooth, low convex and cream colored after incubation for 3 days on MA at 25°C. Positive for esculin hydrolysis, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, gelatin hydrolysis and β-galactosidase in API 20NE. Dose 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 SFD22 (=NIBR BAC000498472) was isolated from a *Sargassum fulvellum* sample, Jeju Island, Korea.

Description of *Xanthomonas saccahri* SN5

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, raise, entire and pale-yellow colored after incubation for 2 days on MA at 30°C. Positive for esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, N-acetyl-glucosamine, D-maltose, malic acid and trisodium citrate are utilized as sole carbon sources, but not D-mannitol, potassium gluconate, capric acid, adipic acid and phenylacetic acid. Strain SN5 (=NIBRBAC000498425) was isolated from a sewage treatment plant sample, Busan, Korea.

Description of *Pantoea stewartii* subsp. *indologenes* SN10

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, raise, entire and pale yellow colored after incubation for 2 days on MA at 30°C. Positive for esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, N-acetyl-glucosamine, D-maltose, malic acid and trisodium citrate are utilized as sole carbon sources, but not D-mannitol, potassium gluconate, capric acid, adipic acid and phenylacetic acid. Strain SN10 (=NIBRBAC000498426) was isolated from a sewage treatment plant sample, Busan, Korea.

Description of *Psychrobacter piscatorii* UL158

Cells are Gram-stain-negative, non-flagellated, non-

pigmented and rod-shaped. Colonies are circular, opaque, convex and beige colored after incubation for 3 days on TSA at 25°C. Positive for esculin hydrolysis, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, gelatin hydrolysis and β-galactosidase in API 20NE. L-Arabinose and malic acid are utilized as sole carbon sources, but not D-glucose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate and phenylacetic acid. Strain UL158 (=NIBRBAC000498615) was isolated from a seawater sample, Ulleung Island, Korea.

Description of *Haemophilus piscium* UL222

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are circular, opaque, convex and beige colored after incubation for 3 days on TSA at 25°C. Positive for nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, gelatin hydrolysis and β-galactosidase, but negative for arginine dihydrolase and urease in API 20NE. D-Glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, malic acid and trisodium citrate are utilized as sole carbon sources, but not adipic acid and phenylacetic acid. Strain UL222 (=NIBRBAC000498616) was isolated from a seawater sample, Ulleung Island, Korea.

Description of *Pseudomonas guineae* UL498-1

Cells are Gram-stain-negative, flagellated, pigmented and rod-shaped. Colonies are circular, convex, smooth, glistening and pale yellow colored after incubation for 2 days on TSA at 25°C. Positive for gelatin hydrolysis, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, β-galactosidase in API 20NE. D-Glucose, capric acid, malic acid and trisodium citrate are utilized as sole carbon sources, but not L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid and phenylacetic acid. Strain UL498-1 (=NIBRBAC000498618) was isolated from a seawater sample, Ulleung Island, Korea.

Description of *Pseudomonas salina* UL506

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, convex, entire and pale yellow colored after incubation for 3 days on TSA at 30°C. Negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. 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 UL506 (=NIBRBAC000498619) was isolated from a soil sample, Ulleung Island, Korea.

Description of *Pseudomonas cuatrocienegasensis* YC7-24

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, convex, entire and light yellow colored after incubation for 2 days on TSA at 30°C. Positive for nitrate reduction, but negative for indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. D-Glucose, potassium gluconate, malic acid and trisodium citrate are utilized as sole carbon sources, but not L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, capric acid, adipic acid and phenylacetic acid. Strain YC7-24 (=NIBRBAC000498655) was isolated from a cave sample, Jeju Island, Korea.

Description of *Rhodanobacter glycinis* YHY1

Cells are Gram-stain-negative, flagellated, non-pigmented and rod-shaped. Colonies are circular, smooth, convex and ivory colored after incubation for 2 days on R2A at 25°C. Negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, esculin hydrolysis, gelatin hydrolysis and β-galactosidase in API 20NE. N-Acetyl-glucosamine and D-maltose are utilized as sole carbon sources, but not D-glucose, L-arabinose, D-mannose, D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid. Strain YHY1 (=NIBRBAC000498406) was isolated from a sewage treatment plant sample, Busan, Korea.

Description of *Arenicella chitinivorans* ZOD21

Cells are Gram-stain-negative, non-flagellated, non-pigmented and rod-shaped. Colonies are irregular, circular, smooth, entire and yellow colored after incubation for 5 days on MA at 25°C. Positive for esculin hydrolysis and gelatin hydrolysis, but negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and β-galactosidase in API 20NE. Dose 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 ZOD21 (=NIBRBAC000498478) was isolated from a *Zostera marina* sample, Seosan, Korea.

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