

A report of 29 unrecorded bacterial species belonging to the phylum *Bacteroidetes* in Korea

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Within a comprehensive, widescale investigation of indigenous prokaryotic species in Korea, 29 bacterial strains in the phylum *Bacteroidetes* were isolated from diverse environmental habitats that included soil, plant roots, natural caves, tidal flats, freshwater from lakes, and seawater. Based on their high 16S rRNA gene sequence similarities (>99.1%) and the formation of robust phylogenetic clades with the closest type species, each strain likely belonged to an independent and predefined bacterial species. There are no publications or official reports of the isolation of these 29 species in Korea. Our study provides strong evidence that seven species in three genera in the order *Cytophagales*, 15 species in 13 genera in the order *Flavobacteriales* and seven species in five genera in the order *Sphingobacteriales*, all within the phylum *Bacteroidetes*, are new reports of bacterial species in Korea. Gram reaction, colony and cell morphology, basic biochemical characteristics, isolation source, and strain IDs are described in the species description section.

Keywords: 16S rRNA, bacterial diversity, *Bacteroidetes*, indigenous Korean prokaryotic species, taxonomy, unrecorded species

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INTRODUCTION

The phylum *Bacteroidetes*, also known as the *Cytophaga-Flexibacter-Bacteroides* (CFB) group, is a diverse bacterial phylum whose taxonomic designation has changed several times in the past several years. (Woose, 1987; Woose *et al.*, 1990). Species or strains in the *Bacteroidetes* have been isolated from diverse environmental habitats including terrestrial ecosystems and freshwater and marine systems (Bernardet *et al.*, 1996; Bernardet *et al.*, 2002; Kirchman, 2002). Cultured isolates of *Bacteroidetes* are all gram-negative heterotrophs, notable for their ability to efficiently degrade complex biomacromolecules such as protein, chitin, pectin, agar, starch, and cellulose

(Alain *et al.*, 2008).

In 2015, 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 *Bacteroidetes* that were not previously reported in Korea. Here, we report 29 unrecorded bacterial species belonging to the *Bacteroidetes*, which consisted of 29 genera within three orders.

MATERIALS AND METHODS

A total of 29 bacterial strains assigned to the phylum

Bacteroidetes were isolated from various environmental habitats, including soil, plant roots, natural caves, tidal flats, freshwater, and seawater (Table 1). All each environmental samples were processed separately, serially diluted, spread onto diverse culture agar media including R2A agar (BD), marine agar 2216 (MA, BD), Kuster's agar (KUA: glycerol, 10 g; casein, 0.3 g; KNO₃, 2 g; K₂HPO₄, 2 g; soluble starch, 0.5 g; asparagine, 0.1 g; FeSO₄·7H₂O, 0.01 g; CaCO₃, 0.02 g; MgSO₄·7H₂O, 0.05 g; agar, 15 g per 1,000 mL filtered sea water, pH 7.0) and nutrient agar (NA, BD), and incubated at 25-30°C for 2-5 days (Table 1). The designated strain IDs, isolation sources, culture media, and incubation conditions are summarized in Table 1. All strains were isolated as pure cultures and stored as 10-20% glycerol suspension at -80°C and as lyophilized ampoules.

Colony morphology of the strains was observed by eye or a magnifying glass after the cells were cultivated to their stationary phase on their culture agar media. Cellular morphology and cell size were examined using either transmission electron or scanning electron microscopy. Gram staining was performed using a gram-staining kit according to the standard procedures. 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 standard procedures as described elsewhere (Lee *et al.*, 2014). The 16S rRNA gene sequences of the strains assigned to the *Bacteroidetes* were compared with those of the type strains of validated bacterial species using the EzTaxon-e server (Kim *et al.*, 2012). For phylogenetic analyses, multiple alignments of the 16S rRNA gene sequences of the isolates and those of the valid type strains were carried out using the Clustal_X program (Thompson *et al.*, 1997). Evolutionary distances were calculated using the Kimura two-parameter model (Kimura, 1983) and the phylogenetic trees were constructed using a neighbor-joining algorithm (Saitou and Nei, 1987) with bootstrap values based on 1,000 replications (Felsenstein, 2002).

RESULTS AND DISCUSSION

The 29 strains were distributed into 3 orders in the phylum *Bacteroidetes*: 15 strains in the order *Flavobacteriales*, seven strains in the *Cytophagales*, and seven strains in the *Sphingobacteriales* (Table 1). These strains were gram-staining-negative, chemoheterotrophic, and rod-shaped bacteria (Fig. 1). Colony size, morphology, and physiological characteristics are presented in the species description section.

Seven strains were assigned to the family *Cyclobacte-*

riaceae, *Dyadobacter* and *Cytophagaceae* in the order *Cytophagales* (Fig. 2). Among these strains, three that were assigned to the family *Cyclobacteriaceae* belonged to the genus *Algoriphagus*, one strain that was assigned to the family *Dyadobacter* belonged to the genus *Dyadobacter*, and three strains that were assigned to the family *Cytophagaceae* belonged to the genus *Arcicella*. Strains that were assigned to the order *Flavobacteriales* (Fig. 3) belonged to one family and 13 genera: *Flavobacterium* (3 species), *Arenibacter* (1 species), *Muricauda* (1 species), *Zobellia* (1 species), *Maribacter* (1 species), *Formosa* (1 species), *Mariniflexile* (1 species), *Cellulophaga* (1 species), *Mesonina* (1 species), *Arenitalea* (1 species), *Sediminicola* (1 species), *Zeaxanthinibacter* (1 species), and *Cytophaga* (1 species). Seven strains were assigned to the family *Sphingobacteriaceae* and *Chitinophagaceae* in the order *Sphingobacteriales* (Fig. 4). Among these, three strains that were assigned to the family *Sphingobacteriaceae* belonged to the genus *Sphingobacterium* (1 species) and *Pedobacter* (2 species) and four strains that were assigned to the family *Chitinophagaceae* belonged to the genus *Chitinophaga* (2 species), *Niabella* (1 species) and *Asinibacterium* (1 species). Here, we report 29 unrecorded bacterial species belonging to 6 families in 3 orders in the *Bacteroidetes*, which were isolated in Korea.

Description of *Algoriphagus namhaensis* HN30-2

Cells are gram-staining-negative, non-flagellated, non-pigmented, and rod-shaped. Colonies are circular, convex, smooth, and reddish orange colored after 3 days of incubation at 25°C on MA. Positive for β -galactosidase activity and esculin hydrolysis. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase, gelatinase, and urease activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, D-maltose, *N*-acetyl-glucosamine, capric acid, adipic acid, phenylacetic acid, malic acid, trisodium citrate, and potassium gluconate. Strain HN30-2 (=NIBRBAC000497930) was isolated from a seawater sample, Haenam, Korea.

Description of *Algoriphagus olei* RDH3

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are smooth, shiny, convex, and pinkish red-colored after 2 days of incubation at 30°C on R2A. Positive for esculin hydrolysis and gelatinase and β -galactosidase activities. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase and urease activities. D-Glucose, D-mannose, *N*-acetyl-glucosamine, and D-maltose are utilized. Does not utilize L-arabinose, D-mannitol, adipic acid, malic acid, phenylacetic acid, trisodium citrate,

Table 1. Summary of strains isolated belonging to the *Bacteroidetes* and their taxonomic affiliations.

Order	Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation source	Medium	Incubation conditions	
Cytophagales	Cyclobacteriaceae	<i>Algoriphagus</i>	G4	NIBRBAC000498067	<i>Algoriphagus winogradskyi</i>	99.5	Tidal flat	R2A	30°C, 2d	
		<i>Algoriphagus</i>	RDH3	NIBRBAC000498077	<i>Algoriphagus olei</i>	99.6	Fresh water	R2A	30°C, 2d	
		<i>Algoriphagus</i>	HN30-2	NIBRBAC000497930	<i>Algoriphagus namhaensis</i>	99.4	Seawater	MA	25°C, 3d	
	Dyadobacter_f	<i>Dyadobacter</i>	M2015-1	NIBRBAC000498053	<i>Dyadobacter psychrophilus</i>	100	Soil	R2A	25°C, 2d	
		Cytophagaceae	<i>Arcicella</i>	HMF3809	NIBRBAC000497898	<i>Arcicella aquatica</i>	99.7	Fresh water	R2A	25°C, 2d
	<i>Arcicella</i>		JD36	NIBRBAC000497944	<i>Arcicella rosea</i>	99.8	Fresh water	R2A	25°C, 3d	
	<i>Arcicella</i>		YBF1	NIBRBAC000498047	<i>Arcicella rigui</i>	99.4	Freshwater	R2A	25°C, 2d	
	Flavobacteriales	Flavobacteriaceae	<i>Flavobacterium</i>	RDH2	NIBRBAC000498076	<i>Flavobacterium chleniae</i>	99.9	Lake	R2A	30°C, 2d
			<i>Flavobacterium</i>	HMF4059	NIBRBAC000497910	<i>Flavobacterium chilense</i>	99.6	Fresh water	R2A	30°C, 3d
			<i>Flavobacterium</i>	2015-2	NIBRBAC000498054	<i>Flavobacterium columnare</i>	99.0	Fresh water	R2A	25°C, 2d
<i>Arenibacter</i>			MW24	NIBRBAC000497863	<i>Arenibacter echinorum</i>	99.4	Tidal flat	MA	30°C, 2d	
<i>Muricauda</i>			MW105	NIBRBAC000497883	<i>Muricauda antarctica</i>	99.7	Tidal flat	MA	30°C, 2d	
<i>Zobellia</i>			HMF3932	NIBRBAC000497905	<i>Zobellia galactanivorans</i>	99.9	Seawater	MA	30°C, 3d	
<i>Maribacter</i>			HN1	NIBRBAC000497929	<i>Maribacter caenipelagi</i>	99.9	Tidal flat	MA	25°C, 3d	
<i>Formosa</i>			HN41	NIBRBAC000497931	<i>Formosa spongicola</i>	99.7	Tidal flat	MA	25°C, 3d	
<i>Mariniflexile</i>			HN49	NIBRBAC000497932	<i>Mariniflexile aquimaris</i>	99.9	Tidal flat	MA	25°C, 3d	
Sphingobacteriales			Sphingobacteriaceae	<i>Cellulophaga</i>	KYW1172	NIBRBAC000497941	<i>Cellulophaga baltica</i>	99.6	Seawater	MA
	<i>Mesonima</i>	KYW1047		NIBRBAC000497945	<i>Mesonima algae</i>	99.6	Seawater	MA	25°C, 3d	
	<i>Arenitalea</i>	LPB0108		NIBRBAC000497984	<i>Arenitalea latea</i>	100	Seawater	MA	26°C, 2d	
	<i>Sediminicola</i>	LPB0111		NIBRBAC000497986	<i>Sediminicola luteus</i>	99.4	Seawater	MA	26°C, 2d	
	<i>Zeaxanthinibacter</i>	LPB0115		NIBRBAC000497987	<i>Zeaxanthinibacter enoshimensis</i>	100	Seawater	MA	26°C, 2d	
	<i>Cytophaga</i>	DF-2		NIBRBAC000498044	<i>Cytophaga massiliensis</i>	99.9	Fresh water	R2A	25°C, 2d	
	<i>Sphingobacterium</i>	HMF3876		NIBRBAC000497901	<i>Sphingobacterium multivorum</i>	99.4	Soil	R2A	30°C, 3d	
	<i>Pedobacter</i>	HMF3898		NIBRBAC000497903	<i>Pedobacter piscium</i>	99.8	Soil	R2A	30°C, 3d	
	<i>Pedobacter</i>	NU3		NIBRBAC000498049	<i>Pedobacter glucosidilyticus</i>	98.8	Fresh water	R2A	25°C, 2d	
	<i>Chitinophaga</i>	NR 2-02		NIBRBAC000498082	<i>Chitinophaga orycterrae</i>	99.1	Plant root	R2A	30°C, 2d	
Chitinophagaceae	<i>Chitinophaga</i>	C2-40	NIBRBAC000498025	<i>Chitinophaga arvensicola</i>	99.6	Natural cave	TSA	30°C, 5d		
	<i>Niabella</i>	HMF2508	NIBRBAC000497896	<i>Niabella thaonhiensis</i>	99.9	Soil	R2A	30°C, 3d		
	<i>Asinibacterium</i>	M2015-5	NIBRBAC000498048	<i>Asinibacterium lactis</i>	100	Soil	R2A	25°C, 2d		

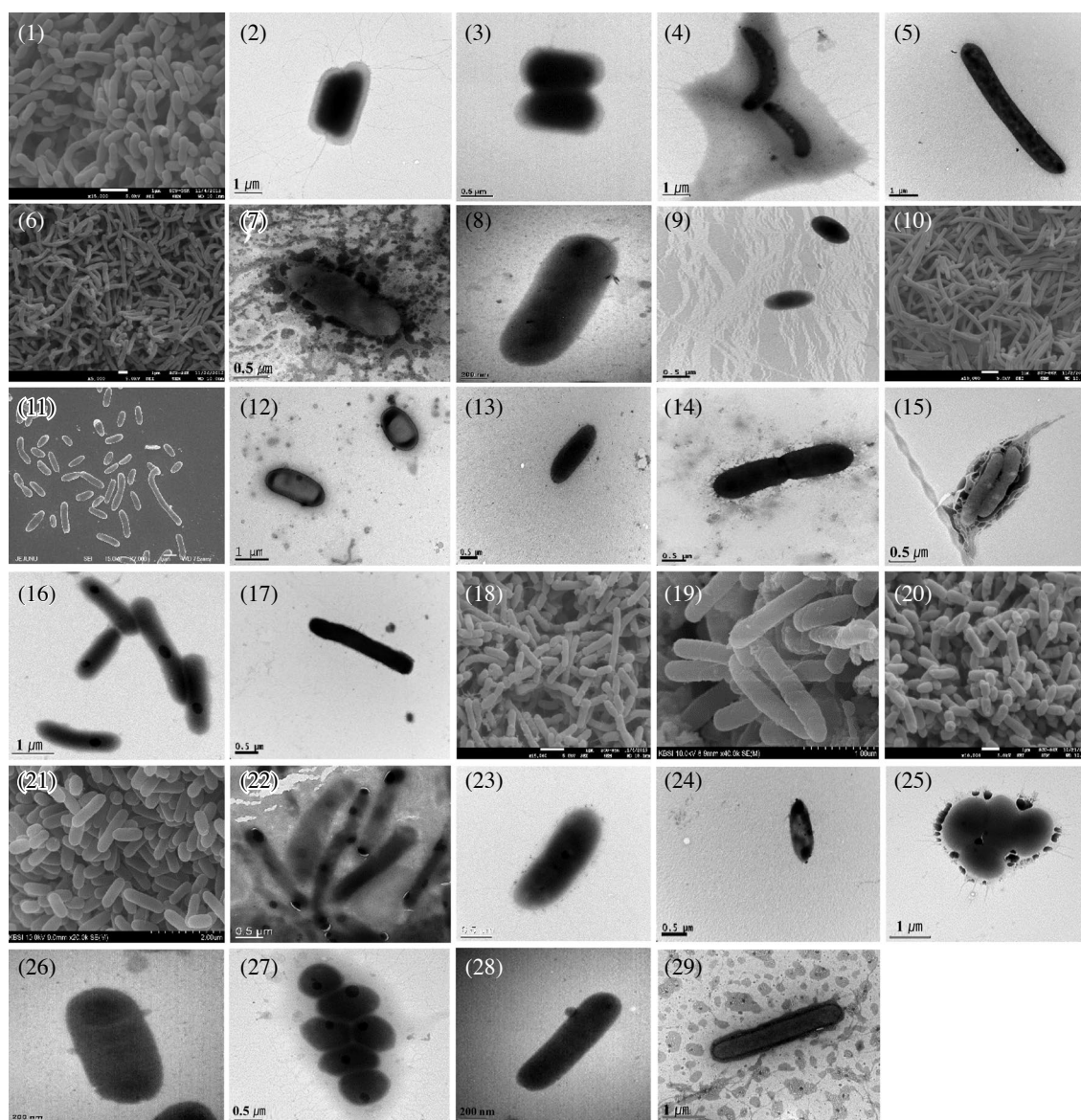


Fig. 1. Transmission electron micrographs or scanning electron micrographs of cells of the strains isolated in this study. The cells were cultured at their optimal growth conditions. Strains: 1, HN30-2; 2, RDH3; 3, G4; 4, HMF3809; 5, YBF1; 6, JD36; 7, MW24; 8, LPB0108; 9, M2015-5; 10, KYW1172; 11, C2-40; 12, NR 2-02; 13, DF-2; 14, M2015-1; 15, RDH2; 16, HMF4059; 17, 2015-2; 18, HN41; 19, HN1; 20, HN49; 21, KYW1047; 22, MW105; 23, HMF2508; 24, NU3; 25, HMF3898; 26, LPB0111; 27, HMF3876; 28, LPB0115; 29, HMF3932.

capric acid, and potassium gluconate. Strain RDH3 (= NIBRBAC000498077) was isolated from a lake water sample, Chung-Ang University, Korea.

Description of *Algoriphagus winogradskyi* G4

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, shiny, entire, and bright-pink-colored after 2 days of incubation at 30°C on R2A. Positive for esculin hydrolysis and β -galactosidase activity. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase,

gelatinase, and urease activities. D-Glucose, L-arabinose, D-mannitol, D-maltose, adipic acid, malic acid, D-mannose, potassium gluconate, *N*-acetyl-glucosamine, and trisodium citrate are utilized. Does not utilize capric acid and phenylacetic acid. Strain G4 (= NIBRBAC000498067) was isolated from a tidal flat sample, Ganghwa-gun, Korea.

Description of *Arcicella aquatic* HMF3809

Cells are gram-staining-negative, non-flagellated, non-pigmented, and curved rod-shaped. Colonies are circu-

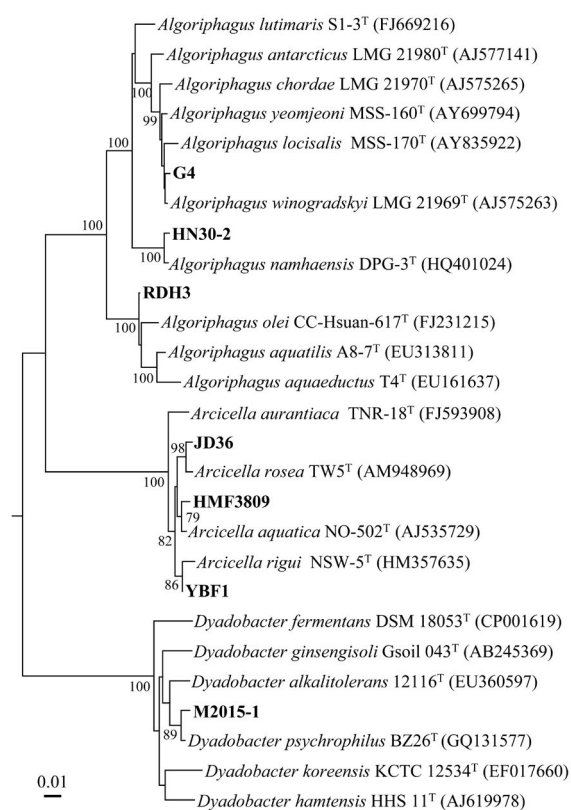


Fig. 2. Neighbor-joining phylogenetic tree based on 16S rRNA gene sequences, showing the phylogenetic relationships between the strains isolated in this study and their relatives of the order *Cytophagales* in the phylum *Bacteroidetes*. *Escherichia coli* ATCC 11775^T (X80725) was used as an outgroup (not shown). Bootstrap values (>70%) are shown above nodes. Scale bar: 0.01 changes per nucleotide.

lar, convex, entire, and pink-colored after 3 days of incubation at 30°C on R2A agar. Positive for esculin hydrolysis and β -galactosidase activity. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase, urease, and gelatinase activities. Does not utilize D-glucose, D-mannose, D-mannitol, L-arabinose, malic acid, trisodium citrate, *N*-acetyl-glucosamine, capric acid, potassium gluconate, adipic acid, D-maltose, and phenylacetic acid. Strain HMF3809 (= NIBRBAC000497898) was isolated from a freshwater sample, Yongin, Korea.

Description of *Arcicella rigui* YBF1

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, mucous, and pink-colored after 2 days of incubation at 25°C on R2A agar. Positive for β -galactosidase activity. Negative for nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, and arginine dihydrolase, urease, and gelatinase activities. Does not utilize D-glucose, L-arab-

inose, D-mannose, D-mannitol, D-maltose, *N*-acetyl-glucosamine, capric acid, adipic acid, trisodium citrate, phenylacetic acid, potassium gluconate, and malic acid. Strain YBF1 (= NIBRBAC000498047) was isolated a fresh water sample, Yeonggwang-gun, Korea.

Description of *Arcicella rosea* JD36

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are smooth, circular, translucent, and pale pink-colored after 3 days of incubation at 25°C on R2A agar. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase and urease activities. Positive for esculin hydrolysis and gelatinase and β -galactosidase activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-maltose, D-mannitol, *N*-acetyl-glucosamine, adipic acid, malic acid, potassium gluconate, phenylacetic acid, trisodium citrate, and capric acid. Strain JD36 (= NIBRBAC000497944) was isolated from a fresh water sample, Changwon, Korea.

Description of *Arenibacter echinorum* MW24

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, raised, and entire pale yellow-colored after 2 days of incubation at 30°C on MA. Positive for nitrate reduction, esculin hydrolysis, and β -galactosidase activity. Negative for indole production, glucose fermentation, and arginine dihydrolase, urease, and gelatinase activities. D-Glucose, D-mannose, *N*-acetyl-glucosamine, and D-maltose are utilized. Does not utilize L-arabinose, D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid. Strain MW24 (= NIBRBAC000497863) was isolated from a tidal flat sample, Taean, Korea.

Description of *Arenitalea lutea* LPB0108

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular and yellow-colored after 2 days of incubation on MA at 26°C. Positive for esculin hydrolysis. Negative for nitrate production, glucose fermentation, indole production, and urease, arginine dihydrolase, β -galactosidase, and gelatinase activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, malic acid, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid. Strain LPB0108 (= NIBRBAC000497984) was isolated from a seawater sample, Busan, Korea.

Description of *Asinibacterium lactis* M2015-5

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

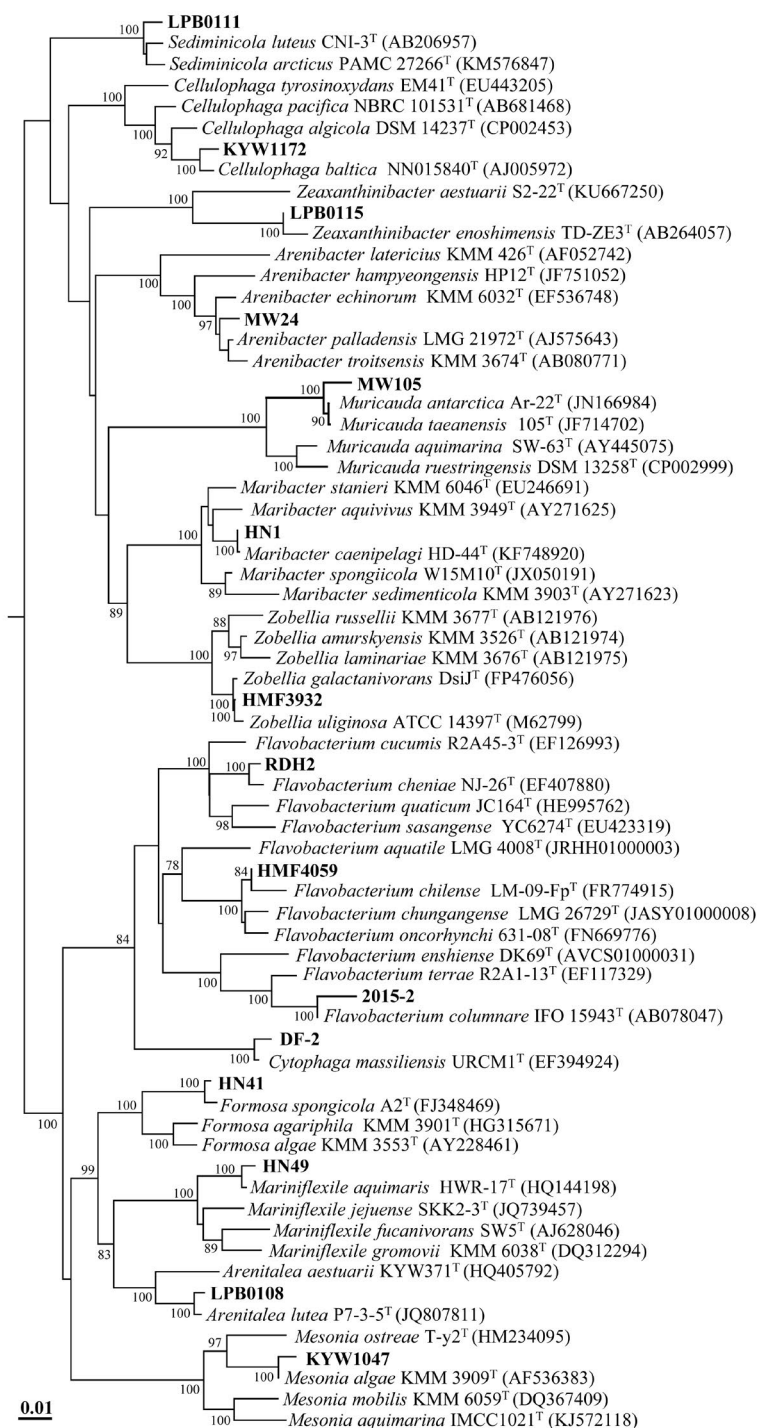


Fig. 3. Neighbor-joining phylogenetic tree based on 16S rRNA gene sequences, showing the phylogenetic relationships between the strains isolated in this study and their relatives of the order *Flavobacteriales* in the phylum *Bacteroidetes*. *Escherichia coli* ATCC 11775^T (X80725) was used as an outgroup (not shown). Bootstrap values (>70%) are shown above nodes. Scale bar: 0.01 changes per nucleotide.

rod-shaped. Colonies are circular, convex, and yellow-colored after 2 days of incubation at 25°C on R2A. Positive for esculin hydrolysis. Negative for nitrate reduction, indole production, glucose fermentation, and ure-

ase, arginine dihydrolase, gelatinase, and β -galactosidase activities. L-Arabinose is utilized. Dose not assimilate D-glucose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, trisodium ci-

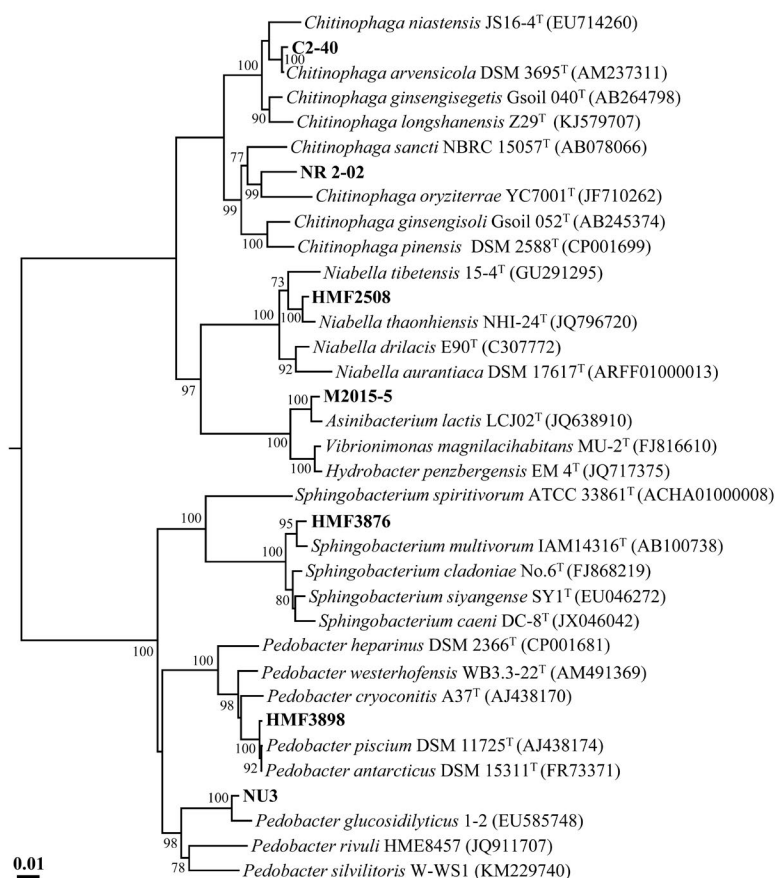


Fig. 4. Neighbor-joining phylogenetic tree based on 16S rRNA gene sequences, showing the phylogenetic relationships between the strains isolated in this study and their relatives of the order *Sphingobacteriales* in the phylum *Bacteroidetes*. *Escherichia coli* ATCC 11775^T (X80725) was used as an outgroup (not shown). Bootstrap values (> 70%) are shown above nodes. Scale bar: 0.01 changes per nucleotide.

trate, capric acid, phenylacetic acid, and adipic acid. Strain M2015-5 (= NIBRBAC000498048) was isolated from a soil sample, Wanju, Korea.

Description of *Cellulophaga baltica* KYW1172

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are irregular, opaque, and yellow-colored after 4 days of incubation at 25°C on MA. Positive for nitrate reduction, esculin hydrolysis, and β -galactosidase activity. Negative for indole production, glucose fermentation, and arginine dihydrolase, urease, and gelatinase activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, potassium gluconate, capric acid, trisodium citrate, phenylacetic acid, adipic acid, *N*-acetyl-glucosamine, D-maltose, and malic acid. Strain KYW1172 (= NIBRBAC000497941) was isolated from a seawater sample, Gwangyang, Korea.

Description of *Chitinophaga arvensicola* C2-40

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, entire, and

bright yellow-colored after 5 days of incubation on TSA at 30°C. Positive for esculin hydrolysis and β -galactosidase activities. Negative for nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, and gelatinase activities. D-Glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine and D-maltose is utilized. Does not utilize, malic acid, adipic acid, D-mannitol, potassium gluconate, phenylacetic acid, trisodium citrate, and capric acid. Strain C2-40 (= NIBRBAC000498025) was isolated from a natural cave sample, Jeju island, Korea.

Description of *Chitinophaga oryzae* NR 2-02

Cells are gram-staining-negative, non-flagellated, and short rod-shaped. Colonies are circular, raised, entire and yellow-colored after 3 days of incubation on R2A agar at 30°C. Positive for nitrate reduction, esculin hydrolysis, and β -galactosidase activity. Negative for indole production, glucose fermentation, and arginine dihydrolase, urease, and gelatinase activities. D-Glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine, and

D-maltose are utilized. Does not utilize D-mannitol, potassium gluconate, malic acid, phenylacetic acid, trisodium citrate, capric acid, and adipic acid. Strain NR 2-02 (=NIBRBAC000498082) was isolated from a plant root sample, Jeongeuup, Korea.

Description of *Cytophaga massiliensis* DF-2

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies irregular, convex, and yellow-colored after 2 days of incubation at 25°C on R2A. Positive for esculin hydrolysis. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase, β -galactosidase, urease, and gelatinase activities. D-Glucose, L-arabinose, D-mannose, and D-maltose are utilized. Does not utilize D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, adipic acid, malic acid, phenylacetic acid, trisodium citrate, and capric acid. Strain DF-2 (=NIBRBAC000498044) was isolated from a fresh water sample, Jeonju, Korea.

Description of *Dyadobacter psychrophilus* M2015-1

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and yellow-colored after 2 days of incubation on R2A agar at 25°C. Positive for esculin hydrolysis and β -galactosidase activity. Negative for nitrate reduction, glucose fermentation, indole production, and urease, arginine dihydrolase, and gelatinase activities. D-Glucose, D-mannose, and adipic acid are utilized. Does not utilize L-arabinose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, malic acid, potassium gluconate, phenylacetic acid, trisodium citrate, and capric acid. Strain M2015-1 (=NIBRBAC000498053) was isolated from a soil sample, Wanju, Korea.

Description of *Flavobacterium cheniae* RDH2

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, smooth, entire, and yellow-colored after 2 days of incubation at 30°C on R2A. Positive for gelatinase activity. D-Glucose, L-arabinose, D-maltose, D-mannose, D-mannitol, trisodium citrate, potassium gluconate, adipic acid, malic acid, and *N*-acetyl-glucosamine are utilized. Negative for nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, and arginine dihydrolase, urease, and β -galactosidase activities. Does not utilize phenylacetic acid and capric acid. Strain RDH2 (=NIBRBAC000498076) was isolated from a lake water sample, Chung-Ang University, Korea.

Description of *Flavobacterium chilense* HMF4059

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, entire, and

yellow-colored after 3 days of incubation at 30°C on R2A agar. Positive for esculin hydrolysis and gelatinase and β -galactosidase activities. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase and urease activities. Does not utilize D-mannitol, potassium gluconate, capric acid, trisodium citrate, phenylacetic acid, adipic acid, and malic acid. D-Glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine, and D-maltose are utilized. Strain HMF4059 (=NIBRBAC000497910) was isolated from a fresh water sample, Jeju island, Korea.

Description of *Flavobacterium columnare* 2015-2

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and yellow-colored after 2 days of incubation at 25°C on R2A agar. Positive for nitrate reduction and gelatinase activity. Negative for indole production, glucose fermentation, esculin hydrolysis, and arginine dihydrolase, β -galactosidase, and urease activities. Does not utilize D-glucose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, malic acid, trisodium citrate, phenylacetic acid, L-arabinose, capric acid, and adipic acid. Strain 2015-2 (=NIBRBAC000498054) was isolated from a fresh water sample, Jeonju, Korea.

Description of *Formosa spongicola* HN41

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and yellow-colored after 3 days on MA at 25°C. Positive for gelatinase activity. Negative for nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, and arginine dihydrolase, urease, and β -galactosidase activities. Does not utilize D-glucose, L-arabinose, D-maltose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, malic acid, trisodium citrate, phenylacetic acid, capric acid, and adipic acid. Strain HN41 (=NIBRBAC000497931) was isolated from a tidal flat sample, Haenam, Korea.

Description of *Maribacter caenipelagi* HN1

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are irregular, smooth, and light yellow-colored after 3 days of incubation at 25°C on MA. Positive for β -galactosidase activity and esculin hydrolysis. Negative for nitrate reduction, glucose fermentation, indole production, and arginine dihydrolase, urease, and gelatinase activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, malic acid, trisodium citrate, phenylacetic acid, and capric acid. Strain HN1 (=NIBRBAC000497929) was isolated from a tidal flat sample, Haenam, Korea.

Description of *Mariniflexile aquimaris* HN49

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, smooth, and yellow-colored after 3 days of incubation at 25°C on MA. Positive for nitrate reduction, esculin hydrolysis, and β -galactosidase activity. Negative for indole production, glucose fermentation, and arginine dihydrolase, urease, and gelatinase activities. D-Glucose, D-mannose, D-mannitol, and D-maltose are utilized. Does not utilize L-arabinose, *N*-acetyl-glucosamine, potassium gluconate, malic acid, capric acid, trisodium citrate, adipic acid, and phenylacetic acid. Strain HN49 (=NIBRBAC000497932) was isolated from a seawater sample, Haenam, Korea.

Description of *Mesonia algae* KYW1047

Cells are Gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, opaque, entire, and yellow-colored after 3 days on MA at 25°C. Positive for β -galactosidase activity. Negative for nitrate reduction, esculin hydrolysis, indole production, glucose fermentation, and gelatinase, arginine dihydrolase, and urease activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, D-maltose, *N*-acetyl-glucosamine, potassium gluconate, trisodium citrate, malic acid, phenylacetic acid, capric acid, and adipic acid. Strain KYW1047 (=NIBRBAC000497945) was isolated from a sea water sample, Gwangyang, Korea.

Description of *Muricauda antarctica* MW105

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, raised, entire and pale yellow colored after 2 days on MA at 30°C. Positive for esculin hydrolysis and β -galactosidase activity. Negative for nitrate reduction, glucose fermentation, indole production, and arginine dihydrolase, urease, and gelatinase activities. D-Mannose and *N*-acetyl-glucosamine are utilized. Does not utilize D-glucose, L-arabinose, D-mannitol, D-maltose, potassium gluconate, adipic acid, malic acid, trisodium citrate, phenylacetic acid, and capric acid. Strain MW105 (=NIBRBAC000497883) was isolated from a tidal flat sample, Taean, Korea.

Description of *Niabella thaonhiensis* HMF2508

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, entire, and yellow-colored after 3 days of incubation at 30°C on R2A agar. Positive esculin hydrolysis and arginine dihydrolase activity. Negative for nitrate reduction, indole production, glucose fermentation, and urease, gelatinase, and β -galactosidase activities. Does not utilize potassium gluconate, malic acid, trisodium citrate, D-mannitol,

capric acid, adipic acid, and phenylacetic acid, but utilizes D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine, and D-maltose. Strain HMF2508 (=NIBRBAC000497896) was isolated from a soil sample, Yongin, Korea.

Description of *Pedobacter glucosidilyticus* NU3

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, and pink-colored after 2 days of incubation at 25°C on R2A agar. Positive for esculin hydrolysis. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase, β -galactosidase, urease and gelatinase activities. D-Glucose, L-arabinose, D-mannitol, *N*-acetyl-glucosamine, and D-maltose are utilized. Does not utilize D-mannose, capric acid, adipic acid, trisodium citrate, phenylacetic acid, potassium gluconate, and malic acid. Strain NU3 (=NIBRBAC000498049) was isolated from a fresh water sample, Jeonju, Korea.

Description of *Pedobacter piscium* HMF3898

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular, convex, entire, and cream-colored after 3 days of incubation at 30°C on R2A. Positive for esculin hydrolysis and β -galactosidase activity. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase, urease, and gelatinase activities. D-Glucose, L-arabinose, D-mannose, D-mannitol, and D-maltose are utilized. Does not utilize *N*-acetyl-glucosamine, potassium gluconate, adipic acid, trisodium citrate, malic acid, phenylacetic acid, and capric acid. Strain HMF3898 (=NIBRBAC000497903) was isolated from a soil sample, Yongin, Korea.

Description of *Sediminicola luteus* LPB0111

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular and dark yellow after 2 days of incubation at 26°C on MA. Positive for esculin hydrolysis and β -galactosidase activity. Negative for nitrate reduction, glucose fermentation, indole production, and arginine dihydrolase, urease, and gelatinase activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, malic acid, trisodium citrate, potassium gluconate, adipic acid, D-maltose, *N*-acetyl-glucosamine, capric acid, and phenylacetic acid. Strain LPB0111 (=NIBRBAC000497986) was isolated from a sea water sample, Busan, Korea.

Description of *Sphingobacterium multivorum* HMF3876

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

rod-shaped. Colonies are circular, convex, entire, and cream-colored after 3 days of incubation at 30°C on R2A agar. Positive for esculin hydrolysis and arginine dihydrolase, urease, and β -galactosidase activities. Negative for nitrate reduction, indole production, glucose fermentation, and gelatinase activity. D-Glucose, L-arabinose, D-mannose, D-maltose, and *N*-acetyl-glucosamine are utilized. Does not utilize D-mannitol, potassium gluconate, adipic acid, trisodium citrate, malic acid, phenylacetic acid, and capric acid. Strain HMF3876 (= NIBR BAC000497901) was isolated from a soil sample, Yongin, Korea.

Description of *Zeaxanthinibacter enoshimensis* LPB0115

Cells are gram-staining-negative, non-flagellated, and rod-shaped. Colonies are circular and yellow-colored after 2 days of incubation on MA at 26°C. Positive for esculin hydrolysis. Negative for glucose fermentation, nitrate reduction, indole production, and arginine dihydrolase, urease, gelatinase, and β -galactosidase activities. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, malic acid, capric acid, trisodium citrate, phenylacetic acid, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, and adipic acid. Strain LPB0115 (= NIBRBAC000497987) was isolated from a sea water sample, Busan, Korea.

Description of *Zobellia galactanivorans* HMF3932

Cells are gram-staining-negative, flagellated, and rod-shaped. Colonies are circular and yellow-colored after 3 days of incubation at 30°C on MA. Positive for esculin hydrolysis and urease, gelatinase, and β -galactosidase activities. Negative for nitrate reduction, indole production, glucose fermentation, and arginine dihydrolase activity. Does not utilize D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, trisodium citrate, capric acid, malic acid, and phenylacetic acid. Strain HMF3932 (= NIBRBAC000497905) was isolated from a seawater sample, Pohang, Korea.

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