Journal of Species Research 8(2):176-190, 2019

A report of 38 unrecorded bacterial species in Korea within the classes *Bacilli* and *Deinococci* isolated from various sources

Heeyoung Kang[1], Haneul Kim[1], Jin-Woo Bae[2], Soon Dong Lee[3], Wonyong Kim[4], Myung Kyum Kim[5], Chang-Jun Cha[6], Hana Yi[7], Wan-Taek Im[8], Seung Bum Kim[9], Chi Nam Seong[10] and Kiseong Joh[1,*]

[1]*Department of Bioscience and Biotechnology, Hankuk University of Foreign Studies, Yongin 17035, Republic of Korea*
[2]*Department of Biology, Kyung Hee University, Seoul 02447, Republic of Korea*
[3]*Department of Science Education, Jeju National University, Jeju 63243, Republic of Korea*
[4]*Department of Microbiology, Chung-Ang University College of Medicine, Seoul 06973, Republic of Korea*
[5]*Department of Bio & Environmental Technology, Seoul Women's University, Seoul 01797, Republic of Korea*
[6]*Department of Bitechnology, Chung-Ang University, Anseong 17546, Republic of Korea*
[7]*School of Biosystem and Biomedical Science, Korea University, Seoul 02841, Republic of Korea*
[8]*Department of Biotechnology, Hankyong National University, Anseong 17579, Republic of Korea*
[9]*Department of Microbiology, Chungnam National University, Daejeon 34134, Republic of Korea*
[10]*Department of Biology, Sunchon National University, Suncheon 57922, Republic of Korea*

**Correspondent: ksjoh@hufs.ac.kr*

A total of 38 bacterial strains within the classes *Bacilli* and *Deinococci* were isolated from various sources in Korea. Samples were collected from animal intestine, urine, soil, tidal flat mud, and kimchi. In the sequence comparison and phylogenetic analysis of 16S rRNA sequences, the 38 isolates were assigned to the classes *Bacilli* and *Deinococci* with sequence similarities more than 98.7%. Twenty-four strains and 13 strains were classified the order *Bacillales* and *Lactobacillales* in the class *Bacilli*, respectively. In the order *Bacillales*, there were nine species in the genus *Bacillus*, seven species in the genus *Paenibacillus*, and the remaining eight species in the genera *Domibacillus*, *Halobacillus*, *Virgibacillus*, *Lysinibacillus*, *Paenisporosarcina*, *Planococcus*, *Savagea*, and *Staphylococcus*. In the order *Lactobacillales*, there were four species in the genus *Lactobacillus*, three species in the genus *Leuconostoc*, three species in the genus *Lactococcus*, and the remaining three species in the genera *Aerococcus*, *Enterococcus*, and *Streptococcus*. One species was related to the genus *Deinococcus* of the order *Deinococcales*. Most of the isolated strains were Gram-stain-positive, but some were Gram-stain-variable or Gram-stain-negative. Cells were rod or cocci-shaped. Based on the results of 16S rRNA analysis, we report 38 strains as previously unrecorded species to Korea, and the basic characteristics of strains are described herein.

Keywords: 16S rRNA, bacterial diversity, *Bailli*, *Deinococci*, unrecorded species

© 2019 National Institute of Biological Resources
DOI:10.12651/JSR.2019.8.2.176

Introduction

Securing and conservation of biological resources are important in accordance with the Nagoya Protocol and the Convention on Biological Diversity (Jang *et al*., 2015). Bacteria need to be considered a biological resource because they can promote various fields such as the food, medical, and agriculture industries (Du *et al*., 2011; Rhee *et al*., 2011; Lee *et al*., 2015). For the bacteria isolation of unrecorded species, samples were collected from various domestic environments in 2017. Approximately 200 strains of unrecorded species were identified from diverse samples, and 38 strains of those belonged to the classes *Bacilli* and *Deinococci*. The class *Bacilli* is known for low G+C Gram-positive bacteria, with or without endospores. Most *Bacilli* bacteria are aerobes or microaerobes, while some are facultative anaerobes (Ludwig *et al*., 2009). The class *Deinococci* are Gram-positve, chemoorganotrophs, aerobic mesophilic, or thermophilic bacteria (Garrity *et al*., 2001). Some species of these two classes are recognized as important taxa because they are extremophiles (Takami *et al*., 2000; Makarova *et al*., 2001; Al-

bert *et al*., 2005). Here, 38 unrecorded species belonging to the classes *Bacilli* and *Deinococci* are reported and described.

Materials and Methods

A total of 38 bacterial strains previously unrecorded in Korea were isolated from a diversity of sources. The soil and intestinal bacteria were cultured using various agar plates such as Reasoner's 2A agar (R2A), tryptic soy agar (TSA), nutrient agar (NA), marine agar (MA), and de Man, Rogosa and Sharpe agar (MRS). The bacteria of marine environments, urine, and kimchi were isolated using MA, brain heart infusion (BHI), and MRS agars, respectively. These agar plates were incubated at 20-37°C for 2-7 days. After isolated strains were purified by streaking, bacterial cells were maintained as 10-20% glycerol stock at −80°C. The detailed information such as designated strain IDs, sources, culture media, and incubation conditions are listed in Table 1. The bacterial identification and phylogenetic position of 38 strains were determined using 16S rRNA sequence analysis. 16S rRNA sequences were obtained by PCR amplification and DNA sequencing. The closely related type species were retrieved and identification was confirmed using the EzBioCloud server (Yoon *et al*., 2017). The 16S rRNA sequences of unrecorded and related type species were aligned by using the Clustal W (Thompson *et al*., 1994). Phylogenetic trees were constructed by neighbor-joining methods using MEGA7 (Kumar *et al*., 2016) with bootstrap resampling methods based on 1000 replicates (Felsenstein, 1985). Colony morphology was observed on agar plates and cellular morphology was examined by transmission electron microscopy. Gram-staining was performed using a Gram stain kit (Becton Dickinson) or the standard procedures (Magee *et al*., 1975). Oxidase activity was evaluated via the oxidation of 1% *N,N,N′,N*-tetramethyl-*p*-phenylenediamine dihydrochloride (Sigma). Biochemical characteristics were tested by using API 20NE or API 20A galleries (bioMérieux) according to the manufacturer's instructions.

Results and Discussion

Based on the 16S rRNA sequence similarity comparison and phylogenetic analysis, 37 bacterial strains were assigned to the class *Bacilli*. The remaining one strain belonged to the class *Deinococci* (Table 1). The 37 strains were distributed in the orders *Bacillales* and *Lactobacillales* of the class *Bacilli*; 24 strains for the order *Bacillales* and 13 strains for the order *Lactobacillales*. Unrecorded bacterial strains in the order *Bacillales* were identified as following species (Fig. 1): *Bacillus asahii* (Yumoto *et al*., 2004), *Bacillus clausii* (Nielsen *et al*., 1995), *Bacillus galliciensis* (Balcazar *et al*., 2010), *Bacillus gibsonii* (Nielsen *et al*., 1995), *Bacillus humi* (Heyrman *et al*., 2005), *Bacillus hunanensis* (Chen *et al*., 2011), *Bacillus patagoniensis* (Olivera *et al*., 2005), *Bacillus thermotolerans* (Yang *et al*., 2013), *Bacillus vireti* (Heyrman *et al*., 2004), *Domibacillus enclensis* (Sonalkar *et al*., 2014), *Halobacillus faecis* (An *et al*., 2007), *Virgibacillus salinus* (Carrasco *et al*., 2009), *Paenibacillus assamensis* (Saha *et al*., 2005), *Paenibacillus chitinolyticus* (Lee *et al*., 2004), *Paenibacillus endophyticus* (Carro *et al*., 2013), *Paenibacillus odorifer* (Berge *et al*., 2002), *Paenibacillus polymyxa* (Ash *et al*., 1993), *Paenibacillus profundus* (Romanenko *et al*., 2013), *Paenibacillus provencensis* (Roux *et al*., 2008), *Lysinibacillus acetophenoni* (Azmatunnisa *et al*., 2015), *Paenisporosarcina indica* (Reddy *et al*., 2013), *Planomicrobium alkanoclasticum* (Dai *et al*., 2005), *Savagea faecisuis* (Whitehead *et al*., 2015), and *Staphylococcus hominis* subsp. *hominis* (Kloos *et al*., 1998). Unrecorded bacterial strains of the order *Lactobacillales* were identified as following species (Fig. 2): *Aerococcus urinaeequi* (Felis *et al*., 2005), *Enterococcus gallinarum* (Collins *et al*., 1984), *Lactobacillus curvatus* (Klein *et al*., 1996), *Lactobacillus johnsonii* (Fujisawa *et al*., 1992), *Lactobacillus reuteri* (Kandler *et al*., 1980), *Lactobacillus taiwanensis* (Wang *et al*., 2009), *Leuconostoc citreum* (Farrow *et al*., 1989), *Leuconostoc pseudomesenteroides* (Farrow *et al*., 1989), *Leuconostoc rapi* (Lyhs *et al*., 2015), *Lactococcus lactis* subsp. *lactis* (Schleifer *et al*., 1985), *Lactococcus lactis* subsp. *tructae* (Perez *et al*., 2011), *Lactococcus petauri* (Goodman *et al*., 2017), and *Streptococcus mitis* (Coykendall *et al*., 1989). Strain NM-1 was closely related to *Deinococcus gobiensis* (Yuan *et al*., 2009) within the family *Deinococcaceae* of the order *Deinococcales* (Fig. 3). Most isolates were Gram-stain-positive, but some strains were Gram-stain-variable or Gram-stain-negative. Cells were rod- or cocci-shaped (Fig. 3). Other physiological and biochemical characteristics are detailed in the species descriptions. As a result, these 38 strains of the classes *Bacilli* and *Deinococci* are new records to Korea.

Description of *Bacillus asahii* 17J49-1

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for four days on R2A at 25°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase and urease is positive. Enzyme activity for gelatinase and β-galactosidase is negative. D-Glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, malic acid and phenylacetic acid are assimilated. Capric acid and trisodium citrate are not assimilated. Nitrate is not

Table 1. Taxonomic affiliation and isolation information of the isolates belonging to the phylum *Firmicutes* and *Deinococcus-Thermus*.

Class	Order	Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation source	Medium	Incubation condition
Bacilli	*Bacillales*	*Bacillaceae*	*Bacillus*	17J49-1	NIBRBAC000501327	*Bacillus asahii*	99.8	Soil	R2A	25°C, 4d
				GH4-58	NIBRBAC000501046	*Bacillus clausii*	99.6	Tidal flat mud	MA	30°C, 4d
				GH1-30	NIBRBAC000501044	*Bacillus galliciensis*	99.6	Tidal flat mud	MA	30°C, 7d
				LM2308	NIBRBAC000501186	*Bacillus gibsonii*	99.8	Animal intestine	MA	20°C, 3d
				MMS17-SY053	NIBRBAC000501211	*Bacillus humi*	99.0	Soil	TSA	30°C, 3d
				LM2412	NIBRBAC000501187	*Bacillus hunanensis*	99.9	Animal intestine	MA	20°C, 3d
				LM2319	NIBRBAC000501181	*Bacillus patagoniensis*	99.7	Animal intestine	MA	20°C, 3d
				NA_4	NIBRBAC000500998	*Bacillus thermotolerans*	100.0	Soil	NA	30°C, 2d
				17J48-21	NIBRBAC000501343	*Bacillus vireti*	99.5	Soil	R2A	25°C, 4d
			Domibacillus	MMS17-SY085	NIBRBAC000501206	*Domibacillus enclensis*	99.2	Soil	TSA	30°C, 3d
			Halobacillus	HMF8043	NIBRBAC000501166	*Halobacillus faecis*	99.7	Solar saltern	MA	30°C, 3d
			Virgibacillus	GH4-63	NIBRBAC000501047	*Virgibacillus salinus*	99.2	Tidal flat mud	MA	30°C, 7d
		Paenibacillaceae	*Paenibacillus*	r2a103fa330	NIBRBAC000501078	*Paenibacillus assamensis*	99.2	Ginseng soil	R2A	30°C, 2d
				HC_97	NIBRBAC000501069	*Paenibacillus chitinolyticus*	99.4	Mud	R2A	30°C, 2d
				17J76-8	NIBRBAC000501346	*Paenibacillus endophyticus*	98.7	Soil	R2A	25°C, 4d
				16_H1_F15	NIBRBAC000501079	*Paenibacillus odorifer*	99.8	Sediment	TSA	30°C, 2d
				LT3404	NIBRBAC000501185	*Paenibacillus polymyxa*	99.9	Animal intestine	R2A	37°C, 3d
				HC_63	NIBRBAC000501068	*Paenibacillus profundus*	99.7	Mud	R2A	30°C, 3d
				KYW1352	NIBRBAC000501134	*Paenibacillus provencensis*	100.0	Seawater	MA	25°C, 3d
		Planococcaceae	*Lysinibacillus*	17J30-13	NIBRBAC000501340	*Lysinibacillus acetophenoni*	99.5	Soil	R2A	25°C, 4d
			Paenisporosarcina	17J49-7	NIBRBAC000501328	*Paenisporosarcina indica*	98.9	Soil	R2A	25°C, 4d
			Planococcus	GH4-13	NIBRBAC000501037	*Planomicrobium alkanoclasticum*	99.4	Tidal flat mud	MA	30°C, 5d
			Savagea	NA_7	NIBRBAC000500999	*Savagea faecisuis*	99.3	Soil	NA	30°C, 2d
		Staphylococcaceae	*Staphylococcus*	CAU 1472	NIBRBAC000501236	*Staphylococcus hominis* subsp. *hominis*	99.9	Urine	BHI	37°C, 2d
	Lactobacillales	*Aerococcaceae*	*Aerococcus*	R2A_1	NIBRBAC000501000	*Aerococcus urinaeequi*	100.0	Soil	R2A	30°C, 2d
		Enterococcaceae	*Enterococcus*	VM3406	NIBRBAC000501190	*Enterococcus gallinarum*	99.9	Animal intestine	TSA	37°C, 2d
		Lactobacillaceae	*Lactobacillus*	CAU 1479	NIBRBAC000501229	*Lactobacillus curvatus*	100.0	Kimchi	MRS	30°C, 2d
				LPB0164	NIBRBAC000501024	*Lactobacillus johnsonii*	99.4	Animal intestine	MRS	30°C, 3d
				LPB0165	NIBRBAC000501005	*Lactobacillus reuteri*	99.6	Animal intestine	MRS	30°C, 3d
				LPB0166	NIBRBAC000501006	*Lactobacillus taiwanensis*	99.7	Animal intestine	MRS	30°C, 3d
		Leuconostocaceae	*Leuconostoc*	CAU 1476	NIBRBAC000501224	*Leuconostoc citreum*	98.7	Kimchi	MRS	30°C, 2d
				CAU 1477	NIBRBAC000501225	*Leuconostoc pseudomesenteroides*	99.9	Kimchi	MRS	30°C, 2d
				CAU 1478	NIBRBAC000501227	*Leuconostoc rapi*	99.3	Kimchi	MRS	30°C, 2d
		Streptococcaceae	*Lactococcus*	BT3501	NIBRBAC000501146	*Lactococcus lactis* subsp. *lactis*	99.9	Animal intestine	TSA	37°C, 3d
				VR3408	NIBRBAC000501184	*Lactococcus lactis* subsp. *tructae*	99.9	Animal intestine	TSA	37°C, 3d
				LR3301	NIBRBAC000501183	*Lactococcus petauri*	99.9	Animal intestine	TSA	37°C, 3d
			Streptococcus	HMF7345	NIBRBAC000501157	*Streptococcus mitis*	99.7	Soil	R2A	30°C, 3d
Deinococci	*Deinococcales*	*Deinococcaceae*	*Deinococcus*	NM-1	NIBRBAC000501033	*Deinococcus gobiensis*	100	Mud	R2A	30°C, 3d

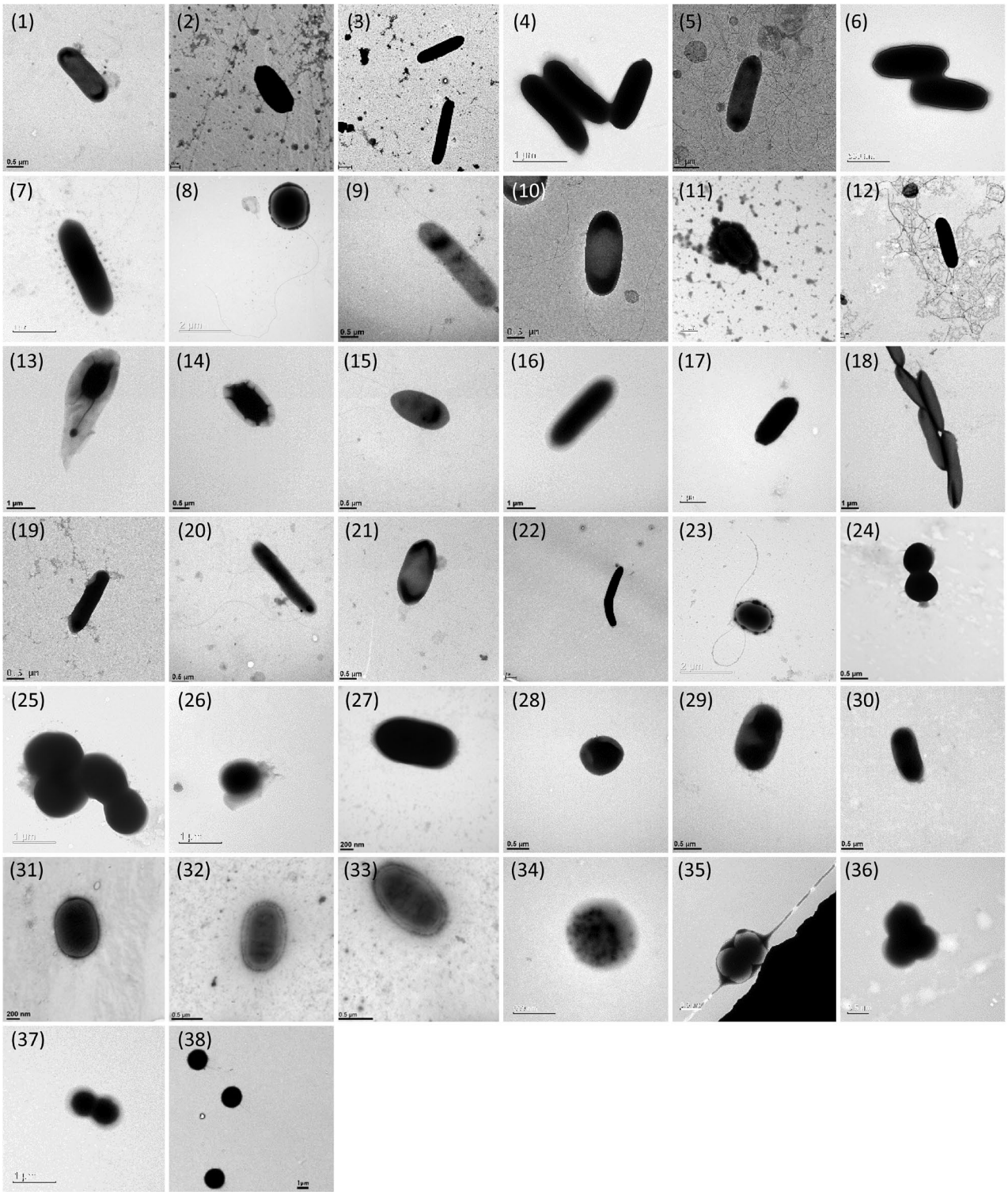

Fig. 1. Transmission electron micrographs of cells. Strains: 1, 17J49-1; 2, GH4-58; 3, GH1-30; 4, LM2308; 5, MMS17-SY053; 6, LM2412; 7, LM2319; 8, NA_4; 9, 17J48-21; 10, MMS17-SY085; 11, HMF8043; 12, GH4-63; 13, r2a103fa330; 14, HC_97; 15, 17J76-8; 16, 16_H1_F15; 17, LT3404; 18, HC_63; 19, KYW1352; 20, 17J30-13; 21, 17J49-7; 22, GH4-13; 23, NA_7; 24, CAU 1472; 25, R2A_1; 26, VM3406; 27, CAU 1479; 28, LPB0164; 29, LPB0165; 30, LPB0166; 31, CAU 1476; 32, CAU 1477; 33, CAU 1478; 34, BT3501; 35, VR3408; 36, LR3301; 37, HMF7345; 38, NM-1.

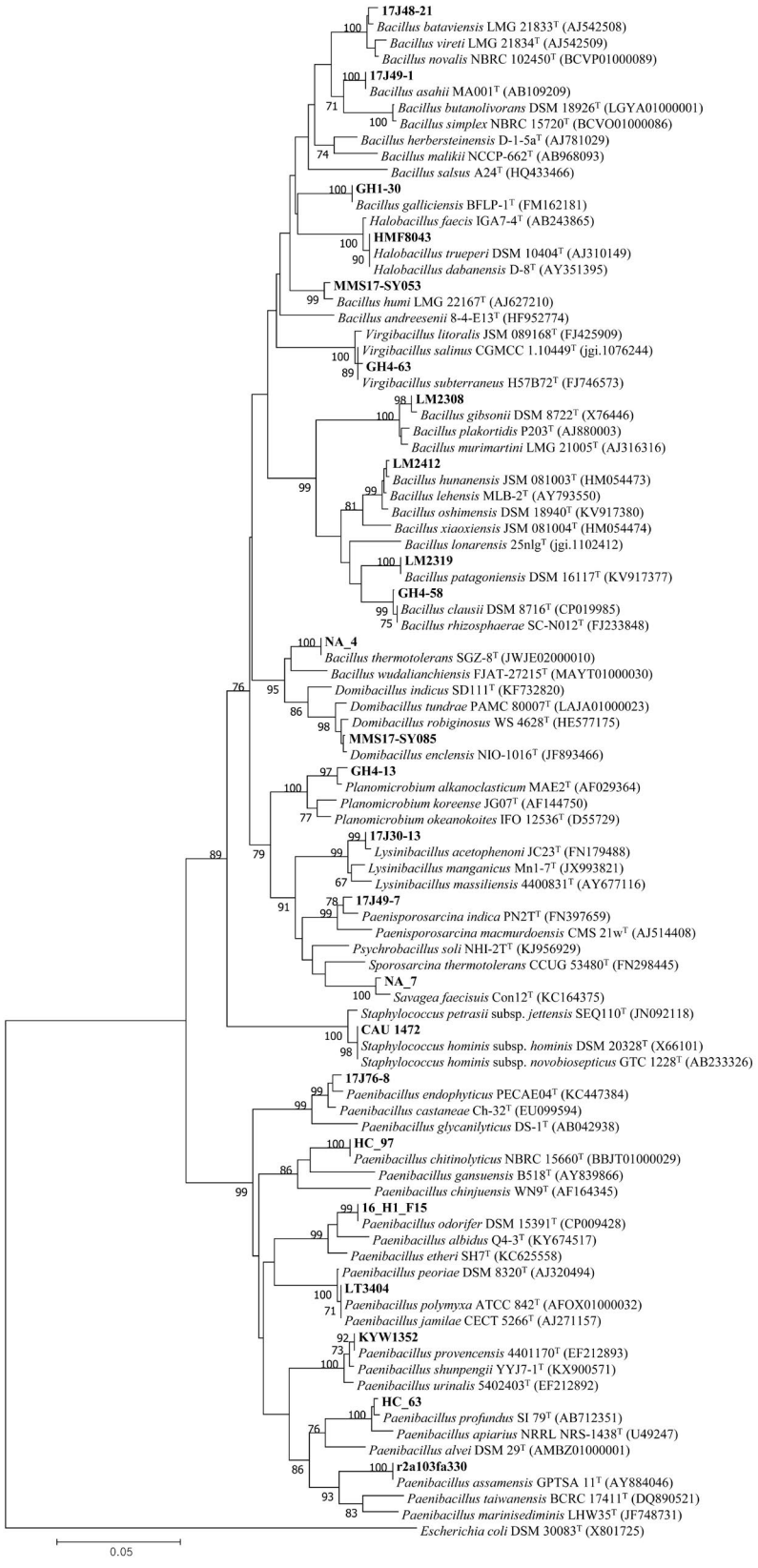

Fig. 2. Neighbor-joining phylogenetic tree based on 16S rRNA sequences, showing the relationship between the isolates and their relatives of the order *Bacillales*. Bootstrap values ($>70\%$) are shown. *Escherichia coli* DSM 30083^T (X801725) was used as an outgroup. Bar, 0.05 substitutions per nucleotide position.

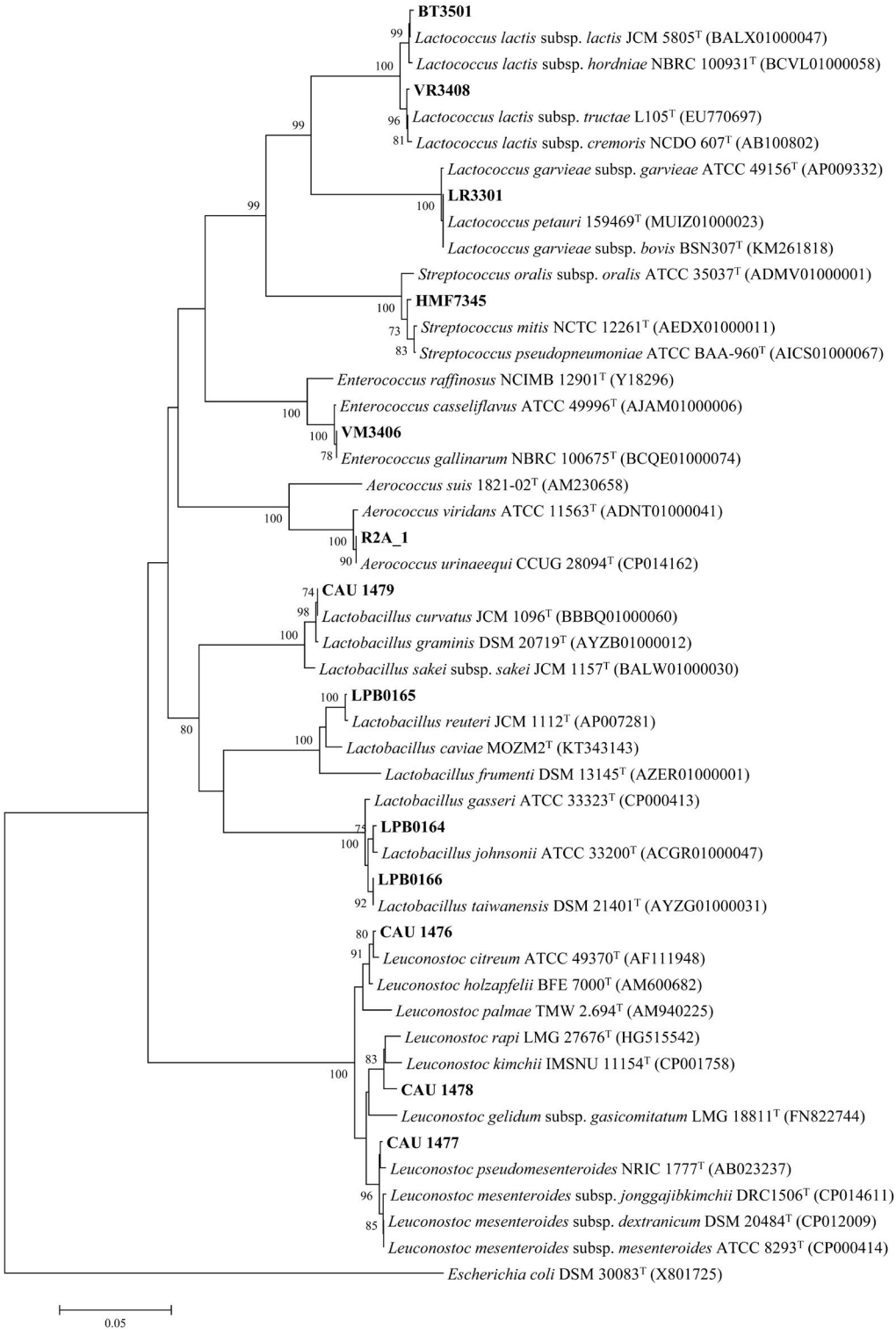

Fig. 3. Neighbor-joining phylogenetic tree based on 16S rRNA sequences, showing the relationship between the isolates and their relatives of the order *Lactobacillales*. Bootstrap values (>70%) are shown. *Escherichia coli* DSM 30083^T (X801725) was used as an outgroup. Bar, 0.05 substitutions per nucleotide position.

reduced to nitrite. Indole is not produced and glucose is not fermented. Strain 17J49-1 (=NIBRBAC000501327) was isolated from a soil sample, Jeju, Republic of Korea (33°30′14.9″N 126°27′55.5″E).

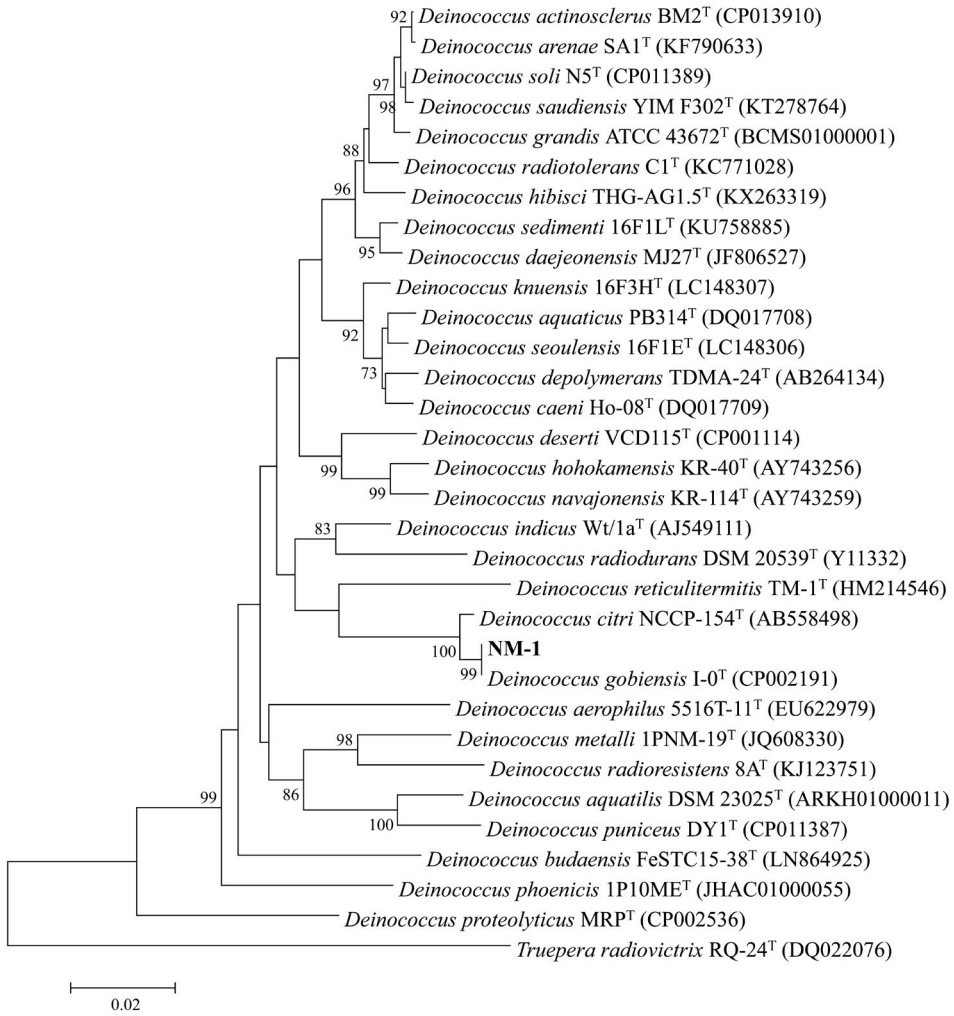

Fig. 4. Neighbor-joining phylogenetic tree based on 16S rRNA sequences, showing the relationship between the isolates and their relatives of the order *Deinococcales*. Bootstrap values (>70%) are shown. *Truepera radiovictrix* RQ-24^T (DQ022076) was used as an outgroup. Bar, 0.02 substitutions per nucleotide position.

Description of *Bacillus clausii* GH4-58

Cells are Gram-stain-positive and rod-shaped. Colonies are punctiform, convex, entire, and cream colored after incubation for four days on MA at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. D-Glucose, D-mannose, D-mannitol, *N*-acetyl-glucosamine and D-maltose are assimilated. L-Arabinose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain GH4-58 (=NIBRBAC000501046) was isolated from a tidal flat mud sample, Incheon, Republic of Korea (37°35′33″N 126°27′29″E).

Description of *Bacillus galliciensis* GH1-30

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, entire, and cream colored after incubation for seven days on MA at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for gelatinase is positive. Enzyme activity for arginine dihydrolase, urease, and gelatinase is negative. 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 are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain GH1-30 (=NIBRBAC000501044) was isolated from a tidal flat mud sample, Incheon, Republic of Korea (37°35′33″N 126°27′29″E).

Description of *Bacillus gibsonii* LM2308

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, entire, and beige colored after incubation for three days on MA at 20°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. D-Glucose, D-mannose, D-mannitol, D-maltose, malic acid and trisodium citrate are assimilated. L-Arabinose, *N*-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain LM2308 (=NIBRBAC000501186) was isolated from an intestinal of an animal (pheasant), Gwacheon, Republic of Korea (37°25′39.7″N 127°01′01.2″E).

Description of *Bacillus humi* MMS17-SY053

Cells are Gram-stain-positive, flagellated, and rod-shaped. Colonies are circular, convex, entire, smooth, and pale yellow colored after incubation for three days on TSA at 30°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for urease and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and gelatinase is negative. D-Glucose, D-mannitol, *N*-acetyl-glucosamine, D-maltose and trisodium citrate are assimilated. L-Arabinose, D-mannose, potassium gluconate, capric acid, adipic acid, malic acid, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain MMS17-SY053 (=NIBRBAC000501211) was isolated from a soil sample, Gunsan, Republic of Korea (35°48′46″N 126°24′36″E).

Description of *Bacillus hunanensis* LM2412

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, entire, and beige-colored after incubation for three days on MA at 20°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for β-galactosidase is positive. Enzyme activity for arginine dihydrolase, urease, and gelatinase is negative. D-Glucose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, and malic acid are assimilated. L-Arabinose, D-mannose, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain LM2412 (=NIBRBAC000501187) was isolated from an intestinal sample of an animal (*Lophura swinhoii*), Gwacheon, Republic of Korea (37°25′39.7″N 127°01′01.2″E).

Description of *Bacillus patagoniensis* LM2319

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, entire, and beige colored after incubation for three days on MA at 20°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. D-Glucose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, malic acid and trisodium citrate are assimilated. L-Arabinose, potassium gluconate, capric acid, adipic acid, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain LM2319 (=NIBRBAC000501181) was isolated from an intestinal sample of an animal (*Lophura swinhoii*), Gwacheon, Republic of Korea (37°25′39.7″N 127°01′01.2″E).

Description of *Bacillus thermotolerans* NA_4

Cells are Gram-stain-positive and oval-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for two days on NA at 30°C. Oxidase activity is negative. Aesculin is not hydrolyzed. Enzyme activity for arginine dihydrolase, urease, gelatinase, and β-galactosidase is negative. Potassium gluconate, malic acid and phenylacetic acid are assimilated. D-Glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, capric acid, adipic acid, and trisodium citrate is not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain NA_4 (=NIBRBAC000500998) was isolated from a soil sample, Anseong, Republic of Korea (37.075911N 127.370204E).

Description of *Bacillus vireti* 17J48-21

Cells are Gram-stain-positive and rod-shaped. Colonies are irregular, undulate, convex, and cream colored after incubation for four days on R2A at 25°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase, urease, gelatinase, and β-galactosidase is positive. D-Glucose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, adipic acid, malic acid, trisodium citrate, and phenylacetic acid are assimilated. L-Arabinose and capric acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain 17J48-21 (=NIBRBAC000501343) was isolated from a soil sample, Jeju, Republic of Korea (33°27′05.2″N 126°33′28.9″E).

Description of *Domibacillus enclensis* MMS17-SY085

Cells are Gram-stain-positive, flagellated, and rod-shaped. Colonies are circular, convex, smooth, and yellow colored after incubation for three days on TSA at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for β-galactosidase is positive. Enzyme activity for arginine dihydrolase, urease, and gelatinase

is negative. L-Arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, malic acid, and trisodium citrate are assimilated. D-Glucose, capric acid, adipic acid, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain MMS17-SY085 (=NIBRBAC000501206) was isolated from a soil sample, Gunsan, Republic of Korea (35°48′46″N 126°24′36″E).

Description of *Halobacillus faecis* HMF8043

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, smooth and pale orange-colored after incubation for three days on MA at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. D-Glucose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, and potassium gluconate are assimilated. L-Arabinose, D-mannose, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain HMF8043 (=NIBRBAC000501166) was isolated from brine of a solar saltern, Shinan, Republic of Korea (34°59′47″N 126°10′02″E).

Description of *Virgibacillus salinus* GH4-63

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, entire, and cream colored after incubation for seven days on MA at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase, urease, gelatinase, and β-galactosidase is negative. 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 are not assimilated. Nitrate is reduced to nitrite. Indole is not produced, glucose is not fermented. Strain GH4-63 (=NIBRBAC000501047) was isolated from a tidal flat mud sample, Incheon, Republic of Korea (37°35′33″N 126°27′29″E).

Description of *Paenibacillus assamensis* r2a103fa330

Cells are Gram-stain-variable and rod-shaped. Colonies are circular and yellowish cream colored after incubation for two days on R2A at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase and gelatinase is positive. Enzyme activity for urease and β-galactosidase is negative. D-Glucose, D-maltose, *N*-acetyl-glucosamine, potassium gluconate, and malic acid are assimilated. L-Arabinose, D-mannose, D-mannitol, capric acid, adipic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain r2a103fa330 (=NIBRBAC000501078) was isolated from a soil sample, Anseong, Republic of Korea (37°00′12.1″N 127°14′00.0″E).

Description of *Paenibacillus chitinolyticus* HC_97

Cells are Gram-stain-variable and rod-shaped. Colonies are flat, irregular, and white colored after incubation for two days on R2A at 30°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. D-Glucose, D-mannose, *N*-acetyl-glucosamine, D-maltose, and potassium gluconate are assimilated. L-Arabinose, D-mannitol, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced. Glucose is fermented. Strain HC_97 (=NIBRBAC000501069) was isolated from a mud sample, Hwacheon, Republic of Korea (38°01′53.0″N 127°38′41.3″E).

Description of *Paenibacillus endophyticus* 17J76-8

Cells are Gram-stain-positive and rod-shaped. Colonies are irregular, flat, undulate, and cream colored after incubation for four days on R2A at 25°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase, urease, and β-galactosidase is positive. Enzyme activity for gelatinase is negative. D-Glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, and malic acid are assimilated. Capric acid, adipic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain 17J76-8 (=NIBRBAC000501346) was isolated from a soil sample, Jeju, Republic of Korea (33°27′33.6″N 126°56′32.1″E).

Description of *Paenibacillus odorifer* 16_H1_F15

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, smooth, and cream colored after incubation for two days on TSA at 30°C. Oxidase activity is weakly positive. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. D-Glucose, D-mannose, *N*-acetyl-glucosamine, D-maltose, malic acid, and trisodium citrate are assimilated. L-Arabinose, D-mannitol, potassium gluconatec, capric acid, adipic acid, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced. Glucose is fermented. Strain 16H_1F_15 (=NIBRBAC000501079) was isolated from a sediment sample, Namyangju, Re-

public of Korea (37°32′51.6″N 127°14′21.1″E).

Description of *Paenibacillus polymyxa* LT3404

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, entire, and transparent after incubation for three days on R2A at 37°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. *N*-Acetyl-glucosamine and potassium gluconate are assimilated. D-Glucose, L-arabinose, D-mannose, D-mannitol, D-maltose, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain LT3404 (=NIBRBAC000501185) was isolated from an intestinal sample of an animal (*Lophura swinhoii*), Gwacheon, Republic of Korea (37° 25′39.7″N 127°01′01.2″E).

Description of *Paenibacillus profundus* HC_63

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, flat and, cream colored after incubation for three days on R2A at 30°C. Oxidase activity is weak positive. Aesculin hydrolyzed. Enzyme activity for urease, gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase is negative. D-Glucose, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, and trisodium citrate are assimilated. L-Arabinose, D-mannose, D-mannitol, capric acid, adipic acid, malic acid, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced. Glucose is fermented. Strain HC_63 (=NIBRBAC000501068) was isolated from a mud sample, Hwacheon, Republic of Korea (38°01′53.0″N 127°38′41.3″E).

Description of *Paenibacillus provencensis* KYW1352

Cells are Gram-stain-negative and rod-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for three days on MA at 25°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. 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 are not assimilated. Nitrate not is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain KYW1352 (=NIBRBAC000501134) was isolated from a seawater sample, Gwangyang, Republic of Korea (34°53′26.22″N, 127°45′23.52″E).

Description of *Lysinibacillus acetophenoni* 17J30-13

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for four days on R2A at 25°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase, urease, and gelatinase is positive. Enzyme activity for β-galactosidase is negative. D-Mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, and malic acid are positive. D-Glucose, L-arabinose, capric acid, adipic acid, trisodium citrate, and phenylacetic acid are negative. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain 17J30-13 (=NIBRBAC000501340) was isolated from a soil sample, Jeju, Republic of Korea (33°14′42.2″N 126°34′18.2″E).

Description of *Paenisporosarcina indica* 17J49-7

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for four days on R2A at 25°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase, urease, and gelatinase is positive. Enzyme activity for β-galactosidase is negative. D-Glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, and malic acid is assimilated. Potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain 17J49-7 (=NIBRBAC000501328) was isolated from a soil sample, Jeju, Republic of Korea (33°30′14.9″N 126°27′55.5″E).

Description of *Planomicrobium alkanoclasticum* GH4-13

Cells are Gram-stain-positive and rod-shaped. Colonies are circular, convex, entire, and orange colored after incubation for five days on MA at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. 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 are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain GH4-13 (=NIBRBAC000501037) was isolated from a tidal flat mud sample, Incheon, Republic of Korea (37°35′33″N 126°27′29″E).

Description of *Savagea faecisuis* NA_7

Cells are Gram-stain-positive and oval-shaped. Colonies are circular, convex, and cream colored after incubation for two days on NA at 30°C. Oxidase activity is negative. Aesculin is not hydrolyzed. Enzyme activity

for arginine dihydrolase, urease, gelatinase, and β-galactosidase is negative. Malic acid and trisodium citrate are assimilated. D-Glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and, glucose is not fermented. Strain NA_7 (=NIBRBAC000500999) was isolated from a soil sample, Anseong, Republic of Korea (37.075911N 127.370204E).

Description of *Staphylococcus hominis* subsp. *hominis* CAU 1472

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, raised, smooth, opaque, and cream colored after incubation for two days on BHI at 37°C. Oxidase activity is negative. Aesculin is not hydrolyzed. Enzyme activity for arginine dihydrolase and urease is positive. Enzyme activity for gelatinase and β-galactosidase is negative. D-Glucose is assimilated. L-Arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid trisodium citrate, and phenylacetic acid is not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain CAU 1472 (=NIBRBAC000501236) was isolated from urine, Seoul, Republic of Korea (37°33′13.1″N 127°09′28.0″E).

Description of *Aerococcus urinaeequi* R2A_1

Cells are Gram-stain-positive and oval-shaped. Colonies are circular, raised, and white colored after incubation for two days on R2A at 30°C. Oxidase activity is positive. Aesculin is not hydrolyzed. Enzyme activity for arginine dihydrolase, urease, gelatinase, and β-galactosidase is negative. D-Glucose, D-maltose, potassium gluconate and malic acid are assimilated. L-Arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, capric acid, adipic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain R2A_1 (=NIBRBAC000501000) was isolated from a soil sample, Anseong, Republic of Korea (37.075911N 127.370204E).

Description of *Enterococcus gallinarum* VM3406

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, flat, entire, and white colored after incubation for two days on TSA at 37°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase and β-galactosidase is positive. Enzyme activity for urease and gelatinase is negative. D-Mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, and potassium gluconate are assimilated. D-Glucose, L-arabinose, capric acid, adipic acid, malic acid trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced. Glucose is fermented. Strain VM3406 (=NIBRBAC000501190) was isolated from an intestinal sample of an animal (*Vultur gryphus*), Gwacheon, Republic of Korea (37°25′39.7″N 127°01′01.2″E).

Description of *Lactobacillus curvatus* CAU 1479

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, smooth, transparent, and cream colored after incubation for two days on MRS at 30°C. Aesculin is hydrolyzed. Oxidase activity is negative. Enzyme activity for arginine dihydrolase, urease, gelatinase and β-galactosidase is negative. 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 are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced. Glucose is fermented. Strain CAU 1479 (=NIBRBAC000501229) was isolated from kimchi, Seoul, Republic of Korea (37°33′04.9″N 126°57′48.9″E).

Description of *Lactobacillus johnsonii* LPB0164

Cells are anaerobic, Gram-stain-positive, and coccus-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for three days on MRS at 30°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for urease, gelatinase, and caltase is negative. D-Glucose, D-lactose, D-saccharose and D-mannose are acidified. D-Mannitol, D-maltose, salicin, D-xylose, L-arabinose, glycerol, D-cellobiose, D-melezitose, D-raffinose, D-sorbitol, L-rhamnose, and D-trehalose are not acidified. Indole is not produced. Strain LPB0164 (=NIBRBAC000501024) was isolated from an intestinal sample of mouse, Seoul, Republic of Korea (37°35′10.3″ N 127°01′30.5″E).

Description of *Lactobacillus reuteri* LPB0165

Cells are anaerobic, Gram-stain-positive, and rod-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for three days on MRS at 30°C. Oxidase activity is negative. Aesculin is not hydrolyzed. Enzyme activity for urease, gelatinase, and caltase is negative. D-Glucose, D-lactose, D-saccharose, D-maltose, D-xylose, L-arabinose, and D-raffinose are acidified. D-mannitol, salicin, glycerol, D-cellobiose, D-mannose, D-melezitose, D-sorbitol, L-rhamnose and D-trehalose are not acidified. Indole is not produced. Strain LPB0165 (=NIBRBAC000501005) was isolated from an intestinal sample of mouse, Seoul, Republic of Korea (37°35′10.3″

N 127°01′30.5″E).

Description of *Lactobacillus taiwanensis* LPB0166

Cells are anaerobic, Gram-stain-positive, and rod-shaped. Colonies are circular, convex, smooth, and cream colored after incubation for three days on MRS at 30°C. Oxidase activity is negative. Aesculin is not hydrolyzed. Enzyme activity for urease, gelatinase, and caltase is negative. D-Glucose, D-saccharose, D-maltose and D-mannose, and D-raffinose are acidified. D-Mannitol, D-lactose, salicin, D-xylose, L-arabinose, glycerol, D-cellobiose, D-melezitose, D-sorbitol, L-rhamnose, and D-trehalose are not acidified. Indole is not produced. Strain LPB0166 (=NIBRBAC000501006) was isolated from an intestinal sample of mouse, Seoul, Republic of Korea (37°35′10.3″ N 127°01′30.5″E).

Description of *Leuconostoc citreum* CAU 1476

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, smooth, transparent, and cream colored after incubation for two days on MRS at 30°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase, urease, gelatinase, and β-galactosidase is negative. 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 are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain CAU 1476 (=NIBRBAC000501224) was isolated from kimchi, Seoul, Republic of Korea (37°33′04.9″N 126°57′48.9″E).

Description of *Leuconostoc pseudomesenteroides* CAU 1477

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, smooth, transparent, and cream colored after incubation for two days on MRS at 30°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for β-galactosidase is positive. Enzyme activity for arginine dihydrolase, urease, and gelatinase is negative. 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 are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose fermented. Strain CAU 1477 (=NIBRBAC000501225) was isolated from kimchi, Seoul, Republic of Korea (37°33′04.9″N 126°57′48.9″E).

Description of *Leuconostoc rapi* CAU 1478

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, smooth, transparent, and cream colored after incubation for two days on MRS at 30°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase, urease, gelatinase, and β-galactosidase is negative. 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 are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain CAU 1478 (=NIBRBAC000501227) was isolated from kimchi, Seoul, Republic of Korea (37°33′04.9″N 126°57′48.9″E).

Description of *Lactococcus lactis* subsp. *lactis* BT3501

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, and white colored after incubation for three days on TSA at 37°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase and β-galactosidase is positive. Enzyme activity for urease and gelatinase is negative. D-Glucose, D-mannose, *N*-acetyl-glucosamine, trisodium citrate and phenylacetic acid are assimilated. L-Arabinose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, and malic acid are negative. Nitrate is not reduced to nitrite. Indole is not produced. Glucose is fermented. Strain BT3501 (=NIBRBAC000501146) was isolated from an intestinal sample of an animal (*Hipparchia autonoe*), Jeju, Republic of Korea (33°21′10.5″N 126°30′12.2″E).

Description of *Lactococcus lactis* subsp. *tructae* VR3408

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, entire, and white colored after incubation for three on TSA at 37°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase is positive. Enzyme activity for urease, gelatinase, and β-galactosidase is negative. D-Mannose, D-mannitol and *N*-acetyl-glucosamine are assimilated. D-glucose, L-arabinose, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced. Glucose is fermented. Strain VR3408 (=NIBRBAC000501184) was isolated an intestinal sample of an animal (*Vultur gryphus*), Gwacheon, Republic of Korea (37°25′39.7″N 127°01′01.2″E).

Description of *Lactococcus petauri* LR3301

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, entire, and white colored after incubation on for three days TSA at 37°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for arginine dihydrolase and β-galactosidase is positive.

Enzyme activity for urease and gelatinase is negative. 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 are not assimilated. Nitrate is reduced to nitrite. Indole is not produced. Glucose is fermented. Strain LR3301 (=NIBRBAC000501183) was isolated from an intestinal sample of an animal (*Lophura swinhoii*), Gwacheon, Republic of Korea (37°25′39.7″N 127°01′01.2″E).

Description of *Streptococcus mitis* HMF7345

Cells are Gram-stain-positive and diplococci-shaped. Colonies are circular, convex, smooth and, white-colored after incubation for three days on R2A at 30°C. Oxidase activity is negative. Aesculin is hydrolyzed. Enzyme activity for β-galactosidase is positive. Enzyme activity for arginine dihydrolase, urease, and gelatinase is negative. 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 are not assimilated. Nitrate is reduced to nitrite. Indole is not produced and glucose is not fermented. Strain HMF7345 (=NIBRBAC000501157) was isolated from soil, Yongin, Republic of Korea (37°20′18″N 127°16′11″E).

Description of *Deinococcus gobiensis* NM-1

Cells are Gram-stain-positive and coccus-shaped. Colonies are circular, convex, entire, and pink colored after incubation for three days on R2A at 30°C. Oxidase activity is positive. Aesculin is hydrolyzed. Enzyme activity for gelatinase and β-galactosidase is positive. Enzyme activity for arginine dihydrolase and urease is negative. D-Mannitol and malic acid are assimilated. D-Glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, trisodium citrate, and phenylacetic acid are not assimilated. Nitrate is not reduced to nitrite. Indole is not produced and glucose is not fermented. Strain NM-1 (=NIBRBAC000501033) was isolated from a mud sample, Jeju, Republic of Korea (33°25′23″N 126°29′18″E).

Acknowledgements

This study was supported by the research grant "The Survey of Korean Indigenous Species" from the National Institute of Biological Resources of the Ministry of Environment in Korea.

References

Albert, R.A., J. Archambault, R. Rossello-Mora, B.J. Tindall and M. Matheny. 2005. *Bacillus acidicola* sp. nov., a novel mesophilic, acidophilic species isolated from acidic Sphagnum peat bogs in Wisconsin. International Journal of Systematic and Evolutionary Microbiology 55(5):2125-2130.

An, S.Y., K. Kanoh, H. Kasai, K. Goto and A. Yokota. 2007. *Halobacillus faecis* sp. nov., a spore-forming bacterium isolated from a mangrove area on Ishigaki Island, Japan. International Journal of Systematic and Evolutionary Microbiology 57(11):2476-2479.

Ash, C., F.G. Priest and M.D. Collins. 1993. Molecular identification of rRNA group 3 bacilli (Ash, Farrow, Wallbanks and Collins) using a PCR probe test. Antonie van Leeuwenhoek 64(3-4):253-260.

Azmatunnisa, M., K. Rahul, K.V. Lakshmi, C. Sasikala and C. Ramana. 2015. *Lysinibacillus acetophenoni* sp. nov., a solvent-tolerant bacterium isolated from acetophenone. International Journal of Systematic and Evolutionary Microbiology 65(6):1741-1748.

Balcazar, J.L., J. Pintado and M. Planas. 2010. *Bacillus galliciensis* sp. nov., isolated from faeces of wild seahorses (*Hippocampus guttulatus*). International Journal of Systematic and Evolutionary Microbiology 60(4):892-895.

Berge, O., M.H. Guinebretiere, W. Achouak, P. Normand and T. Heulin. 2002. *Paenibacillus graminis* sp. nov. and *Paenibacillus odorifer* sp. nov., isolated from plant roots, soil and food. International Journal of Systematic and Evolutionary Microbiology 52(2):607-616.

Carrasco, I.J., M.C. Marquez and A. Ventosa. 2009. *Virgibacillus salinus* sp. nov., a moderately halophilic bacterium from sediment of a saline lake. International Journal of Systematic and Evolutionary Microbiology 59(12):3068-3073.

Carro, L., J.D. Flores-Felix, E. Cerda-Castillo, M.H. Ramirez-Bahena, J.M. Igual, C. Tejedor, E. Velazquez and A. Peix. 2013. *Paenibacillus endophyticus* sp. nov., isolated from nodules of *Cicer arietinum*. International Journal of Systematic and Evolutionary Microbiology 63(12):4433-4438.

Chen, Y.G., D.F. Hao, Q.H. Chen, Y.Q. Zhang, J.B. Liu, J.W. He, S.K. Tang and W.J. Li. 2011. *Bacillus hunanensis* sp. nov., a slightly halophilic bacterium isolated from non-saline forest soil. Antonie van Leeuwenhoek 99(3):481-488.

Collins, M.D., D. Jones, J. Farrow, R. Kilpper-Balz and K.-H. Schleifer. 1984. *Enterococcus avium* nom. rev., comb. nov.; *E. casseliflavus* nom. rev., comb. nov.; *E. durans* nom. rev., comb. nov.; *E. gallinarum* comb. nov.; and *E. malodoratus* sp. nov. International Journal of Systematic and Evolutionary Microbiology 34(2):220-223.

Coykendall, A.L. 1989. Rejection of the Type Strain of *Streptococcus mitis* (Andrewes and Horder 1906). International Journal of Systematic and Evolutionary Microbiology 39(2):207-209.

Dai, X., Y.N. Wang, B.J. Wang, S.J. Liu and Y.G. Zhou. 2005. *Planomicrobium chinense* sp. nov., isolated from coast-

al sediment, and transfer of *Planococcus psychrophilus* and *Planococcus alkanoclasticus* to *Planomicrobium* as *Planomicrobium psychrophilum* comb. nov. and *Planomicrobium alkanoclasticum* comb. nov. International Journal of Systematic and Evolutionary Microbiology 55(2):699-702.

Du, J., Z. Shao and H. Zhao. 2011. Engineering microbial factories for synthesis of value-added products. J Ind Microbiol Biotechnol 38:873-890.

Farrow, J.A., R.R. Facklam and M.D. Collins. 1989. Nucleic acid homologies of some vancomycin-resistant leuconostocs and description of *Leuconostoc citreum* sp. nov. and *Leuconostoc pseudomesenteroides* sp. nov. International Journal of Systematic and Evolutionary Microbiology 39(3):279-283.

Felis, G.E., S. Torriani and F. Dellaglio. 2005. Reclassification of *Pediococcus urinaeequi* (ex Mees 1934) Garvie 1988 as *Aerococcus urinaeequi* comb. nov. International Journal of Systematic and Evolutionary Microbiology 55(3):1325-1327.

Felsenstein, J. 1985. Confidence limits on phylogenies: an approach using the bootstrap. Evolution 39(4):783-791.

Fujisawa, T., Y. Benno, T. Yaeshima and T. Mitsuoka. 1992. Taxonomic study of the *Lactobacillus acidophilus* group, with recognition of *Lactobacillus gallinarum* sp. nov. and *Lactobacillus johnsonii* sp. nov. and synonymy of *Lactobacillus acidophilus* group A3 (Johnson *et al*. 1980) with the type strain of *Lactobacillus amylovorus* (Nakamura 1981). International Journal of Systematic Bacteriology 42(3):487-491.

Garrity, G.M. and J.G. Holt. (editors) 2001. Bergey's Manual of Systematic Bacteriology, 2nd edn, vol. 1, *Deinococci* class. nov. New York: Springer.

Goodman, L.B., M.R. Lawton, R.J. Franklin-Guild, R.R. Anderson, L. Schaan, A.J. Thachil, M. Wiedmann, C.B. Miller, S.D. Alcaine and J. Kovac. 2017. *Lactococcus petauri* sp. nov., isolated from an abscess of a sugar glider. International Journal of Systematic and Evolutionary Microbiology 67(11):4397-4404.

Heyrman, J., M. Rodriguez-Diaz, J. Devos, A. Felske, N.A. Logan and P. De Vos. 2005. *Bacillus arenosi* sp. nov., *Bacillus arvi* sp. nov. and *Bacillus humi* sp. nov., isolated from soil. International Journal of Systematic and Evolutionary Microbiology 55(1):111-117.

Heyrman, J., B. Vanparys, N.A. Logan, A. Balcaen, M. Rodriguez-Diaz, A. Felske and P. De Vos. 2004. *Bacillus novalis* sp. nov., *Bacillus vireti* sp. nov., *Bacillus soli* sp. nov., *Bacillus bataviensis* sp. nov. and *Bacillus drentensis* sp. nov., from the Drentse A grasslands. International Journal of Systematic and Evolutionary Microbiology 54(1):47-57.

Jang, S., Y. Jang and J. Kim. 2015. New records of two agarics: *Galerina sideroides* and *Gymnopus luxurians* in South Korea. The Korean Journal of Mycology 43(2):88-91.

Kandler, O., K. Stetter and R. Köhl. 1980. *Lactobacillus reuteri* sp. nov., a new species of heterofermentative lactobacilli. Zentralblatt für Bakteriologie: I. Abt. Originale C: Allgemeine, angewandte und ökologische Mikrobiologie 1(3):264-269.

Klein, G., L.M. Dicks, A. Pack, B. Hack, K. Zimmermann, F. Dellaglio and G. Reuter. 1996. Emended Descriptions of *Lactobacillus* sake (Katagiri, Kitahara, and Fukami) and *Lactobacillus curvatus* (Abo-Elnaga and Kandler): Numerical Classification Revealed by Protein Figerprinting and Identification Based on Biochemical Patterns and DNA-DNA Hybridizations. International Journal of Systematic and Evolutionary Microbiology 46(2):367-376.

Kloos, W.E., C.G. George, J.S. Olgiate, L. Van Pelt, M.L. McKinnon, B.L. Zimmer, E. Muller, M.P. Weinstein and S. Mirrett. 1998. *Staphylococcus hominis* subsp. *novobiosepticus* subsp. nov., a novel trehalose- and *N*-acetyl-D-glucosamine-negative, novobiocin- and multiple-antibiotic-resistant subspecies isolated from human blood cultures. International Journal of Systematic Bacteriology 48(3):799-812.

Kumar, S., G. Stecher and K. Tamura 2016. MEGA7: Molecular Evolutionary Genetics Analysis Version 7.0 for Bigger Datasets. Molecular Biology and Evolution 33(7):1870-1874.

Lee, J.S., Y.R. Pyun and K.S. Bae. 2004. Transfer of *Bacillus ehimensis* and *Bacillus chitinolyticus* to the genus *Paenibacillus* with emended descriptions of *Paenibacillus ehimensis* comb. nov. and *Paenibacillus chitinolyticus* comb. nov. International Journal of Systematic and Evolutionary Microbiology 54(3):929-933.

Lee, S.Y., H.Y. Weon, W.G. Kim, J.J. Kim and J.H. Han. 2015. Selection of *Bacillus amyloliquefaciens* M27 for Biocontrol on Lettuce Sclerotinia Rot. The Korean Journal of Mycology 43(3):180-184.

Ludwig, W., K.-H. Schleifer and W.B. Whitman. (editors) 2009. Bergey's Manual of Systematic Bacteriology, 2nd edn, vol. 3, Bacilli class. nov. New York: Springer.

Lyhs, U., I. Snauwaert, S. Pihlajaviita, L. De Vuyst and P. Vandamme. 2015. *Leuconostoc rapi* sp. nov., isolated from sous-vide-cooked rutabaga. International Journal of Systematic and Evolutionary Microbiology 65(8):2586-2590.

Magee, C.M., G. Rodenheaver, M.T. Edgerton and R.F. Edlich. 1975. A more reliable Gram staining technique for diagnosis of surgical infections. American Journal of Surgery 130(3):341-346.

Makarova, K.S., L. Aravind, Y.I. Wolf, R.L. Tatusov, K.W. Minton, E.V. Koonin and M.J. Daly. 2001. Genome of the extremely radiation-resistant bacterium *Deinococcus radiodurans* viewed from the perspective of comparative genomics. Microbiology and Molecular Biology Reviews 65(1):44-79.

Nielsen, P., D. Fritze and F.G. Priest. 1995. Phenetic diversity of alkaliphilic *Bacillus* strains: proposal for nine new spe-

cies. Microbiology 141(7):1745-1761.

Olivera, N., F. Sineriz and J.D. Breccia. 2005. *Bacillus patagoniensis* sp. nov., a novel alkalitolerant bacterium from the rhizosphere of *Atriplex lampa* in Patagonia, Argentina. International Journal of Systematic and Evolutionary Microbiology 55(1):443-447.

Perez, T., J.L. Balcazar, A. Peix, A. Valverde, E. Velazquez, de I. Blas and I. Ruiz-Zarzuela. 2011. *Lactococcus lactis* subsp. *tructae* subsp. nov. isolated from the intestinal mucus of brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). International Journal of Systematic and Evolutionary Microbiology 61(8):1894-1898.

Reddy, G.S., B.P. Manasa, S.K. Singh and S. Shivaji. 2013. *Paenisporosarcina indica* sp. nov., a psychrophilic bacterium from a glacier, and reclassification of *Sporosarcina antarctica* Yu *et al*., 2008 as *Paenisporosarcina antarctica* comb. nov. and emended description of the genus *Paenisporosarcina*. International Journal of Systematic and Evolutionary Microbiology 63(8):2927-2933.

Rhee, S.J., J. Lee and C. Lee. 2011. Importance of lactic acid bacteria in Asian fermented foods. 10, S5.

Romanenko, L.A., N. Tanaka, V.I. Svetashev and N.I. Kalinovskaya. 2013. *Paenibacillus profundus* sp. nov., a deep sediment bacterium that produces isocoumarin and peptide antibiotics. Archives of Microbiology 195(4):247-254.

Roux, V., L. Fenner and D. Raoult. 2008. *Paenibacillus provencensis* sp. nov., isolated from human cerebrospinal fluid, and *Paenibacillus urinalis* sp. nov., isolated from human urine. International Journal of Systematic and Evolutionary Microbiology 58(3):682-687.

Saha, P., A.K. Mondal, S. Mayilraj, S. Krishnamurthi, A. Bhattacharya and T. Chakrabarti. 2005. *Paenibacillus assamensis* sp. nov., a novel bacterium isolated from a warm spring in Assam, India. International Journal of Systematic and Evolutionary Microbiology 55(6):2577-2581.

Schleifer, K.-H., J. Kraus, C. Dvorak, R. Kilpper-Bälz, M.D. Collins and W. Fischer. 1985. Transfer of *Streptococcus lactis* and related streptococci to the genus *Lactococcus* gen. nov. Systematic and applied microbiology 6(2):183-195.

Sonalkar, V.V., R. Mawlankar, S. Krishnamurthi, S.K. Tang and S.G. Dastager. 2014. *Domibacillus enclensis* sp. nov., isolated from marine sediment, and emended description of the genus *Domibacillus*. International Journal of Systematic and Evolutionary Microbiology 64(12):4098-4102.

Takami, H. and K. Horikoshi. 2000. Analysis of the genome of an alkaliphilic *Bacillus* strain from an industrial point of view. Extremophiles : life under extreme conditions 4(2):99-108.

Thompson, J.D., D.G. Higgins and T.J. Gibson. 1994. CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Research 22(22):4673-4680.

Wang, L.T., H.P. Kuo, Y.C. Wu, C.J. Tai and F.L. Lee. 2009. *Lactobacillus taiwanensis* sp. nov., isolated from silage. International Journal of Systematic and Evolutionary Microbiology 59(8):2064-2068.

Whitehead, T.R., C.N. Johnson, N.B. Patel, M.A. Cotta, E.R. Moore and P.A. Lawson. 2015. *Savagea faecisuis* gen. nov., sp. nov., a tylosin- and tetracycline-resistant bacterium isolated from a swine-manure storage pit. Antonie van Leeuwenhoek 108(1):151-161.

Yang, G., X. Zhou, S. Zhou, D. Yang, Y. Wang and D. Wang. 2013. *Bacillus thermotolerans* sp. nov., a thermophilic bacterium capable of reducing humus. International Journal of Systematic and Evolutionary Microbiology 63(10):3672-3678.

Yoon, S.H., S.M. Ha, S. Kwon, J. Lim, Y. Kim, H. Seo and J. Chun. 2017. Introducing EzBioCloud: a taxonomically united database of 16S rRNA gene sequences and whole-genome assemblies. International Journal of Systematic and Evolutionary Microbiology 67(5):1613-1617.

Yuan, M., W. Zhang, S. Dai, J. Wu, Y. Wang, T. Tao, M. Chen and M. Lin. 2009. *Deinococcus gobiensis* sp. nov., an extremely radiation-resistant bacterium. International Journal of Systematic and Evolutionary Microbiology 59(6):1513-1517.

Yumoto, I., K. Hirota, S. Yamaga, Y. Nodasaka, T. Kawasaki, H. Matsuyama and K. Nakajima. 2004. *Bacillus asahii* sp. nov., a novel bacterium isolated from soil with the ability to deodorize the bad smell generated from short-chain fatty acids. International Journal of Systematic and Evolutionary Microbiology 54(6):1997-2001.

Submitted: August 30, 2018
Revised: December 27, 2018
Accepted: January 7, 2019