A report of 26 unrecorded bacterial species in Korea, belonging to the Bacteroidetes and Firmicutes

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An outcome of the study to discover indigenous prokaryotic species in Korea, a total of 26 bacterial species assigned to the classes Bacteroidetes and Firmicutes were isolated from diverse environmental samples collected from soil, tidal flat, freshwater, seawater, wetland, plant roots, and fermented foods. From the high 16S rRNA gene sequence similarity (>99.0%) and formation of a robust phylogenetic clade with the closest species, it was determined that each strain belonged to each independent and predefined bacterial species. There is no official report that these 26 species have been described in Korea; therefore 14 strains for the order Flavobacteriales and two strains for the order Cytophagales were assigned to the class Bacteroidetes, and 8 strains for the order Bacillales and 4 strains for the order Lactobacillales were assigned to the class Firmicutes are reported for new bacterial species found in Korea. Gram reaction, colony and cell morphology, basic biochemical characteristics, isolation source, and strain IDs are also described in the species description section.

Keywords: 16S rRNA, bacterial diversity, Bacteroidetes, Firmicutes, unrecorded species

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DOI:10.12651/JSR.2016.5.1.166

INTRODUCTION

Firmicutes includes industrially important groups as well as causative agents of various diseases. Lactic acid bacteria are the representative probiotic bacteria, and thus one of the most industrially important bacterial groups (Tannock, 2005). In contrast, some species of Bacillus (anthrax, food poisoning), Clostridium (tetanus, food poisoning, gas gangrene), Enterococcus (urinary tract infection), Streptococcus (pneumonia, meningitis, dental caries) and Staphylococcus (scalded skin syndrome) are some examples of medically significant bacteria of Firmicutes (Dworkin et al., 2006).

The phylum Firmicutes encompasses broad bacterial taxa that have Gram positive cell walls and low DNA G+C contents (Dworkin et al., 2006; De Vos et al., 2009). The phylum currently contains three classes, namely Bacilli, Clostridia and Erysipelotrichia (De Vos et al., 2009). The class Bacilli includes endospore-forming groups and lactic acid producing groups, Clostridia includes endospore forming or non-forming anaerobic groups and anoxygenic phototrophic groups, and Erysipelotrichia includes non-motile, non-spore-forming and aerobic groups.

The phylum Bacteroidetes is a very diverse bacterial phylum, the name of which changed several times over the past years. It is also known as the Cytophaga-Flexibacter-Bacteroides (CFB) group, an appellation that reflects the diversity of organisms found in this phylogenetic group (Woese, 1987; Woese et al., 1990). Among this phylum, members of the genus Bacteroides are the
most abundantly represented in the fecal microbiota (Moore and Holdeman, 1974; Sghir et al., 2000) and normal microbiota of the oral cavity, either in the saliva or dental plaque (Keijser et al., 2008; Nasidze et al., 2009a, 2009b). The largest class of Bacteroidetes is Flavobacteria (Thomas et al., 2011). These bacteria are all Gram-negative, covering a mixture of physiological types, from strictly anaerobic Bacteroides to strictly aerobic Flavobacteria. They are non-motile, flagellated, or motile by gliding.

In 2013, we collected diverse environmental samples and isolated myriads of novel bacterial species and unrecorded bacterial species in Korea. As a subset of this study, the present report focuses on the description of unrecorded species belonging to the Bacteroidetes and Firmicutes. Here we report 26 unrecorded bacterial species in Korea belonging to 2 orders in the Bacteroidetes and 2 orders in the Firmicutes.

MATERIALS AND METHODS

A total of 28 bacterial strains assigned to the classes Bacteroidetes and Firmicutes. The strains were isolated from diverse environmental samples such as freshwater, lagoon water, seawater, tidal flat, sand of seashore, plant roots, ginseng field and fermented food kimchi. Each sample was processed separately, spread onto diverse culture media including R2A, Marine Agar 2216 and Tryptic Soy Agar, and incubated at 20-30°C for 2-3 days. The designated strain IDs, sources, culture media, and incubation conditions are summarized in Table 1. All strains were purified as single colonies and stored as 10-20% glycerol suspension ~80°C as well as lyophilized ampoules.

The phylogenetic position of the strains assigned to the Bacteroidetes and Firmicutes was investigated by 16S rRNA gene analysis. The 16S rRNA genes were amplified by PCR and sequenced. The 16S rRNA gene sequences of the strains assigned to the Bacteroidetes and Firmicutes were analyzed using the EzTaxon-e server (Kim et al., 2012b) and confirmed using GenBank database (http://ncbi.nlm.nih.gov). For phylogenetic analyses, the 16S rRNA gene sequences were aligned using the SILVA Incremental Aligner (SINA v.1.2.11) (Pruesse et al., 2012). Phylogenetic tree was constructed by neighbor-joining (Saitou and Nei, 1987) and maximum-likelihood (Felsenstein, 1981) methods in MEGA version 6 (Tamura et al., 2013). The topology of phylogenetic tree was evaluated via a bootstrap analysis (Felsenstein, 1985), based on 1000 replications.

Colony morphology of the strains was observed on agar plates with a magnifying glass after cells grew up to stationary phase. Cellular morphology and cell size were examined by either transmission electron microscopy or scanning electron microscopy. Gram staining was performed using a Gram-staining kit or the standard procedures. Biochemical characteristics were tested by using API 20NE galleries (bioMérieux) according to the manufacturer’s instructions.

RESULTS AND DISCUSSION

Strains assigned to the Bacteroidetes

On the basis of 16S rRNA gene sequence comparisons and phylogenetic analyses, a total of 16 strains were assigned to the class Bacteroidetes. The 16 strains were distributed in 2 orders of the Bacteroidetes; 14 strains for the order Flavobacteriales and two strains for the order Cytophagales (Table 1). These strains were Gram-staining-negative, chemoheterotrophic and rod-shaped bacteria except for strain BM17 showing cocccid- or oval-shaped (Fig. 1). Colony size, morphology and physiological characteristics are also shown in the species description section.

Fig. 3 shows phylogenetic assignment of 16 strains into 14 species of the orders Flavobacteriales and Cytophagales. These strains belonged to Flavobacterium anhuiense (Liu et al., 2008), F. compostarboris (Kim et al., 2012a), F. glaciei (Zhang et al., 2006), F. glycines (Madaihyan et al., 2010), F. xinjiangense (Zhu et al., 2003), Arenibacter echinorum (Nedashkovskaya et al., 2007), Cloacibacterium normanense (Allen et al., 2006), Cellulophaga lytica (Johansen et al., 1999), Chryseobacterium rhizophaeae (Cho et al., 2010), Elizabethkingia miricola (Kim et al., 2005), Lacinutrix himadriensis (Srinivas et al., 2013) and Marinibacter orientalis (Nedashkovskaya et al., 2004) of the family Flavobacteriaceae and Algoraphagus manntolivorans (Shahina et al., 2014) and Flaviimonas pallidilutea (Sheu et al., 2013) of the family Cytophagales.

There is no official report that these 14 species have been isolated in Korea; therefore 12 species in 8 genera of one family in the order Flavobacteriales and two species in the order Cytophagales are reported for Bacteroidetes species found in Korea.

Strains assigned to the Firmicutes

On the basis of 16S rRNA gene sequence comparisons and phylogenetic analyses, a total of 12 strains were assigned to the class Firmicutes. The 12 strains were distributed in 2 orders of the Firmicutes; 8 strains for the order Bacillales and 4 strains for the order Lactobacillales (Table 1). These strains were Gram-staining-positive, chemoheterotrophic and rod- or coccus-shaped bacteria (Fig. 1). Colony size, morphology and physiologi-
| Phylum       | Family             | Genus             | Strain ID | NIBR ID       | Most closely related species                      | Similarity (%) | Isolation source | Medium | Incubation conditions |
|--------------|--------------------|-------------------|-----------|---------------|--------------------------------------------------|----------------|------------------|--------|-----------------------|
| Bacteroidetes|                    |                   |           |               |                                                  |                |                  |        |                       |
| Flavobacteriaceae |                  | Flavobacterium    | WM10      | NIBR BA0000114425 | F. anhuiense D3<sup>T</sup>                      | 99.5           | Freshwater       | R2A    | 25°C, 3d             |
|               |                    |                   | WW2       | NIBR BA0000114435 | F. compostarboris 15C3<sup>T</sup>               | 99.3           | Freshwater       | R2A    | 25°C, 3d             |
|               |                    |                   | JJ9006    | NIBR BA0000114157 | F. glacii 0499<sup>T</sup>                      | 100.0          | Freshwater       | R2A    | 25°C, 2d             |
|               |                    |                   | JJ9011    | NIBR BA0000114162 | F. glycini Gm-149<sup>T</sup>                  | 99.9           | Freshwater       | R2A    | 25°C, 2d             |
|               |                    |                   | HME8661   | NIBR BA0000114392 | F. xingangense JCM 11314<sup>T</sup>            | 99.6           | Freshwater       | R2A    | 20°C, 2d             |
|               |                    | Arthrobacter      | HME9268   | NIBR BA0000114395 | A. echinorhor KMM 6032<sup>T</sup>             | 99.7           | Lagoon water     | R2A    | 30°C, 3d             |
|               |                    | Cellephaga        | M-M24     | NIBR BA0000114319 | C. lytica DSM 7489<sup>T</sup>                 | 99.8           | Sand of seashore | MA     | 25°C, 3d             |
|               |                    |                   | BM17      | NIBR BA0000114306 | C. rhizosphaerensis RSB3-1<sup>T</sup>         | 99.7           | Tidal flat       | MA     | 30°C, 3d             |
|               |                    |                   | 2013 C18  | NIBR BA0000114166 | C. normanense CCUG 46293<sup>T</sup>         | 99.7           | Freshwater       | R2A    | 25°C, 2d             |
|               |                    |                   | JJ9009    | NIBR BA0000114160 | E. miricola GTC 862<sup>T</sup>                | 99.8           | Freshwater       | R2A    | 25°C, 2d             |
|               |                    |                   | HDW8      | NIBR BA0000114317 | L. himadriensis E4-9a<sup>T</sup>             | 99.2           | Sand of seashore | MA     | 25°C, 3d             |
|               |                    |                   | HD32      | NIBR BA0000114316 | M. orientalis KMM 3947<sup>T</sup>            | 99.3           | Tidal flat       | MA     | 30°C, 3d             |
| Firmicutes    |                    |                   |           |               |                                                  |                |                  |        |                       |
| Bacilliaceae  |                    | Bacillus          | G9-2      | NIBR BA0000114358 | B. algicola KMM 3737<sup>T</sup>              | 99.5           | Tidal flat       | MA     | 25°C, 2d             |
|               |                    |                   | DT7-08    | NIBR BA0000114189 | B. gibsonia DSM 8722<sup>T</sup>              | 99.8           | Plant root       | TSA    | 30°C, 2d             |
|               |                    |                   | DT2-01    | NIBR BA0000114177 | B. humanaensis DSM 81003<sup>T</sup>          | 99.9           | Plant root       | TSA    | 30°C, 2d             |
|               |                    |                   | M4Y-2-1   | NIBR BA0000114264 | B. thermoduricola ATCC 10792<sup>T</sup>       | 99.9           | Ginseng soil     | MA     | 30°C, 3d             |
| Paenibacilliaceae |                  | Paenibacillus     | JJ9001    | NIBR BA0000114152 | P. typhoe x7<sup>T</sup>                      | 99.6           | Freshwater       | R2A    | 25°C, 2d             |
| Planococciaceae |                    | Planosporosarcina | G-MI 3    | NIBR BA0000114315 | P. quisquiliarum SK 55<sup>T</sup>            | 99.0           | Sand of seashore | MA     | 25°C, 3d             |
| Spoilocobacilliaceae |              | Fictibacillus     | 2013 C17  | NIBR BA0000114165 | F. nanhaiensis DSM 80206<sup>T</sup>      | 99.9           | Freshwater       | R2A    | 25°C, 2d             |
| Staphylococciaceae |                  | Staphylococcus    | ST5-08    | NIBR BA0000011482 | S. hominis subsp. novobioticus GTC 1228<sup>T</sup> | 99.9           | Plant root       | TSA    | 30°C, 2d             |
| Lactobacilliaceae |                  | Lactobacillus     | WT2K-1    | NIBR BA0000114227 | L. brevis ATCC 14869<sup>T</sup>              | 99.9           | Kimchi           | R2A    | 25°C, 2d             |
|               |                    |                   | PA4       | NIBR BA0000114226 | L. coryniformis subsp. torquens KCTC 3535<sup>T</sup> | 100.0          | Kimchi           | R2A    | 25°C, 2d             |
|               |                    |                   | EMB6      | NIBR BA0000114225 | L. harbinensis STH 10908<sup>T</sup>          | 100.0          | Kimchi           | R2A    | 25°C, 2d             |
|               |                    |                   | WT2K-2    | NIBR BA0000114228 | L. pentosus JCM 1558<sup>T</sup>              | 100.0          | Kimchi           | R2A    | 25°C, 2d             |
cal characteristics are also shown in the species description section.

Fig. 3 shows phylogenetic assignment of 12 strains into 12 species of the orders Bacillales and Lactobacillales. These strains belonged to B. algicola (Ivanova et al., 2004a), B. gibsonii (Nielsen et al., 1995), B. hunanensis (Chen et al., 2011), B. thuringiensis (Berliner, 1915), P. typhae (Kong et al., 2013), P. quisquiliarum (Krish-
Fig. 2. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the class *Bacteroidetes*. Bootstrap values (> 70%) are shown above nodes for the neighbor-joining and below nodes for the maximum-likelihood methods. Filled circles indicate the nodes recovered by the two treeing methods. Bar, 0.05 substitutions per nucleotide position.
Fig. 3. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the class *Firmicutes*. Bootstrap values (> 70%) are shown above nodes for the neighbor-joining and below nodes for the maximum-likelihood methods. Filled circles indicate the nodes recovered by the two treeing methods. Bar, 0.02 substitutions per nucleotide position.
namurthi et al., 2009), *F. nanhaiensis* (Glaeser et al., 2013) and *S. hominis* subsp. *noviosepticus* (Kloos et al., 1998) of the family *Bacillales* and *L. brevis* (Ivanova et al., 2004b), *L. cyniformis* subsp. *torquens* (Abo-El-Naga and Kandler, 1965), *L. harbinensis* and *L. pentosus* (Zanoni et al., 1987) of the family *Lactobacillales*.

There is no official report that these 12 species have been isolated in Korea; therefore 8 species in 5 genera of one family in the order *Bacillales* and 4 species in the order *Lactobacillales* are reported for *Firmicutes* species found in Korea.

**Description of Flavobacterium anhuiense WM10**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are raised, entire and light yellow colored after 3 days on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, N-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WM10 (= NIBRBA0000114425) has been isolated from a fresh water sample, Woopo wetland, Changnyeong, Korea.

**Description of Flavobacterium compostarboris WW2**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are round, smooth, translucent and dark-yellow colored after 3 days on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, N-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WW2 (= NIBRBA0000114435) has been isolated from a fresh water sample, Woopo wetland, Changnyeong, Korea.

**Description of Flavobacterium glaciei JJ9006**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose, D-mannose and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannitol, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain JJ9006 (= NIBRBA0000114157) has been isolated from a fresh water sample, Wanju, Korea.

**Description of Flavobacterium glycines JJ9011**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose, D-mannose and D-maltose are positive, but indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain JJ9011 (= NIBRBA0000114162) has been isolated from a fresh water sample, Juwang Mountain, Cheongsong, Korea.

**Description of Flavobacterium glycines WS101**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are opaque, round, umbonate and yellow colored after 3 days on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose, D-mannose and D-maltose are positive, but indole production, arginine dihydrolase, urease and gelatinase activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WS101 (= NIBRBA0000113915) has been isolated from a fresh water sample, Woopo wetland, Changnyeong, Korea.

**Description of Flavobacterium xinjiangense HME8661**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex, entire and yellow colored after 2 days on R2A at 20°C. Oxidase-activity is positive. In the API 20NE strip, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, D-mannose and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannitol, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are
negative. Strain HME8661 (= NIBRBA0000114392) has been isolated from a fresh water sample, Inje, Korea.

**Description of Cloacibacterium normanense 2013 C18**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are round, waxy and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, glucose fermentation, esculin hydrolysis, arginine dihydrolase and urease activities and assimilation of D-mannose are positive, but indole production, gelatinase and β-galactosidase activities and assimilation of 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 negative. Strain 2013 C18 (= NIBRBA0000114166) has been isolated from a fresh water sample, Andong, Korea.

**Description of Cloacibacterium normanense WS78**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are opaque, round, smooth, convex and yellow colored after 3 days of incubation on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, nitrate reduction and esculin hydrolysis are positive, but indole production, glucose fermentation, arginine dihydrolase, urease, gelatinase and β-galactosidase activities and assimilation of 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 negative. Strain WS78 (= NIBRBA0000114432) has been isolated from a fresh water sample, Woopo wetland, Changnyeong, Korea.

**Description of Arenibacter echinorum HME9268**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex, entire and yellow colored after 3 days on MA at 30°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis, urease, gelatinase and β-galactosidase activities and assimilation of D-glucose, D-mannose, D-mannitol, D-maltose and trisodium citrate are positive, but indole production, glucose fermentation and arginine dihydrolase activity and assimilation of L-arabinose, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid and phenylacetic acid are negative. Strain M-M24 (= NIBRBA0000114319) has been isolated from a sand of seashore, Pohang, Korea.

**Description of Cellulophaga lytica M-M24**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are irregular, smooth, glistening and yellow colored after 3 days on MA at 25°C. Oxidase-activity is positive. In the API 20NE strip, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, D-mannose, D-mannitol, N-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain M-M24 (= NIBRBA0000114319) has been isolated from a sand of seashore, Pohang, Korea.

**Description of Chryseobacterium rhizosphaerae BM17**

Cells are Gram-staining-negative, non-flagellated and coccolid- or oval-shaped. Colonies are irregular, smooth, convex, glistening and cream yellow colored after 3 days on MA at 30°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis, urease, gelatinase and β-galactosidase activities and assimilation of D-glucose, D-mannose, D-mannitol, D-maltose and trisodium citrate are positive, but indole production, glucose fermentation and arginine dihydrolase activity and assimilation of L-arabinose, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid and phenylacetic acid are negative. Strain BM17 (= NIBRBA0000114306) has been isolated from a tidal flat sample, Wando, Korea.

**Description of Elizabethkingia miricola JJ9009**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex and beige colored after 2 days of incubation on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, indole production, esculin hydrolysis, urease, gelatinase and β-galactosidase activities and assimilation of D-glucose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid and trisodium citrate are positive, but nitrate reduction, glucose fermentation and arginine dihydrolase activity and assimilation of L-arabinose, potassium gluconate, capric acid, adipic acid, malic acid and phenylacetic acid are negative. Strain JJ9009 (= NIBRBA0000114160) has been isolated from a fresh water sample, Juwang Mountain, Cheongsong, Korea.

**Description of Lacinutrix himadriensis HDW 8**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are irregular, smooth, convex, glistening and strong orange yellow colored after 3 days
on MA at 25°C. Oxidase-activity is positive. In the API 20NE strip, gelatinase activity is positive, but nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, arginine dihydrolase, urease and β-galactosidase activities and assimilation of 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 negative. Strain HDW 8 (= NIBRBA0000114317) has been isolated from a sand of seashore sample, Pohang, Korea.

**Description of *Maribacter orientalis* HD32**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, smooth, convex, glistening and yellow colored after 3 days on MA at 30°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis and β-galactosidase activity are positive, but indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, phenylacetic acid are negative. Strain HD32 (= NIBRBA0000114316) has been isolated from a sand of seashore sample, Pohang, Korea.

**Description of *Algoriphagus mannitolivorans* 2013 C56**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are convex, opaque and orange-colored after 2 days of incubation on MA at 25°C. Oxidase-activity is positive. In the API 20NE strip, glucose fermentation, esculin hydrolysis, arginine dihydrolase, urease and β-galactosidase activities and assimilation of D-glucose, D-mannose and D-maltose are positive, but nitrate reduction, indole production and gelatin hydrolysis and assimilation of L-arabinose, D-mannitol, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain 2013 C56 (= NIBRBA0000114169) has been isolated from a sand of seashore sample, Yeongdeok, the East Sea, Korea.

**Description of *Fluvimonas pallidilutea* HME8520**

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex, entire and orange colored after 2 days on R2A at 30°C. Oxidase-activity is positive. In the API 20NE strip, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose, D-mannose, N-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain HME8520 (= NIBRBA0000114391) has been isolated from a fresh water sample, Yongin, Korea.

**Description of *Bacillus algicola* G9-2**

Cells are Gram-staining-positive, flagellated and rod-shaped. Colonies are circular, raised, entire and white colored after 2 days on MA at 25°C. In the API 20NE strip, nitrate reduction, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-mannose, potassium gluconate and malic acid are positive, but indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of D-glucose, L-arabinose, D-mannitol, N-acetyl-glucosamine, D-maltose, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain G9-2 (= NIBRBA0000114358) has been isolated from a tidal flat sample, Taean, Korea.

**Description of *Bacillus gibsonii* DT7-08**

Cells are Gram-staining-positive, flagellated and coccus-shaped. Colonies are circular, glistening, moist and yellow-colored after 2 days of incubation on TSA at 30°C. Oxidase-activity is negative. In the API 20NE strip, nitrate reduction, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-glucose, D-mannose, D-mannitol, D-maltose and malic acid are positive, but indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of L-arabinose, N-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain DT7-08 (= NIBRBA 0000114189) has been isolated from a plant root sample, Daejeon, Korea.

**Description of *Bacillus hunanensis* DT2-01**

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, glistening, moist and beige colored after 2 days of incubation on TSA at 30°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis, urease and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, D-maltose are malic acid are positive, but indole production, glucose fermentation, arginine dihydrolase and gelatinase activities and assimilation of potassium gluconate, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain DT2-01 (= NIBRBA0000114177) has been isolated from a
Description of Bacillus thuringiensis M4Y-2-1

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, entire, rough, convex and yellow colored after 3 days of incubation on MA at 30°C. Oxidase-activity is negative. In the API 20NE strip, nitrate reduction, esculin hydrolysis arginine dihydrolase and gelatinase activities and assimilation of D-glucose, N-acetyl-glucosamine and D-maltose, potassium gluconate and malic acid are positive, but indole production, glucose fermentation, urease and β-galactosidase activities and assimilation of L-arabinose, D-mannose, D-mannitol, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain M4Y-2-1 (= NIBRBA0000114264) has been isolated from a ginseng soil sample, Anseong, Korea.

Description of Paenibacillus typhae JJ9001

Cells are Gram-staining-positive, flagellated and rod-shaped. Colonies are circular, and ivory colored after 2 days on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, esculin hydrolysis is positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, gelatinase and β-galactosidase activities and assimilation of 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 negative. Strain JJ9001 (= NIBRBA0000114152) has been isolated from a fresh water sample, Wanju, Korea.

Description of Paenibacillus torquens ST5-08

Cells are Gram-staining-positive, flagellated and rod-shaped. Colonies are circular, raised, entire and white colored after 2 days of incubation on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, glucose fermentation, esculin hydrolysis, arginine dihydrolase, gelatinase and β-galactosidase activities and assimilation of 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 negative. Strain ST5-08 (= NIBRBA0000114182) has been isolated from a plant root sample, Daejeon, Korea.

Description of Fictibacillus nanhaiensis 2013 C17

Cells are Gram-staining-positive, non-flagellated and straight rod-shaped. Colonies are flat, translucent, glistening and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, esculin hydrolysis, urease and gelatinase activities and assimilation of D-glucose, D-maltose, potassium gluconate and malic acid are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and β-galactosidase activities and assimilation of L-arabinose, D-mannose, D-mannitol, N-acetyl-glucosamine, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain 2013 C17 (= NIBRBA0000114165) has been isolated from a freshwater sample, Andong, Korea.
and gelatinase activities and assimilation of L-arabinose, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain PA4 (= NIBRBA0000114226) has been isolated from a kimchi sample, Daejeon, Korea.

Description of Lactobacillus harbinensis EMB6

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire and beige colored after 2 days on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose and N-acetyl-glucosamine are positive, but nitrate reduction, indole production, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain EMB6 (= NIBRBA0000114225) has been isolated from a kimchi sample, Daejeon, Korea.

Description of Lactobacillus pentosus WT2K-2

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire, and white colored after 2 days on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose and N-acetyl-glucosamine are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WT2K-2 (= NIBRBA0000114228) has been isolated from a kimchi sample, Daejeon, Korea.

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.

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Submitted: November 12, 2015
Revised: December 1, 2015
Accepted: February 16, 2016