Algibacter mikhailovii sp. nov., a novel marine bacterium of the family Flavobacteriaceae, and emended description of the genus Algibacter

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A novel marine bacterium, designated strain KMM 6171T, was subjected to taxonomic analysis by using a polyphasic approach. Colonies were yellow-pigmented and cells were Gram-negative, heterotrophic rods displaying slow gliding motility. 16S rRNA gene sequence analysis indicated that strain KMM 6171T was closely related to the genus Algibacter, a member of the family Flavobacteriaceae, with sequence similarity of 96.7–96.8 %. The predominant cellular fatty acids were iso-C15 : 1, iso-C15 : 0, anteiso-C15 : 0, C15 : 0, iso-C15 : 0 3-OH, iso-C17 : 0 3-OH and summed feature 3, comprising C16 : 1ω7c and/or iso-C15 : 0 2-OH. The DNA G + C content was 35.1 mol%. On the basis of the phenotypic, genotypic, chemotaxonomic and phylogenetic data, strain KMM 6171T represents a novel species of the genus Algibacter, for which the name Algibacter mikhailovii sp. nov. is proposed. The type strain is KMM 6171T (=KCTC 12710T =LMG 23988T). An emended description of the genus Algibacter based on the new data is also given.

The genus Algibacter, a member of the family Flavobacteriaceae (Bernardet et al., 2002), was erected to accommodate Gram-negative, facultatively anaerobic, gliding, orange-pigmented and agarolytic marine bacteria isolated from the surfaces of green algae (Nedashkovskaya et al. 2004).

In the present work, we report the isolation and identification of a novel Gram-negative, gliding, yellow-pigmented marine bacterium, designated strain KMM 6171T. As a result of a polyphasic study, including phylogenetic, genotypic, chemotaxonomic and phenotypic methods, the isolate was identified as a novel member of the genus Algibacter.

The agarolytic strain KMM 6171T was isolated from a sea urchin, Strongylocentrotus intermedius, collected in Troitsa Bay, Gulf of Peter the Great, the East Sea (also known as the Sea of Japan). For strain isolation, 0.1 ml homogenates of the sea urchin tissues were transferred onto plates of marine agar 2216 (Difco). After primary isolation and purification, strains were cultivated at 28 °C on the same medium and stored at −80 °C in marine broth (Difco) supplemented with 20 % (v/v) glycerol.

DNA extraction, PCR and 16S rRNA gene sequencing were carried out as described previously (Vancanneyt et al., 2006). Sequence data obtained were aligned with those of representative members of the family Flavobacteriaceae retrieved from GenBank, and construction of a neighbour-joining (Saitou & Nei, 1987) phylogenetic tree and bootstrap analysis were carried out as described previously (Cho et al., 2006). In addition, trees were constructed on the basis of maximum-parsimony (Kluge & Farris, 1969) and maximum-likelihood (Felsenstein, 1993) algorithms. Phylogenetic analysis of the almost-complete 16S rRNA gene sequence of strain KMM 6171T (1473 nt) revealed that the strain was affiliated with the family Flavobacteriaceae and formed a distinct lineage within the genus Algibacter, which was supported by a high bootstrap level and by the different tree-making algorithms (Fig. 1). The closest relatives of the strain studied were strains of...
**Algibacter lectus** with 16S rRNA gene sequence similarity of 96.7–96.8 %, suggesting that strain KMM 6171 T may represent a novel species in the genus **Algibacter** according to the recommendations of Stackebrandt & Goebel (1994). DNA was isolated following the method of Marmur (1961) and the DNA G + C content was determined by the thermal denaturation method (Marmur & Doty, 1962). The DNA G + C content of KMM 6171T was 35.1 mol%.

Analysis of fatty acid methyl esters of strain KMM 6171T was carried out according to the standard protocol of the Microbial Identification System (Microbial ID), except that the biomass was obtained from culture grown on marine agar 2216 at 25 °C for 48 h.

The fatty acid composition of strain KMM 6171 T was characterized by the predominance of branched-chain saturated and unsaturated fatty acids, namely iso-C15:1, iso-C15:0, anteiso-C15:0, C15:0, iso-C15:0 3-OH, iso-C17:0 3-OH and summed feature 3, comprising C16:1o7c and/or iso-C15:0 2-OH. A similar fatty acid composition was reported for the type strain of *A. lectus* (Nedashkovskaya et al., 2004).

Phenotypic analysis was performed by using methods described previously (Nedashkovskaya et al., 2003, 2004). API 20E, API 20NE and API ZYM galleries (bioMérieux) were also used for studying the phenotypic features of the strain according to the manufacturer’s instructions, except that the galleries were incubated at 28 °C.

Cells of strain KMM 6171T were heterotrophic, Gram-negative, motile by gliding, agarolytic and formed pale-yellow colonies. Other physiological and biochemical characteristics are listed in the species description and Table 1. Similar to *A. lectus*, the novel bacterium was oxidase-, catalase-, β-galactosidase- and agarase-positive, and was able to grow in media containing 1–6 % NaCl. However, strain KMM 6171T could be readily distinguished from *A. lectus* by the presence of nitrate reductase and DNase activities, by the absence of amylase and Tween esterase activities, and by its inability to form acid from carbohydrates.

Consequently, significant molecular distinctiveness and clear phenotypic differences support the description of strain KMM 6171T as a novel species of the genus **Algibacter**, for which the name **Algibacter mikhailovii** sp. nov. is proposed.

The representatives of the single species of the genus **Algibacter**, *A. lectus*, can ferment D-glucose. Consequently, *A. lectus* was characterized as a facultatively anaerobic organism in the genus description (Nedashkovskaya et al., 2004). Conversely, the novel isolate is strictly aerobic and unable to ferment D-glucose. In addition, fatty acid C15:1o6c, one of the major components of *A. lectus*, only amounts to 1.7 % in strain KMM 6171T. These facts justify an emendation of the description of the genus **Algibacter**.

**Description of **Algibacter mikhailovii** sp. nov.**

**Algibacter mikhailovii** (mik.ha’i.lo.vi.i. N.L. masc. gen. n. mikhailovii of Mikhailov, in honour of Valery V. Mikhailov, a Russian microbiologist, for his contributions to the development of marine microbiology).

Cells range from 0.3 to 0.4 μm in width by 2 to 10 μm in length and move slowly by gliding. On marine agar colonies are circular, 1–3 mm in diameter after 72 h of incubation at 25 °C, convex, shiny, sunken into the agar and pale-yellow-pigmented. Requires Na + ions for growth. Growth occurs at 4–37 °C and with 1–6% NaCl. Optimal growth is observed at 23–25 °C and with 2–3% NaCl. Heterotrophic, strictly aerobic. D-Glucose is not fermented. Flexirubin-type pigments are not produced. Oxidase, catalase, β-galactosidase and alkaline phosphatase activities...
Table 1. Differential phenotypic characteristics of Algibacter species

All strains were positive for: gliding motility; oxidase, catalase, β-galactosidase and alkaline phosphatase activities; requirement of NaCl for growth; growth at 1–6% NaCl and at 4–35 °C; hydrolysis of agar and gelatin; utilization of d-glucose, d-lactose and d-mannose; susceptibility to carbenicillin, oleandomycin and lincomycin. All strains were negative for: production of flexirubin pigments; urease activity; H2S, indole and acetoin production; hydrolysis of casein, cellulose (CM-cellulose and filter paper), chitin and Tween 80; acid formation from L-arabinose, D-lactose, D-melibiose, D-raffinose, L-cellulose (CM-cellulose and filter paper), chitin and Tween 80; acid from amygdalin. Esterase (C4), esterase lipase (C8), leucine dihydrolase activity is absent, and acid is not produced. Susceptible to ampicillin, benzylpenicillin, gentamicin, kanamycin, neomycin, polymixin B and streptomycin. The fatty acids amounting to more than 1% of total are iso-C15:1 (13%), anteiso-C15:0 (2.1%), iso-C15:0 (11.3%), anteiso-C15:0 (4.6%), C15:0 (7%), C15:1ω6c (1.7%), iso-C16:1 H (2%), C16:0 10 methyl (2.1%), C16:0 (2.3%), iso-C15:0 3-0H (5.8%), C15:0 2-0H (2.4%), C15:0 3-0H (1.3%), C16:0 3-0H (1.4%), iso-C17:0 3-0H (13%), C17:0 2-0H (2.4%), C18:1ω9c (1.8%) and summed feature 3 (22.2%), consisting of iso-C15:0 2-0H and/or C16:1ω7c. The DNA G + C content is 35.1 mol%.

The type strain, KMM 6171T (=KCTC 12710T=LMG 23988T), was isolated from a sea urchin, Strongylocentrotus intermedius, collected in Troitsa Bay, East Sea.

Emended description of the genus Algibacter

Nedashkovskaya et al. 2004

The description of the genus Algibacter is as given by Nedashkovskaya et al. (2004) and this study, with the following amendments. Some strains can ferment d-glucose. The main cellular fatty acids are straight-chain unsaturated and branched-chain unsaturated iso-C15:0, anteiso-C15:0, iso-C15:1, C15:0, iso-C15:0 3-0H, iso-C17:0 3-0H and summed feature 3, consisting of iso-C15:0 2-0H and/or C16:1ω7c. As determined by 16S rRNA gene sequence analysis, the genus Algibacter is a member of the family Flavobacteriaceae, phylum Bacteroidetes. The type species is A. lectus.

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