Geodermatophilaceae fam. nov., a formal description

Philippe Normand

Correspondence
Philippe Normand
normand@biomserv.univ-lyon1.fr

UMR 5557 CNRS Ecologie Microbienne, IFR41 Bio-Environnement et Santé, Université Lyon 1, 43 Bd du 11 Novembre 1918, 69622 Villeurbanne Cedex, France

The family name '*Geodermatophilaceae*' was first published by Normand *et al.* (1996) to contain the genera *Geodermatophilus* and *Blastococcus*, but a formal description and the designation of the type genus were not included, thus making the name invalid. Since then, the genus *Modestobacter* has been described as a member of the family '*Geodermatophilaceae*' by Mevs *et al.* (2000). We hereby formally describe the family '*Geodermatophilaceae*' which includes the recently described genus *Modestobacter*. The type genus of the family is *Geodermatophilus*.

In *Bergey's Manual of Systematic Bacteriology*, Lechevalier (1989) grouped the genera *Geodermatophilus*, *Dermatophilus* and *Frankia* in the section 'Actinomycetes with multilocular sporangia'. These three genera share the remarkable morphological feature of the formation of sporangia of up to 100 µm in diameter that divide in all three planes. A few years before, Ahrens & Moll (1970) isolated and described a bacterium from the Baltic sea that formed budding structures, *Blastococcus aggregatus*. Recently, Urzi *et al.* (2004) published an emended description of genus *Blastococcus* and the genus now comprises two species, *Blastococcus aggregatus* and *Blastococcus saxobidens*. Using 16S rRNA gene sequences, Hahn *et al.* (1989) showed that the genus *Dermatophilus* was only distantly related to the genus *Geodermatophilus* and that the genera *Geodermatophilus*, *Blastococcus* and *Frankia* were indeed closely related and proposed an emended description of the family *Frankiaceae* to include these three genera.

The family '*Geodermatophilaceae*' was initially proposed by Normand *et al.* (1996) to contain the genera

Geodermatophilus and *Blastococcus* that were previously assigned to the family *Frankiaceae*, and which thus retained only one genus, *Frankia*. No formal description of the family was provided and the type genus was not designated, therefore the family was not considered to be validly published. Stackebrandt *et al.* (1997) emended the description of the family by describing signature nucleotides and assigning the genus *Geodermatophilus* as the type genus for the family, but since the original description was not valid, the emended description was also not valid.

A phylogenetic analysis based on 16S rRNA gene sequences shows the family '*Geodermatophilaceae*' to be highly coherent with a bootstrap value of 100 % and to have the genera *Frankia* and *Acidothermus* as its closest neighbours (Fig. 1). The morphological, chemotaxonomic and physiological characteristics of the family are given in Table 1.

Description of *Geodermatophilaceae* fam. nov.

Geodermatophilaceae (Geo.der.ma.to.phi.la'ce.ae. N.L. masc. n. *Geodermatophilus* type genus of the family; suff.

Fig. 1. Phylogenetic tree showing representatives of the three genera and recognized species of the family '*Geodermatophilaceae*', together with representatives of the type species of the genera in the *Frankineae*. 16S rRNA gene sequences were aligned using CLUSTAL_X (Thompson *et al.*, 1997). Indel-containing regions were excluded from the analysis. Matrix pairwise comparisons were corrected for multiple base substitutions by the method of Kimura (1980). The tree was constructed by the neighbour-joining method (Saitou & Nei, 1987). A bootstrap confidence analysis was performed on 1000 replicates to determine the reliability of the tree topologies obtained (Felsenstein, 1985). Bootstrap values are shown at branch points. The graphic representation of the resulting tree was constructed using NJPLOT software (Perrière & Gouy, 1996). Bar, 0.01 nucleotide substitutions per site.

Table 1. Characteristics of the three genera of the family 'Geodermatophilaceae'

Data are from Mevs *et al.* (2000), Urzi *et al.* (2004) and Lechevalier (1989). +, Positive/present; –, negative/not present.

Characteristic	<i>Geodermatophilus</i>	<i>Blastococcus</i>	<i>Modestobacter</i>
Morphology			
Hyphae	Rudimentary	–	–
Spores	Motile	Motile	Motile
Sporangia	+	–	–
Buds	–	+	+
Colony colour	White, red, black	Pink, orange	White, pink, black
Physiology			
Requirement for O ₂	Aerobic	Aerobic/microaerophilic	Aerobic
Temperature range (°C)	18–37	3–40	0–28
Temperature optimum (°C)	24–28	25	19–21
Tolerance of 3 % NaCl	–	+	+
Hydrolysis of starch	+	–	–
D-Glucose	+	–	+
Chemistry			
Menaquinone	MK-9(H ₄)	MK-9(H ₄)	MK-9(H ₄)
DNA G + C (mol%)	73–75	74	70
Habitat	Soil, rock surfaces	Rock surfaces, sea	Polar 'soil'

-aceae ending to denote a family; N.L. fem. pl. n. *Geodermatophilaceae* the *Geodermatophilus* family).

Exhibits the following properties in addition to those given in the family description by Stackebrandt *et al.* (1997). Includes rods or rudimentary hyphae. Motile spores. Colonies are red- or black-pigmented. Aerobic growth. MK-9(H₄) menaquinones are present. DNA G + C content is between 70 and 75 mol%. 16S rRNA nucleotide signatures are 139–224 (C–G), 157–164 (A–U), 158–163 (A–U), 186–191 (C–G), 263 (G), 293–304 (G–U), 986–1219 (U–A), 987–1218 (A–U), 1059–1198 (U–A) and 1308–1329 (U–A) with the specific motif CaGCTCTGGGATAAC-TCCAAGAAATT at coordinates 139–165 in the 16S rRNA gene. Habitat ranges from dry soils and rock surfaces to seawater. The family *Geodermatophilaceae* contains the genera *Geodermatophilus*, *Blastococcus* and *Modestobacter*.

The type genus is *Geodermatophilus* (Luedemann, 1968).

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