Pseudomonas cepacia sp. nov., nom. rev.

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The name *Pseudomonas cepacia* Burkholder was omitted from the Approved Lists of Bacterial Names and therefore lost standing in bacterial nomenclature. In this paper we revive this name; it is used for the same taxon to which it was originally applied by Burkholder. A description of the species and a comparison with other species of *Pseudomonas* ribonucleic acid homology group II are included. Since no type strain was chosen by Burkholder, strain ATCC 25416 is designated the type, following the suggestion of Ballard et al.

In this paper we revive the name *Pseudomonas cepacia*, which was previously validly published by Burkholder (2) for the causative agent of a bacterial rot of onion bulbs. The description of Burkholder was expanded considerably by Ballard et al. (1). The name lost its validity by being excluded from the Approved Lists of Bacterial Names (12). In accordance with Rule 28a of the *International Code of Nomenclature of Bacteria* (5), the name is here revived.

The following description of *P. cepacia* is based on the study of Ballard et al. (1), which included observations by Stanier et al. (14) on strains labeled *Pseudomonas multivorans*, which was found to be a synonym of *P. cepacia* (1, 11). The synonymy of "*Pseudomonas kingii*" Jonsson (4) (names in quotation marks are not on the Approved Lists of Bacterial Names [12] and have not been published validly since 1 January 1980; hence, they are without standing in bacterial nomenclature) with *P. cepacia* was established by Snell et al. (13).

Pseudomonas cepacia (ex Burkholder, 1950) nom. rev. (*P. multivorans* Stanier et al., 1966; "*P. kingii*" Jonsson, 1970) (ce pa'ci a.L. fem.n. *caepa* or *cepa* onion; M.L. fem. adj. *Cepacius* of or like onion.)

Rods 0.8 to 1 by 1.6 to 3.2 μ m. Cells occur singly or in pairs and are motile by means of a tuft of polar flagella. Cells accumulate poly-beta-hydroxybutyrate as a carbon reserve material, especially in nitrogen-deficient media.

Pigments which do not fluoresce under low-wavelength ultraviolet light (254 nm) are produced by most strains. On ordinary complex media, the pigmentation is yellow or greenish, but on chemically defined media the pigments may show a great variety of colors, depending on the carbon source used for growth. In some cases the pigments are associated with the cells, and in other cases they diffuse into the medium.

Denitrification is negative; nitrate is reduced to nitrite.

Lipolytic. Some strains hydrolyze gelatin, and some give a positive lecithinase (egg yolk) reaction.

No organic growth factors are required. Nutritionally, the most versatile of the *Pseudomonas* species known to date. Out of about 150 organic compounds, one-third or more can be used as sole carbon and energy sources for growth (1, 14); these compounds include a large variety of carbohydrates, mono- and dicarboxylic acids, mono- and polyalcohols, aromatic compounds, amino acids, and amines. Substrates which are of diagnostic value and are used by the great majority of the strains but which are used only infrequently by strains of other *Pseudomonas* species include D-arabinose, D-fucose, cellobiose, saccharate, mucate, 2,3-butylene glycol, sebacate, *meso*-tartrate, citraconate, α -hydroxybenzoate, *m*-hydroxybenzoate, L-threonine, DL-ornithine, and tryptamine. D-(-)-Tartrate, mesaconate, and erythritol are among the compounds not utilized for growth (1, 14). Only three strains originally labeled *P. multivorans* can use maltose for growth (14).

Obligately aerobic. Optimal growth temperature, 30 to 35°C. No growth at 4°C. Most strains grow at 41°C, and almost all grow at 40°C.

Strains have been isolated from rotten onions, soils, and various clinical specimens, including benzalkonium chloride solutions (3).

The average guanine-plus-cytosine content of the deoxyribonucleic acid is 67.4 mol%, as determined by buoyant density centrifugation. Deoxyribonucleic acid-deoxyribonucleic acid hybridization experiments have indicated that this species is related to *Pseudomonas gladioli* ("*Pseudomonas marginata*," "*Pseudomonas alliicola*"), *Pseudomonas caryophylli*, *Pseudomonas mallei*, and *Pseudomonas pseudomallei* (1; M. Rogul, J. Brendle, D. K. Haapala, and A. D. Alexander, *Bacteriol. Proc.*, p. 19, 1968). In addition, ribosomal ribonucleic acid-deoxyribonucleic acid hybridization studies have shown a

TABLE 1. Characters of diagnostic value in distinguishing *P. cepacia* from other species of *Pseudomonas* group II^a

Characteristic	<i>P. cepacia</i>	<i>P. gladioli</i>	<i>P. caryophylli</i>	<i>P. pseudomallei</i>	<i>P. mallei</i>	<i>P. solanacearum</i>	<i>P. pickettii</i>
Denitrification	— ^b	—	+	+	v	+	+
Arginine dihydrolase	—	—	+	+	+	—	—
Hydrolysis of gelatin	v	+	—	+	+	—	—
Hydrolysis of PHB ^c	—	—	—	+	v	—	—
Hydrolysis of starch	—	—	—	+	v	—	—
Utilization of:							
L-Rhamnose	v	—	+	—	—	—	—
Maltose, starch	(—)	—	—	+	v	—	—
Saccharate, mucate	+	+	+	—	—	+	+
Malonate	+	+	+	—	v	—	+
Glutarate	+	v	—	v	v	—	v
Adipate	+	+	—	+	+	—	+
Azelate, sebacate	+	+	—	+	v, —	v	+
D-(—)-Tartrate	—	+	—	—	—	—	—
Glycolate	v	—	+	—	—	v	+
Hydroxymethylglutarate	+	+	+	+	—	—	+
Aconitate	+	+	+	+	—	+	+
Levulinate	+	—	—	+	—	v	+
Citrate	+	+	—	—	—	—	+
Mesaconate	—	+	—	—	—	—	—
Erythritol	—	—	—	+	—	—	—
2,3-Butylene glycol	+	—	+	—	—	—	v
Benzoate	+	+	—	+	+	—	—
D-Alanine	+	+	—	+	+	+	+
L-Valine	v	+	v	+	v	—	+
DL- α -Aminobutyrate	—	v	—	—	v	—	—
delta-Aminovalerate	+	—	—	+	v	—	—
Kynurenate, anthranilate	+	+,v	—	+	—, v	—	+,—
Ethanolamine	+	+	—	+	—	—	—
Benzylamine	v	(—)	—	—	—	—	—
Putrescine	+	—	—	+	v	—	—
Spermine	+	—	—	v	—	—	—
Acetamide	v	—	—	—	—	—	—
Nicotinate	v	+	—	—	—	—	—

^a In addition, the guanine-plus-cytosine contents of the deoxyribonucleic acids are as follows: *P. cepacia*, 67.4 mol%; *P. gladioli*, 68.5 mol%; *P. caryophylli*, 65.3 mol%; *P. pseudomallei*, 69.5 mol%; *P. mallei*, 69 mol%; *P. solanacearum*, 66.5 to 68 mol%; and *P. pickettii*, 64 mol%. The data in this table were taken from the following sources: *P. cepacia* (including *P. multivorans* strains), references 1 and 14; *P. gladioli* ("*P. marginata*" and "*P. alliiicola*") and *P. caryophylli*, reference 1; *P. mallei* and *P. pseudomallei*, references 6 and 10; *P. solanacearum*, reference 7; *P. pickettii*, reference 9.

^b +, Positive; —, negative; (—), present in more than 90% of the strains; v, present in more than 10% but less than 90% of the strains.

^c PHB, Poly- β -hydroxybutyrate.

relationship to *Pseudomonas solanacearum* and *Pseudomonas pickettii* (8). At present this species is included in *Pseudomonas* Group II (8). Table 1 lists characters of diagnostic value for the differentiation of *P. cepacia* from other species of this group.

Type strain: Burkholder (=717-ICPB 25, =ATCC 25416, =NCTC 10743) (1). This strain has given the following results for the tests that are not universally positive or negative for the 37 strains of *P. cepacia* that have been characterized fully (1, 14): it liquefies gelatin and gives a positive egg yolk reaction; it is able to grow on trehalose, butanol, glycolate, L-mandelate, benzoylformate, benzoate, testosterone, L-valine, L-

leucine, delta-aminovalerate, butylamine, benzylamine, and acetamide; and it does not grow on L-rhamnose, maltose, starch, isobutanol or nicotinate. The guanine-plus-cytosine content of the deoxyribonucleic acid is 67.8 mol%.

REPRINT REQUESTS

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LITERATURE CITED

1. Ballard, R. W., N. J. Palleroni, M. Doudoroff, R. Y. Stanier, and M. Mandel. 1970. Taxonomy of the aerobic pseudomonads: *Pseudomonas cepacia*, *P. margin-*

- ata, *P. alliicola* and *P. caryophylli*. *J. Gen. Microbiol.* **60**:199-214.
2. Burkholder, W. H. 1950. Sour skin, a bacterial rot of onion bulbs. *Phytopathology* **40**:115-117.
 3. Hardy, P. C., G. M. Ederer, and J. M. Matsen. 1970. Contamination of commercially packed urinary catheter kits with the pseudomonad EO-1. *N. Engl. J. Med.* **282**:33-35.
 4. Jonsson, V. 1970. Proposal of a new species, *Pseudomonas kingii*. *Int. J. Syst. Bacteriol.* **20**:255-257.
 5. Lapage, S. P., P. H. A. Sneath, E. F. Lessel, V. B. D. Skerman, H. P. R. Seeliger, and W. A. Clark (ed.). 1975. International code of nomenclature of bacteria. 1975 Revision. American Society for Microbiology, Washington, D.C.
 6. Mandel, M. 1966. Deoxyribonucleic acid base composition in the genus *Pseudomonas*. *J. Gen. Microbiol.* **43**:273-292.
 7. Palleroni, N. J., and M. Doudoroff. 1971. Phenotypic characterization and deoxyribonucleic acid homologies of *Pseudomonas solanacearum*. *J. Bacteriol.* **107**:690-696.
 8. Palleroni, N. J., R. Kunisawa, R. Contopoulou, and M. Doudoroff. 1973. Nucleic acid homologies in the genus *Pseudomonas*. *Int. J. Syst. Bacteriol.* **23**:333-339.
 9. Ralston, E., N. J. Palleroni, and M. Doudoroff. 1973. *Pseudomonas pickettii*, a new species of clinical origin related to *Pseudomonas solanacearum*. *Int. J. Syst. Bacteriol.* **23**:15-19.
 10. Redfearn, M. S., N. J. Palleroni, and R. Y. Stanier. 1966. A comparative study of *Pseudomonas pseudomallei* and *Bacillus mallei*. *J. Gen. Microbiol.* **43**:293-313.
 11. Sands, D. C., M. N. Schroth, and D. C. Hildebrand. 1970. Taxonomy of phytopathogenic pseudomonads. *J. Bacteriol.* **101**:9-23.
 12. Skerman, V. B. D., V. McGowan, and P. H. A. Sneath (ed.). 1980. Approved lists of bacterial names. *Int. J. Syst. Bacteriol.* **30**:225-420.
 13. Snell, J. J. S., L. R. Hill, S. P. Lapage, and M. A. Curtis. 1972. Identification of *Pseudomonas cepacia* Burkholder and its synonymy with *Pseudomonas kingii* Jonson. *Int. J. Syst. Bacteriol.* **22**:127-138.
 14. Stanier, R. Y., N. J. Palleroni, and M. Doudoroff. 1966. The aerobic pseudomonads: a taxonomic study. *J. Gen. Microbiol.* **43**:159-271.