PSEUDOMONAS AERUGINOSA OR
PSEUDOMONAS PYOCYANEA?

Request for an Opinion

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ABSTRACT. Recently the Judicial Commission of the International Committee on Nomenclature of Bacteria (ICNB) was asked to issue an Opinion conserving the name Pseudomonas pyocyanea (Gessard) Migula and rejecting the name Pseudomonas aeruginosa (Schroeter) Migula. In the present paper evidence is adduced that indicates Pseudomonas aeruginosa is not only the correct scientific name but also that which is in common usage internationally for the type species of the genus Pseudomonas Migula. In the interests of stable nomenclature and popular usage, the authors request that an Opinion be issued by the Judicial Commission, 1) placing the specific epithet aeruginosa, in the combination Pseudomonas aeruginosa (Schroeter) Migula, in the list of Epitheta specifica conservanda, and 2) placing the specific epithet pyocyanea, in the combination Pseudomonas pyocyanea Migula, in the list of Epitheta specifica rejicienda.

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INTRODUCTION

The Judicial Commission (1952, 121) of the International Committee on Nomenclature of Bacteria (ICNB) issued an Opinion (no. 5) which conserved the generic name Pseudomonas Migula 1894; the Opinion states that this name is associated with the species designated and described by Migula in 1895 and that Pseudomonas aeruginosa (Schroeter) Migula

1900 (basionym: Bacterium aeruginosum Schroeter 1872; synonym: Pseudomonas pyocyanea (Gessard) [sic] Migula 1895) is the type species of the genus. Although this action clearly established the biological entity referred to as Pseudomonas aeruginosa as the type species of the genus Pseudomonas, it cannot be construed as having officially fixed the name of this species, in particular, the specific epithet.

Recently Véron (1965, 187) requested an Opinion from the Judicial Commission which, if issued, would conserve the name Pseudomonas pyocyanea (Gessard 1882) Migula 1895 and would place the name Pseudomonas aeruginosa (Schroeter 1872) Migula 1900 in the list of Nomina rejicienda.

According to the rules of nomenclature, there can be only one correct name for a given taxon in a given position: the earliest name which is in accordance with the rules. In those cases where it can be shown convincingly that the correct name of a taxon is a real source of confusion or does not enjoy common usage, the rules have been made flexible enough to yield to the pressure of common sense and permit, by conservation, the use of a later synonym.

The intent of this paper is to show 1) that Pseudomonas aeruginosa, as a validly published and legitimate name with unquestioned priority, is the correct name of the type species of Pseudomonas, and 2) that since P. aeruginosa, not P. pyocyanea, is most commonly used by microbiologists the world over, including those medically oriented, there is no need to make an exception to the established rules to achieve stability in the nomenclature of this organism. However, inasmuch as Pseudomonas aeruginosa has seriously been challenged, the authors deem it advisable to recommend the conservation of the specific epithet aeruginosa in the combination Pseudomonas aeruginosa.

DISCUSSION

Fordos (1860, 215) studied the colored material in blue pus. He crystallized a small amount of the coloring substance, which he named "pyocyanine," and reported it to be soluble in water, alcohol, ether and chloroform, and to be red in acid solution, blue in alkaline solution.

Twelve years later Schroeter (1872, 109) published a paper relating to several pigments produced by bacteria. Under the category "Grün" Schroeter (ibid., p. 122) reported on two observations of green pigment: one involved pieces of cooked

potato, the other concerned so-called "green pus." Although Schroeter was not able to find bacteria in connection with the dark green pigment produced on and in potatoes, he was inclined to implicate bacteria in the production of the pigment because of the lack of any other possible source. On the other hand, Schroeter stated that green pus was a condition which represented a well-known production of pigment by bacteria. On the basis of the investigations of others, which he did not document, Schroeter stated that the pigment was produced by motile bacteria. On many occasions Schroeter had seen green pus, but neither in the quantity nor under the conditions which enabled him to make microscopic or chemical examinations. In all cases the color was verdigris, tending somewhat to blue. It was also apparent to Schroeter that the pigment was eliminated from the bacteria into the surrounding fluid.

Scientific names were given by Schroeter (*ibid.*, p. 126) to the bacteria which produced the pigments he discussed: the motile forms he designated (*ibid.*, pp. 109 and 126) as bacteria (Bacterium) and the nonmotile forms as bacteridia (Bacteridium). Schroeter attributed the production of the pigment in green pus to a specific, distinct bacterium, for which he proposed the name Bacterium aeruginosum. (The Latin adjective aeruginosus, -a, -um means "full of copper rust" or "verdigris," hence "green.") It should be noted that Schroeter did not relate the name Bacterium aeruginosum, or the name of any bacterium, to the dark green pigment which he observed on cooked potato slices because he did not know the source of this pigment, although he believed that bacteria were involved. Without question Schroeter applied the name Bacterium aeruginosum to the bacterium which produces the pigment, pyocyanine, in green pus. Almost without exception, bacteriologists, when referring to the blue-pus organism by scientific name, use Bacterium aeruginosum Schroeter or Pseudomonas aeruginosa (Schroeter) Migula either as the name of the organism or as a synonym of another scientific name, usually Bacillus pyocyaneus or Pseudomonas pyocyanea; in any event, it is obvious that Schroeter applied the name Bacterium aeruginosum to the bacterium which produces the pigment in blue pus.

According to the rules of the International Code of Nomenclature of Bacteria and Viruses (1958) pertaining to the publication of names (*viz.* Rules 10 to 14 inclusive), Bacterium aeruginosum Schroeter 1872, 126 was validly published (see Buchanan *et al.* 1966, 298). Although Schroeter did not cul-

tivate the organism he named, he did describe it: a motile bacterium which produces the pigment of green pus. There are some who would argue that Schroeter's description, being brief, is inadequate, and that the name Bacterium aeruginosum is therefore illegitimate as a nomen dubium (Rule 24f). However the production of pyocyanine is a characteristic which, on the basis of all microbiological experience to date, is unique to the organism best known as Pseudomonas aeruginosa; hence the application of the name Bacterium aeruginosum Schroeter is not doubtful, and the name is not a nomen dubium.

The argument has also been advanced (Véron 1965, 188) that since Schroeter did not cultivate the blue-pus organism, Bacterium aeruginosum Schroeter does not conform to the rules of nomenclature. However the rules relating to the valid publication and legitimacy of names do not require that the organism named be cultivated; in fact, the practice of naming bacteria before they have been cultivated in vitro or isolated in pure culture is not without precedent, to wit, the validly published names (see Buchanan *et al.* 1966: 729, 1177, 1158 and 551, respectively) Mycobacterium leprae, Vibrio cholerae, Treponema carateum, and Eperythrozoon coccoides, to mention but a few. The only principle involved here is whether the characterization of an organism is based on the properties of more than one organism. The pertinent rule (14a, Moscow 1966 revision) of the International Code of Nomenclature of Bacteria reads as follows:

The name of a species is validly published only when its publication conforms to the following requirements:

- (1) It must be published as a binary combination consisting of a generic name followed by a single specific epithet.
- (2) It must be accompanied by a description of the species or by citation of a previously and effectively published description.
- (3) The description must not be based on the properties of more than one species in mixed or impure cultures. This statement does not apply to the name of a species whose description is based on morphology or other characters and not upon growth in cultures.

The basionym Bacterium aeruginosum Schroeter was a correctly formed binary combination. There is no evidence that Schroeter's characterization of the species was based on the

properties of more than one organism. The only known organism that is motile and produces pyocyanine is Pseudomonas aeruginosa (Schroeter) Migula (basonym Bacterium aeruginosum (Schroeter) Migula).

Cohn (1872) acknowledged that Schroeter had given a scientific name to the green-pus organism, citing (ibid., p. 157) Bacteridium aerugineum Schroeter [sic] and (ibid., p. 173) Bacterium aeruginosum. Although Cohn (*loc. cit.*) noted that this organism is at times nonmotile and at other times (in pus) motile, he gave no indication that he intended to transfer Bacterium aeruginosum to the genus Bacteridium Davaine because of the occurrence of nonmotile cells. Bacteridium aerugineum, probably a lapsus calami, must be attributed to Cohn, and, inasmuch as he apparently did not intend to introduce it as a new name, it must be regarded as not validly published (Rule 12c(3)).

Gessard (1882a, 536), using the serial-dilution technique of Pasteur, obtained a culture which showed the production of pyocyanine. The description of the organism presented by Gessard (*loc. cit.*) added very little, and nothing significant, to that given earlier by Schroeter, and, if it were not for the uniqueness of pyocyanine production, his description would be most inadequate, as would Schroeter's. The occurrence of nonmotile forms of this organism, as observed by Cohn, did not present a problem to Gessard because, as he later pointed out (1882b, 44), it was known that one and the same species could be motile or nonmotile, depending upon the medium used to cultivate it.

In Gessard's publications (1882a, 1882b) the only scientific names he used to refer to the green-pus organism are "Bacteridium aeruginosum, Schroeter" and "bacterium [sic] aeruginosum de Schroeter" (1882b, 44 and 64, respectively). It is concluded that Gessard recognized the validity and priority of the scientific names used by Schroeter.

It is most unfortunate that Gessard's fine work should be involved in errors made by subsequent authors. In neither of Gessard's publications did he propose a scientific name for the blue-pus organism. Nevertheless the name Micrococcus pyocyaneus has been credited to Gessard (1882b) by Zopf (1884, 83) and Véron (1965, 189), and Bacillus pyocyaneus has been attributed to Gessard (1882a and 1882b) by the following, among others: Flügge (1886, 286), Migula (1895, 29; 1900, 884), Matzschita (1902, 132), Hauduroy *et al.* (1953, 422), the Judicial Commission (1952, 121-122), Haynes (1957, 99), and Prévot (1961, 43).

The closest Gessard came to using a new scientific name is in the following query (ibid., p. 45): "Si la distinction de deux especes en devait resulter, ne conviendrait-il pas de caracteriser du terme pyocyaneus le micrococcus qui produit la pyocyanine?". Some have interpreted this question to mean that Gessard proposed the name Micrococcus pyocyaneus; however Gessard did not propose such a binary combination (see Rule 14a(1)). Even if it were conceded that Micrococcus pyocyaneus is a binary combination proposed by Gessard, the name would have to be regarded as not validly published because it was merely proposed in anticipation of the future acceptance of the taxon concerned (Rule 12c(2)).

Authors who subsequently used the names Micrococcus pyocyaneus and Bacillus pyocyaneus did not validate the publication of these names because they used the names incidentally, attributing them to Gessard, and did not indicate that they were proposing the names as new (see Rule 12c(3)). Apparently the only scientific name for the blue-pus organism that was validly published using the specific epithet pyocyaneus is Pseudomonas pyocyanea Migula (1895, 29). Later Migula (1900, 884), having discovered the earlier synonym Bacterium aeruginosum Schroeter, and recognizing the priority of the specific epithet aeruginosus (although rules specifically applicable to the nomenclature of bacteria were not formulated until 1947, the early microbiologists who studied bacteria theoretically followed the existing botanical rules of nomenclature), proposed Pseudomonas aeruginosa (Schroeter) Migula to replace P. pyocyanea. Pseudomonas aeruginosa (Schroeter) Migula was validly published and is legitimate (Buchanan et al. 1966, 854).

Pseudomonas aeruginosa is known by many vernacular names which, when translated into English, mean "blue-pus organism," "green-pus organism," "bacillus of blue pus," "bacillus of green pus," "bacillus of blue-green pus," "pyocyanine bacillus," and the like. Vernacular names are not governed by international rules of nomenclature, and have no influence on the correctness, usage or acceptance of scientific names.

In order to determine which of the two specific epithets, aeruginosus¹ or pyocyaneus¹, actually enjoys the greater usage by the world's microbiologists in the scientific name of the blue-pus organism, a large segment of the pertinent

¹ Or the feminine or neuter form of the adjective.

scientific literature was examined, with particular emphasis on the medical literature. Included were texts (the bacteriological holdings of the National Library of Medicine, Bethesda, Maryland, U.S.A., were systematically scrutinized), as well as periodicals and culture-collection catalogues. The results are summarized as follows (specific references will be supplied upon request to the authors: space limitations precluded the inclusion of the references in this paper):

Use of aeruginosus¹ by authors of various nationalities in TEXTBOOKS AND MONOGRAPHS: American (30), Argentinian (2), Brazilian (3), Bulgarian (2), Cuban (1), Czechoslovakian (4), Danish (1), Dutch (1), Egyptian (1), English (5), Finnish (1), French (10), German (10), Hungarian (1), Indian (1), Italian (3), Japanese (5), Mexican (2), Norwegian (1), Polish (1), Romanian (1), Scottish (2), Spanish (3), and Yugoslavian (3), total 94; in PUBLISHED PAPERS (since 1960): American (55), Argentinian (1), Australian (3), Belgian (2), Canadian (9), Dutch (6), English (7), French (5), German (10), Hungarian (2), Israeli (1), Italian (3), Japanese (2), Greek (1), New Zealander (3), Swiss (2), Turkish (1), and Uruguayan (1), total 114; and in CULTURE-COLLECTION CATALOGUES: American, Argentinian, Australian, Canadian, Czechoslovakian, English, Japanese, New Zealander, and Scottish.

Use of pyocyaneus¹ by authors of various nationalities in TEXTBOOKS AND MONOGRAPHS: American (2), Austrian (1), Danish (1), English (9), French (1), German (5), Indian (1), Italian (1), Japanese (2), Polish (1), Russian (3), Scottish (1), and Turkish (1), total 29; in PUBLISHED PAPERS (since 1960): English (2), French (1), Hungarian (1), and Italian (1), total 5; and in CULTURE-COLLECTION CATALOGUES: Russian.

CONCLUSIONS: Pseudomonas aeruginosa (Schroeter) Migula is the correct scientific name for the type species of the genus Pseudomonas Migula. Some authors erroneously maintain that Gessard proposed scientific names (with pyocyaneus as the specific epithet) for this species; Gessard did not propose a new scientific name, but, in fact, recognized and used the scientific name proposed earlier by Schroeter. Irrespective of the vernacular names applied to this species, aeruginosus, not pyocyaneus, is the specific epithet which has been and continues to be used by a large majority of microbiologists of diverse nationalities. Furthermore, contrary to the statement by Wilson and Miles (1964, 636), who accept the priority of P. aeruginosa, but who maintain that

this name is less familiar to medical bacteriologists than P. pyocyanea, the evidence suggests that on a world-wide basis medical bacteriologists prefer the use of P. aeruginosa to P. pyocyanea.

Inasmuch as the name Pseudomonas aeruginosa has recently been challenged in favor of Pseudomonas pyocyanea, it is hereby requested, in the interests of stable nomenclature and popular usage, that the Judicial Commission issue an Opinion:

- 1) placing the specific epithet aeruginosa, in the binary combination Pseudomonas aeruginosa (Schroeter 1872) Migula 1900, in the list of Epitheta specifica conservanda, and
- 2) placing the specific epithet pyocyanea, in the binary combination Pseudomonas pyocyanea Migula 1895, in the list of Epitheta specifica rejicienda.

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