

THE TRIBE PROTEEEAE:  
ITS NOMENCLATURE AND TAXONOMY

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SUMMARY: The status of nomenclatural and taxonomic problems within the tribe Proteeeae was reviewed and proposals were made relative to the genera and species within the tribe. It was suggested that the proposals should be considered by the Judicial Commission of the Nomenclature Committee of the International Association of Microbiological Societies.

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The purpose of this paper is to present proposals concerning the nomenclature and taxonomy of the bacteria of the Proteus and Providence groups and to request consideration of the proposals by the Judicial Commission of the Nomenclature Committee of the International Association of Microbiological Societies.

In an earlier communication (1958) the writer reviewed this subject and expressed the view that the bacteria of the Providence group should not be incorporated into the genus Proteus as it was constituted by Rustigian and Stuart (1945) and in Bergey's Manual (6th ed., 1948; 7th ed., 1957). Although members of the Providence group resemble Proteus morganii and Proteus rettgeri in several respects, they differ markedly from Proteus vulgaris and Proteus mirabilis in fundamental characteristics such as failure to liquefy gelatin and failure to produce abundant amounts of hydrogen sulfide. Therefore, the author does not agree with the incorporation of the Providence group into the genus Proteus as Proteus inconstans as proposed by Shaw and Clarke (1955) and as was done in the 7th edition of Bergey's Manual (1957).

Numerous investigators (e.g. Stuart et al., 1943; 1946; Buttiaux et al., 1954; Ewing et al., 1954; Shaw and Clarke, 1955) have pointed out the resemblance and relationship of

the Providence group to P. morganii and P. rettgeri, hence, there can be little doubt but that they should be placed in the same principal division or tribe, as suggested by Ewing (1958). However, if the classification of the genus Proteus given by Rustigian and Stuart (1945) is retained, it is the writer's opinion that the Providence group should be maintained as a separate entity within that principal division or tribe. In this event the proper generic term for the Providence group would be Providencia, characterized and named by Kauffmann and Edwards (1952).

In his classification of Enterobacteriaceae published in 1953, Kauffmann divided Proteus into three genera: Proteus (including P. vulgaris and P. mirabilis), Morganella (M. morganii), and Rettgerella (R. rettgeri). The Providence group was maintained as a separate entity, Providencia, in that system (Kauffmann, 1953). Proom (1955) pointed out that the Providence group bacteria formed a nutritionally homogeneous group, which differed from P. rettgeri on one hand and from the remaining species of Proteus on the other. Proom also pointed out that if the generic definition of Proteus were widened to include Providence, and rettgeri (sic), the definition would become too vague to be useful and suggested that as an alternative, a new genus might be established to include Providence and rettgeri (sic). Ewing (1958) did not agree with either of the above-mentioned proposals and suggested a compromise schema, in which the gelatin positive, hydrogen sulfide positive species were retained in the genus Proteus, while the gelatin negative, hydrogen sulfide negative species were placed in a genus Morganella. Providence group cultures were included in Morganella as Morganella inconstans. This schema was not particularly advocated or recommended; it was merely presented for consideration as an alternative. Mention should be made of the proposals of several investigators (e.g., Kauffmann and Edwards, 1952; Buttiaux et al, 1954), which included both P. vulgaris and P. mirabilis in a single species called Proteus hauseri. However, it is the opinion of the author that adequate differences exist in the biochemical reactions given by strains of P. vulgaris and P. mirabilis to warrant their status as separate species (v. Ewing, Suassuna and Suassuna, 1960, for references and biochemical reactions).

None of the proposals mentioned in the foregoing paragraph has found wide acceptance or usage. On the contrary,

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the classification of the genus Proteus given by Rustigian and Stuart (1945) has found wide acceptance and usage (as in Bergey's Manual, 6th ed., 1948). Further, the validity of the epithet inconstans as employed in connection with Providence group bacteria now may be questioned and the status of the generic term Morganella Fulton should be reviewed. The specific epithet inconstans is questioned because the ad hoc Commission on Neotype Cultures of the International Enterobacteriaceae Subcommittee found that the available culture of Bacillus inconstans Ornstein was not a member of the Providence group and hence was unacceptable as the neotype strain (Dr. S. T. Cowan, personal communication, 1958). A culture of the same number (NCTC 2481) was examined by the writer at an earlier date (1954) and was reported as a member of the Providence group, although it belonged to a rare biotype and was atypical (sucrose, adonitol, and inositol were not fermented and growth on Simmons' citrate medium was delayed six days). According to information that accompanied it, the strain (NCTC 2481) was not an original Ornstein culture, but one identified as B. inconstans Ornstein by other investigators (Dr. S. T. Cowan, personal communication, 1954; Shaw and Clarke, 1955). Since original cultures of B. inconstans Ornstein are unavailable and since the culture so designated by other investigators is unacceptable as a neotype culture of the species, it is apparent that the epithet inconstans is invalid and should be rejected. The term Morganella was proposed by Fulton (1943) for a genus in which bacteria formerly known as Bacterium morganii (syn. Salmonella morganii) and as Bacterium columbense (Castellani) were included. Bacterium morganii previously was assigned to the genus Proteus by Rauss (1936) and by Rustigian and Stuart (1941, 1943). Further, a culture of B. columbense Castellani examined in 1950 by the writer at the late Prof. R. S. Breed's request was identified as Escherichia coli (06:H1). However it appeared that the term Morganella was valid under the rules of nomenclature and available, if needed, for use in connection with a subdivided genus Proteus (as proposed by Kauffmann, 1953; or by Ewing, 1958), since the valid species P. morganii was included in it as Morganella morganii. The species Morganella columbensis Fulton would be excluded from the genus if it were adopted in the sense proposed by Kauffmann (1953) or by Ewing (1958).

Other specific epithets that have been proposed for use in connection with Providence group bacteria are Providencia alcalifaciens (v. inf.), Providencia providenciae Kauffmann and Edwards (1952), and Proteus stuartii Buttiaux et al., (1954). The latter investigators stated in effect that the only difference between members of the Providence group and cultures of P. rettgeri was the absence of urease in the former and proposed the name Proteus stuartii for the Providence group microorganisms while retaining P. rettgeri in the genus Proteus. The absence of a urease system is not the only difference between cultures of P. rettgeri and members of the Providence group, as will be apparent when more complete biochemical reactions of large numbers of strains of each are compared (v. Ewing, Tanner, and Dennard, 1954; the tabular data summarized by Ewing, Suassuna, and Suassuna, 1960; Kauffmann, 1956; and the work of Proom, 1955, cited above). However, the epithet stuartii employed by Buttiaux et al., (1954) is available, if needed for use in a different combination in connection with the Providence group bacteria i.e. Providencia stuartii comb. nov. On the contrary, the specific epithet providenciae in Providencia providenciae Kauffmann and Edwards is regarded as invalid, since the species was not defined or characterized. Recently, Suassuna and Suassuna (1960) reexamined a culture (ATCC 9886) of Eberthella alcalifaciens, originally isolated, described, and named by De Salles Gomes (1944, quoted by Suassuna and Suassuna, 1960), and found it to be a typical member of the Providence group. Since an authentic culture of this species was available and since the description of the species and the name were validly published, the epithet alcalifaciens clearly had priority as a specific name for the type species of the genus Providencia. Therefore, the name of the type species should be Providencia alcalifaciens (De Salles Gomes, 1944) Ewing comb. nov.

Formerly, the Providence group was divided into two biogroups, each of which contained numerous biotypes (Ewing, Tanner, and Dennard, 1954). More recently, the author has employed the terms subgroup A and subgroup B for biogroups 1 and 2, respectively, since this terminology is analogous to that employed in other groups, e.g. the Aerobacter and Shigella groups (v. Ewing and Edwards, 1960). The two subgroups were established on the basis of the reactions given by 669 cultures of Providence group bacteria

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(Ewing, Tanner and Dennard, 1954; Ewing and Davis, unpublished data). Subgroups A and B are further subdivided into biogroups, as indicated in Table 1. From these data it may be seen that 84% of the cultures could be placed in subgroup A and 16% belonged to subgroup B. About 91% of the subgroup A strains were aerogenic while 9% were not. Only four cultures (0.7%) within subgroup A fermented inositol as well as adonitol and less than 5% of the aerogenic strains failed to produce acid from adonitol. About 6% of subgroup B cultures fermented both adonitol and inositol and only 6.5% of the total number failed to produce acid from either of these substrates.

Table 1. Subgroups within the Providence group.

Subgroup and Biogroups	No. of Cultures	Gas		Adonitol		Inositol		Per cent
		+	-	+	-	+	-	
Subgroup A	562							84
Biogroup 1	490	490	0	490	0	4	486	87
2	28	0	28	28	0	0	28	5
3	20	20	0	0	20	0	20	4
4	24	0	24	0	24	0	24	4
Subgroup B	107							16
Biogroup 5	101	0	101	0	101	101	0	94
6	6	0	6	6	0	6	0	6

Hence, with the exception of the 24 strains of biogroup 4 (Table 1), the division between subgroups A and B was clear. Therefore, two species may be erected within the genus Providencia. These species would be Providencia alcalifaciens, corresponding to subgroup A, and Providencia stuartii corresponding to subgroup B.

The four species of Proteus included in the classification of Rustigian and Stuart (1945) all are named with legitimate specific epithets and these are well known and recognized. Since there is no basis for challenge known at present, the four specific epithets may be conserved.

This review of the status of the nomenclature of members of the Proteus and Providence groups led the writer to the conclusion that it would be better to propose a tribe Proteeae consisting of two genera, Proteus and Providencia than to recommend either consolidation of the two genera into one as proposed by Shaw and Clarke (1955) and as in the 7th edition of Bergey's Manual (1957), or subdivision into several genera as proposed by Kauffmann (1953) and others. The principal reasons for this conclusion are the fact that very little change would be necessary in the existing tribe Proteeae (Bergey's Manual, 1957), the fact that the majority of the epithets are already in use and are well known, and the fact that the nomenclature would be in conformity with taxonomic schemata accepted by many investigators, e.g., that proposed by Ewing and Edwards (1960), which has been accepted by the Subcommittee on Enterobacteriaceae of the American Society for Microbiology (v. Report, 1961). Further, it would be easier to change the nomenclature, should the need arise in future, than would be the case if more extensive revisions were adopted at this time. Nomenclature is not entirely static and changes may be necessary in the future as additional tests of taxonomic value are discovered and applied. However, the writer believes that the proposal for a tribe Proteeae with the two genera Proteus and Providencia adequately fills both nomenclatural and taxonomic needs for the present and probably for some time to come as well. The two genera proposed by Ewing (1958) also would fulfil the needs, but the author does not wish to press this point, principally because that proposal involves the use of new names and combinations of names that would be unfamiliar to many.

As a result of these considerations the following nomenclature and definitions for the tribe Proteeae and the two contained genera Proteus and Providencia are presented.

#### Family X Enterobacteriaceae Rahn

##### Tribe IV Proteeae Castellani and Chalmers

Motile bacteria that conform to the definition of the family Enterobacteriaceae. Phenylpyruvic acid is produced rapidly and abundantly from phenylalanine. Gas volumes produced from fermentable carbohydrates by aerogenic strains are

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relatively small (a bubble to about 15%). Urea is hydrolysed rapidly and abundantly by members of one genus. Lactose is not fermented.

Genus 1. Proteus Hauser

The genus Proteus is composed of motile bacteria that conform to the definition of the family Enterobacteriaceae. The bacteria decompose urea rapidly and actively deaminate phenylalanine to phenylpyruvic acid. Gas volumes produced from fermentable carbohydrates by aerogenic cultures are relatively small (a bubble to about 15%). Lactose is not fermented. Two species, Proteus vulgaris and Proteus mirabilis, produce hydrogen sulfide abundantly, liquefy gelatin, and swarm on moist agar media. Two other species, Proteus morganii and Proteus rettgeri do not possess these particular characteristics.

The type species is Proteus vulgaris Hauser.

Genus 2. Providencia Kauffmann and Edwards

The genus Providencia is composed of motile bacteria that conform to the definition of the family Enterobacteriaceae. Phenylalanine is rapidly deaminated. Gas volumes produced from fermentable carbohydrates by aerogenic cultures are relatively small (a bubble to about 15%). Hydrogen sulfide is not produced, the Voges-Proskauer test is negative, and urea is not hydrolysed. Lactose is not fermented.

The type species is Providencia alcalifaciens (De Salles Gomes) Ewing comb. nov.

Thus, the genera and species within the tribe Proteeae may be given as follows:

Tribe Proteeae Castellani and Chalmers

Genus 1. Proteus Hauser

Proteus vulgaris Hauser

Proteus mirabilis Hauser

Proteus morganii (Winslow et al.) Rauss

Proteus rettgeri (Hadley et al.) Rustigian  
and Stuart

Table 2. Characterization and differentiation of species of Proteus and Providencia.

Substrate or Test	<u>Proteus</u>				<u>Providencia</u>	
	<u>vulgaris</u>	<u>mirabilis</u>	<u>morganii</u>	<u>rettgeri</u>	<u>alcalifaciens</u>	<u>stuartii</u>
Indol	+	-	+	+	+	+
Voges-Proskauer 37°C	-	-	-	-	-	-
22°C	- or +	+ or -	-	-	-	-
Simmons' citrate	d	d	-	+	+	+
Hydrogen sulfide (TSI)	+	+	*,*	-	-	-
Urease	+	+	+	+	-	-
Gelatin 22°C	+	+	-	-	-	-
Lysine decarboxylase	-	-	-	-	-	-
Arginine dihydrolase	-	-	-	-	-	-
Ornithine decarboxylase	-	+	+	-	-	-
Gas from glucose	+	+	+	- or +	+	-
Mannitol	-	-	+	+	-	d
Adonitol	-	-	-	+	+	-
Inositol	-	-	-	+	-	+
Maltose	+	-	-	-	-	- or +
Salicin	d	(+) or -	-	d(45%+)	-	-
Esculin	+ or -	-	-	d(44%+)	-	-
Erythritol	-	-	-	d(79%+)	-	-
$\alpha$ -methyl-glucoside	+ or (+)	-	-	-	-	-

N.B. Gas volumes formed from glucose are relatively small (a bubble to about 15%).

\* A very slight reaction may be apparent after 2 or 3 days' incubation.

+ = positive in 1 or 2 days; - = negative, no reaction; d = different biochemical types;

- or + majority of strains negative, positive varieties occur.

+ or - majority of cultures positive, negative varieties occur.



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Genus 2. Providencia Kauffmann and Edwards

Providencia alcalifaciens (De Salles Gomes)

Ewing

Providencia stuartii (Buttiaux et al.) Ewing

The species of Proteus and Providencia are characterized by means of the biochemical reactions given in Table 2.

A neotype culture of Proteus vulgaris was proposed by the ad hoc Commission on Neotype Cultures of the International Subcommittee on Enterobacteriaceae (v. Report, 1958). Neotype strains of each of the other three species should be designated at an early date. The type culture of Providencia alcalifaciens is ATCC 9886. A neotype culture of Providencia stuartii also should be designated.

It is suggested that the proposal made herein should be considered by the Judicial Commission of the Nomenclature Committee of the International Association of Microbiological Societies and that any action necessary for its presentation, conservation, and acceptance should be taken.

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