

Description of *Deleya* gen. nov. Created to Accommodate the Marine Species *Alcaligenes aestus*, *A. pacificus*, *A. cupidus*, *A. venustus*, and *Pseudomonas marina*

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Recent investigations of the evolutionary relationships of marine species assigned to the genera *Alcaligenes* (*Alcaligenes aestus*, *Alcaligenes pacificus*, *Alcaligenes cupidus*, and *Alcaligenes venustus*) and *Pseudomonas* (*Pseudomonas marina*) are reviewed. Data obtained by a number of different methods indicate that these five species are part of a single evolutionary lineage distinct from their close relatives, the fluorescent pseudomonads, and unrelated to the type species of *Alcaligenes* (*Alcaligenes faecalis*). Consequently, all five species are transferred to a new genus, *Deleya*, with *Deleya aesta* designated as the type species. The phenotype properties of *D. aesta*, *Deleya pacifica*, *Deleya cupida*, *Deleya venusta*, and *Deleya marina* are presented, together with the distinguishing traits of these organisms.

In 1972 we published a taxonomic study of gram-negative, nonfermentative marine bacteria which were motile by flagella and had rigid cell walls (4). Among the species described were four organisms with peritrichous flagella and guanine-plus-cytosine (G+C) contents in their deoxyribonucleic acids (DNAs) of 52 to 68 mol%. By a process of elimination, these organisms were assigned to the genus *Alcaligenes*, which, at that time, was defined primarily by peritrichous flagellation and obligatory respiratory metabolism (4). We recognized that this was a temporary expedient since the defining characters of the genus *Alcaligenes* were so few that further study of these species, as well as other species of *Alcaligenes*, would be required to determine the validity of the assignment.

In the last 5 years, studies of evolutionary relationship by analysis of the highly conserved sequences of ribosomal ribonucleic acid (rRNA) have created major problems with respect to the utility and function of generic assignments. Ideally, a genus should reflect the evolutionary relationships of the constituent species and be characterized by simple, readily determinable traits. In practice, these two goals may not be readily attainable, as is well illustrated in the taxonomy of the genera *Pseudomonas* and *Alcaligenes*.

Palleroni et al. (16) were the first to systematically apply in vitro rRNA-DNA hybridization to studies of *Pseudomonas* taxonomy. The results of these authors delineated five major rRNA homology groups, some of which were more distantly related to each other than to *Escherichia coli*. The possibility of splitting *Pseudomonas*

into five different genera was considered but rejected since it was not possible to distinguish the rRNA homology groups by simple, readily determinable, universally positive or negative traits (16, 20). Furthermore, the major evolutionary lineages in procaryotes had not yet been established, so that practical considerations (such as ease of generic assignment of species) overruled the more attractive goal of a natural classification. As more information on procaryotic lineages has become available, primarily from the laboratories of C. R. Woese and J. De Ley and their collaborators, the practical solution has become less tenable (10-15, 19) since it is clearly more desirable to have genera that reflect evolutionary relationships. The latter alternative has recently been chosen by Swings et al. (22), who transferred *Pseudomonas maltophilia* into the genus *Xanthomonas*, thereby joining two members of rRNA homology group V of Palleroni et al. (16). The consequence of this transfer is that *Xanthomonas* and *Pseudomonas* cannot be distinguished by simple phenotypic traits. Instead, the new definition of *Xanthomonas* is based on the sequence similarities of rRNAs as reflected in heteroduplex stability. Hopefully, future research will provide less difficult means of identifying such genera, such as a simple method for detecting specific, characteristic sequences of informational molecules.

A situation similar to that in *Pseudomonas* exists with *Alcaligenes*, which has proven to be heterogeneous. Many of the species assigned to this genus by Davis et al. (9) resembled *Pseudomonas* in their general properties but differed by

TABLE 1. Phenotypic properties not universally present in *Deleya* species^a

Trait	<i>D. aesta</i>			<i>D. cupida</i>		
	Phenotype of species (<i>n</i> = 6) ^b	Phenotype of strain 134 ^T (= ATCC 27128 ^T)	Strain(s) which is positive or negative	Phenotype of species (<i>n</i> = 5)	Phenotype of strain 79 ^T (= ATCC 27124 ^T)	Strain(s) which is positive or negative
Flagellation ^c	Pr	Pr		Pr	Pr	
Motility	+ ^d	+		+ ^d	+	
Oxidase	+	+		-	-	
NO ₃ ⁻ → NO ₂ ⁻	(5)	+	(-) 138 ^e	(4)	+	(-) 83 ^e
Growth at:						
4°C	-	-		-	-	
40°C	+	+		3	-	(-) 79, 80
45°C	1	+	(+) 134	-	-	
Production of:						
Amylase	2	+	(+) 133, 134	-	-	
Alginase	-	-		-	-	
Utilization of:						
D-Ribose	-	-		(4)	+	(-) 83
D-Xylose	-	-		(4)	+	(-) 83
D-Arabinose	-	-		2	-	(+) 80, 81
L-Arabinose	-	-		+	+	
L-Rhamnose	-	-		2	-	(+) 80, 83
D-Mannose	-	-		+	+	
D-Galactose	3	+	(+) 134, 135, 138	+	+	
D-Fructose	+	+		+	+	
Sucrose	3	-	(+) 133, 136, 137	3	+	(-) 81, 82
Trehalose	3	-	(+) 133, 136, 137	3	+	(-) 81, 82
Maltose	3	-	(+) 133, 136, 137	3	+	(-) 81, 82
Cellobiose	-	-		3	+	(-) 81, 82
Mellibiose	-	-		2	+	(+) 79, 80
Lactose	-	-		2	+	(+) 79, 80
Salicin	-	-		3	+	(-) 81, 82
Gluconate	(5)	+	(-) 133	+	+	
Saccharate	-	-		+	+	
Glucuronate	-	-		+	+	
Galacturonate	-	-		+	+	
N-Acetylglucosamine	-	-		+	+	
Butyrate	+	+		+	+	
Isobutyrate	+	+		+	+	
Valerate	+	+		+	+	
Isovalerate	+	+		+	+	
Caproate	+	+		+	+	
Heptanoate	+	+		+	+	
Caprylate	+	+		+	+	
Pelargonate	1	-	(+) 137	+	+	
Caprate	3	-	(+) 133, 135, 136	+	+	
Malonate	1	-	(+) 135	3	+	(-) 81, 83

their peritrichous flagellation. A close relationship between several of these species and *Pseudomonas* rRNA homology groups II and III has since been established by studies of rRNA sequence similarity (10-15, 19, 22), regulation of key enzymes of aromatic amino acid biosynthesis (7, 23), and evolution of glutamine synthetase (3). The type species of *Alcaligenes* (*Alcaligenes*

faecalis) has been found to belong to a separate lineage closely related to the genus *Bordetella* (11, 13, 22). It is probable that rRNA homology groups II and III, along with their respective *Alcaligenes* species, will eventually become two new genera containing both polarly and peritrichously flagellated organisms.

The rRNA homology studies of De Ley and

TABLE 1—Continued

<i>D. pacifica</i>			<i>D. venusta</i>			<i>D. marina</i>		
Pheno- type of species (n = 6)	Phenotype of strain 62 ^T (= ATCC 27122 ¹)	Strain(s) which is positive or negative	Pheno- type of species (n = 14)	Phenotype of strain 86 ^T (= ATCC 27125 ¹)	Strain(s) which is positive or negative	Pheno- type of species (n = 7)	Phenotype of strain 219 ^T (= ATCC 25374 ¹)	Strain(s) which is positive or negative
Pr + ^d	Pr +		Pr + ^d	Pr +		P 5 ^d	—	(-) 141, 219 ^e
+	+		+	+		—	—	
—	—		+	+		—	—	
—	—		+	+		(6)	+	(-) 140
(5)	+	(-) 60 ^e	—	—		1	+	(+) 219
—	—		—	—		—	—	
—	—		—	—		1	—	(+) 143
—	—		—	—		+	+	
1	—	(+) 65	—	—		—	—	
—	—		—	—		—	—	
—	—		—	—		—	—	
—	—		—	—		—	—	
—	—		—	—		—	—	
—	—		—	—		+	+	
+	+		(11)	+	(-) 88 ^e	+	+	
—	—		9	+	(-) 88, 91, 92, 95, 97	—	—	
—	—		9	+	(-) 88, 91, 92, 95, 97	—	—	
—	—		9	+	(-) 88, 91, 92, 95, 97	—	—	
—	—		—	—		—	—	
—	—		—	—		—	—	
—	—		—	—		—	—	
—	—		—	—		—	—	
+	+		(13)	+	(-) 89	+	+	
—	—		—	—		—	—	
—	—		4	+	(+) 85-88	—	—	
—	—		5	+	(+) 84-88	—	—	
+	+		10	+	(-) 85, 93, 96, 97	—	—	
+	+		+	+		(6)	+	(-) 139
+	+		+	+		1	—	(+) 141
(5)	+	(-) 61	+	+		(6)	+	(+) 139
+	+		+	+		(6)	+	(+) 139
+	+		+	+		5	+	(-) 139, 140
+	+		9	+	(-) 93-97	+	+	
4	—	(-) 62, 65	(13)	+	(-) 97	6	+	(-) 142
(5)	—	(-) 62	(13)	—	(-) 86	+	+	
4	—	(-) 61, 62	+	+		+	+	
—	—		4	—	(+) 84, 85, 87, 97	5	+	(-) 139, 140

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collaborators (10, 11, 15, 22) have revealed further heterogeneity within *Alcaligenes* by showing that the marine *Alcaligenes* species, which are the subject of this paper, constitute a sublineage in an evolutionary branch that gave rise to *Pseudomonas* rRNA homology group I, which contains such well-studied species as *Pseudomonas aeruginosa*, *Pseudomonas pu-*

tida, *Pseudomonas fluorescens*, and *Pseudomonas stutzeri* (16). Our own findings, based on patterns of regulation of aspartokinase activities, are in agreement with a relationship between the marine species of *Alcaligenes* and the species in *Pseudomonas* rRNA homology group I (2, 8). Studies of carbohydrate catabolism have shown that marine species of *Alcaligenes* are

TABLE 1—Continued

Trait	<i>D. aesta</i>			<i>D. cupida</i>		
	Phenotype of species (<i>n</i> = 6) ^b	Phenotype of strain 134 ^f (= ATCC 27128 ¹)	Strain(s) which is positive or negative	Phenotype of species (<i>n</i> = 5)	Phenotype of strain 79 ^f (= ATCC 27124 ¹)	Strain(s) which is positive or negative
Glutarate	4	—	(-) 133, 134	2	—	(+) 82, 83
Adipate	(5)	+	(-) 133	—	—	
Pimelate	+	+		—	—	
Suberate	+	+		—	—	
Azelate	+	+		—	—	
Sebacate	+	+		—	—	
DL-Malate	+	+		+	+	
D(-)-Tartrate	—	—		1	—	(+) 80
L(+)-Tartrate	4	+	(-) 135, 136	3	—	(-) 79, 83
meso-Tartrate	2	—	(+) 137, 138	(4)	+	(-) 83
Glycolate	—	—		+	+	
DL-Glycerate	+	+		+	+	
Citrate	3	—	(+) 135, 136, 138	+	+	
α-Ketoglutarate	4	—	(-) 133, 134	+	+	
Aconitate	—	—		+	+	
Laevulinat	3	+	(+) 133-135	—	—	
Citraconate	1	—	(+) 135	—	—	
Itaconate	1	—	(+) 138	—	—	
Mesaconate	1	—	(+) 138	—	—	
Erythritol	4	+	(-) 135, 137	2	+	(+) 79, 80
Mannitol	+	+		+	+	
Sorbitol	+	+		(4)	+	(-) 82
meso-Inositol	2	+	(+) 133, 134	3	+	(-) 81, 83
Adonitol	—	—		3	+	(-) 82, 83
Ethyleneglycol	—	—		2	—	(+) 80, 82
Propyleneglycol	—	—		—	—	
2,3-Butyleneglycol	3	—	(+) 133, 137, 138	—	—	
Ethanol	+	+		(4)	+	(-) 83
n-Propanol	+	+		(4)	+	(-) 83
n-Butanol	+	+		3	—	(-) 79, 83
Isobutanol	(5)	+	(-) 135	(4)	+	(-) 83
L-Mandelate	—	—		1	—	(+) 83
Benzoylformate	—	—		2	+	(+) 79, 83
Benzoate	—	—		+	+	
o-Hydroxybenzoate	—	—		1	—	(+) 83
m-Hydroxybenzoate	—	—		1	—	(+) 83
p-Hydroxybenzoate	—	—		+	+	

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distinctive in that they utilize D-fructose via a D-fructose:phosphotransferase system and 1-phosphofructokinase, followed by the conversion of the resulting fructose 1,6-diphosphate to fructose 6-phosphate by means of a pyrophosphate-dependent 6-phosphofructokinase, with subsequent catabolism proceeding via the Entner-Doudoroff pathway (17). This combination of enzyme activities, together with a lack of fruc-

tose-1,6-diphosphate phosphatase, has been found in *Pseudomonas marina* but in no other marine or terrestrial *Pseudomonas* or *Alteromonas* species tested (5, 17, 18). The close relationship between *P. marina*, a polarly flagellated species, and the marine *Alcaligenes* species, as well as the more distant relationship of these organisms to *Pseudomonas* rRNA homology group I, has been confirmed by evolutionary

TABLE 1—Continued

<i>D. pacifica</i>			<i>D. venusta</i>			<i>D. marina</i>		
Phenotype of species (<i>n</i> = 6)	Phenotype of strain 62 ^T (= ATCC 27122 ^T)	Strain(s) which is positive or negative	Phenotype of species (<i>n</i> = 14)	Phenotype of strain 86 ^T (= ATCC 27125 ^T)	Strain(s) which is positive or negative	Phenotype of species (<i>n</i> = 7)	Phenotype of strain 219 ^T (= ATCC 25374 ^T)	Strain(s) which is positive or negative
+	+		+	+		-	-	
-	-		7	-	(+) 84, 85, 89, 90, 93-95	-	-	
-	-		1	-	(+) 85	-	-	
-	-		3	-	(+) 93, 94, 95	-	-	
-	-		1	-	(+) 85	-	-	
(5)	-	(-) 62	+	+		+	+	
-	-		-	-		-	-	
-	-		-	-		2	-	(+) 141, 142
-	-		-	-		-	-	
(5)	+	(-) 65	9	-	(-) 84-88	+	+	
+	+		+	+		+	+	
+	+		+	+		+	+	
(5)	+	(-) 61	(13)	+	(-) 88	+	+	
1	-	(+) 63	-	-		-	-	
-	-		-	-		-	-	
-	-		1	-	(+) 91	-	-	
-	-		-	-		-	-	
-	-		1	-	(+) 88	-	-	
-	-		(12)	+	(-) 88, 97	+	+	
-	-		(12)	+	(-) 88, 97	-	-	
-	-		+	+		5	+	(-) 139, 141
1	-	(+) 65	-	-		-	-	
-	-		-	-		-	-	
-	-		5	+	(+) 84-88	-	-	
1	+	(+) 62	8	+	(-) 92-97	3	-	(+) 141, 143, 144
-	-		+	+		5	+	(-) 141, 142
-	-		+	+		5	-	(-) 141, 142
-	-		+	+		1	+	(+) 219
-	-		+	+		-	-	
-	-		4	+	(+) 86-88, 92	-	-	
-	-		4	+	(+) 86-88, 92	-	-	
+	+		5	+	(+) 86-88, 92, 97	-	-	
-	-		4	+	(+) 86-88, 92	-	-	
2	-	(+) 60, 61	1	+	(+) 86	-	-	
3	+	(+) 60-62	5	+	(+) 86-88, 92, 95	-	-	

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studies of glutamine synthetase and iron-containing superoxide dismutase (E. F. DeLong, L. Baumann, R. D. Bowditch, and P. Baumann, Arch. Microbiol., in press). Since the work of J. De Ley has provided the primary evidence of a distinct lineage for the marine species of *Alcaligenes* (10, 11, 15, 22), we propose to place all of

these species, as well as *P. marina*, into a new genus designated *Deleya*.

MATERIALS AND METHODS

We have previously described the methods of isolation and the sources of the strains used in this study, as

TABLE 1—Continued

Trait	<i>D. aesta</i>			<i>D. cupida</i>		
	Phenotype of species (<i>n</i> = 6) ^b	Phenotype of strain 134 ^T (= ATCC 27128 ^T)	Strain(s) which is positive or negative	Phenotype of species (<i>n</i> = 5)	Phenotype of strain 79 ^T (= ATCC 27124 ^T)	Strain(s) which is positive or negative
Phenylacetate	2	—	(+) 135, 138	—	—	
Quinate	—	—		2	—	(+) 80, 81
Glycine	—	—		3	—	(-) 79, 81
β-Alanine	1	—	(+) 138	(4)	+	(-) 83
L-Serine	—	—		+	+	
L-Threonine	—	—		1	—	(+) 83
L-Leucine	3	+	(+) 134, 136, 137	(4)	+	(-) 83
L-Isoleucine	+	+		2	—	(+) 80, 81
L-Valine	2	—	(+) 136, 138	—	—	
L-Aspartate	(5)	—	(-) 134	+	+	
L-Lysine	+	+		+	+	
L-Arginine	+	+		+	+	
L-Ornithine	4	—	(-) 133, 134	3	+	(-) 81, 83
δ-Aminovalerate	—	—		(4)	—	(-) 79
L-Histidine	—	—		(4)	+	(-) 81
L-Tyrosine	—	—		+	+	
L-Phenylalanine	—	—		2	—	(+) 82, 83
L-Tryptophan	—	—		—	—	
DL-Kynurenine	—	—		—	—	
Kynurenate	—	—		2	—	(+) 80, 83
Anthranilate	—	—		1	—	(+) 83
Ethanolamine	—	—		—	—	
Benzylamine	—	—		—	—	
Putrescine	—	—		+	+	
Spermine	—	—		2	+	(+) 79, 82
Histamine	—	—		3	—	(-) 79, 82
Butylamine	—	—		—	—	
Pentylamine	—	—		2	—	(+) 81, 82
Betaine	—	—		+	+	
Sarcosine	—	—		+	+	
Creatine	1	—	(+) 135	1	—	(+) 82
Hippurate	—	—		(4)	+	(-) 82
Acetamide	—	—		—	—	
Nicotinate	—	—		—	—	
Nicotinamide	—	—		—	—	
Trigonelline	—	—		—	—	
Allantoin	—	—		+	+	
Adenine	—	—		—	—	
Cytosine	1	+	(+) 134	—	—	
Uracil	1	+	(+) 134	—	—	

^a The following strains were studied: *D. aesta* strains 133 through 138; *D. cupida* strains 79 through 83; *D. pacifica* strains 60 through 65; *D. venusta* strains 84 through 97; and *D. marina* strains 139 through 144 and 219.

^b Number of strains studied.

^c Pr, Peritrichous; P, polar.

^d +, All strains positive; —, all strains negative. The numbers indicate the numbers of positive strains; parentheses indicate that 80% or more of the strains are positive.

^e (—), Strain(s) indicated is negative; (+), strain(s) indicated is positive.

TABLE 1—Continued

<i>D. pacifica</i>			<i>D. venusta</i>			<i>D. marina</i>		
Phenotype of species (n = 6)	Phenotype of strain 62 ^T (= ATCC 27122 ^T)	Strain(s) which is positive or negative	Phenotype of species (n = 14)	Phenotype of strain 86 ^T (= ATCC 27125 ^T)	Strain(s) which is positive or negative	Phenotype of species (n = 7)	Phenotype of strain 219 ^T (= ATCC 25374 ^T)	Strain(s) which is positive or negative
+	+		+	+		-	-	
-	-		4	+	(+) 86-88, 92	-	-	
+	+		-	-		-	-	
4	-	(-) 61, 62	8	+	(-) 89-94	+	+	
+	+		2	-	(+) 96, 97	+	+	
-	-		-	-		-	-	
(5)	+	(-) 63	(13)	+	(-) 97	(6)	+	(-) 139
-	-		7	+	(+) 84-88, 91, 96	4	-	(-) 139, 140, 219
-	-		(11)	+	(-) 95-97	-	-	
+	+		+	+		+	+	
+	+		+	+		2	-	(+) 141, 142
+	+		(12)	+	(-) 95, 97	5	+	(-) 139, 140
+	+		9	+	(-) 89, 92-95	5	+	(-) 139, 140
+	+		+	+		-	-	
+	+		(12)	+	(-) 96, 97	-	-	
+	+		+	+		+	+	
+	+		(13)	+	(-) 97	1	+	(+) 219
-	-		6	+	(+) 84, 86, 87, 89, 90, 92	-	-	
+	+		-	-		-	-	
+	+		-	-		-	-	
+	+		10	+	(-) 84, 85, 93, 95	-	-	
-	-		(13)	+	(-) 97	-	-	
(5)	+	(-) 65	-	-		-	-	
+	+		+	+		-	-	
+	+		-	-		-	-	
+	+		1	-	(+) 97	-	-	
+	+		8	-	(-) 84-86, 88, 93, 94	-	-	
1	-	(+) 65	-	-		-	-	
+	+		+	+		5	+	(-) 139, 142
+	+		+	+		(6)	+	(-) 140
-	-		-	-		-	-	
4	+	(-) 60, 61	5	+	(+) 86-88, 92, 97	-	-	
-	-		3	+	(+) 86, 87, 96	-	-	
2	+	(+) 61, 62	+	+		-	-	
-	-		6	-	(+) 84, 95, 92-94, 96	-	-	
1	-	(+) 63	-	-		-	-	
(5)	-	(-) 62	+	+		-	-	
3	-	(+) 63-65	-	-		-	-	
-	-		-	-		-	-	
-	-		-	-		-	-	

well as the details of the methodology used for phenotypic characterization (4, 6).

RESULTS

The following phenotypic properties were present in all strains: straight rods; accumulation of

poly-β-hydroxybutyrate as an intracellular reserve product; growth at 20 to 35°C; and utilization of D-glucose, acetate, propionate, succinate, fumarate, DL-β-hydroxybutyrate, DL-lactate, pyruvate, glycerol, L-α-alanine, D-α-alanine, L-glutamate, and L-proline.

TABLE 2. Some distinguishing properties of the species of *Deleya*

Species	No. of strains	Flagellation ^a	Oxidase	Growth at 4°C	Utilization of:					
					D-Ribose	L-Arabinose	D-Mannose	Saccharate	Suberate	Glycolate
<i>D. aesta</i>	6	Pr	+ ^b	—	—	—	—	—	+	—
<i>D. cupida</i>	5	Pr	—	—	(4)	+	+	+	—	+
<i>D. pacifica</i>	6	Pr	+	—	—	—	—	—	—	—
<i>D. venusta</i>	14	Pr	+	+	—	—	—	—	—	—
<i>D. marina</i>	7	P	—	(6)	+	—	—	—	—	—

^a Pr, Peritrichous; P, polar.

^b +, All strains positive; —, all strains negative. The numbers in parentheses indicate the numbers of positive strains which represent over 80% of the strains.

The following phenotypic properties were absent from all strains: denitrification; ability to fix molecular nitrogen; growth with CO₂ as the carbon source and H₂ as the energy source; arginine dihydrolase; production of extracellular lipase, gelatinase, and chitinase; utilization of D-fucose, cellulose, inulin, mucate, formate, oxalate, maleate, methanol, isopropanol, D-mandelate, phenylethanol, phenol, naphthalene, L-norleucine, L-citrulline, D-tryptophan, DL-γ-aminobutyrate, DL-δ-aminovalerate, *m*-aminobenzoate, *p*-aminobenzoate, methylamine, tryptamine, 2-amylamine, pantothenate, guanine, thymine, and *n*-hexadecane.

The phenotypic properties which were not universally present or absent in the strains are presented in Table 1. The traits which distinguish species of *Deleya* are presented in Table 2.

DISCUSSION

Below are descriptions of the genus *Deleya* (De.ley'a. M. L. fem. n. *Deleya* named for Jozef De Ley, a Belgian microbiologist) and the species which constitute this genus.

Description of *Deleya* gen. nov. Straight rods 0.8 to 1.1 μm wide and 1.5 to 3.0 μm long. Accumulate poly-β-hydroxybutyrate as an intracellular reserve product. Involution forms are usually present in old cultures or under adverse conditions of cultivation. Do not form endospores or microcysts. Most species are motile by 4 to 12 peritrichous flagella; one species is motile by 2 to 5 polar flagella. Strict aerobes; molecular oxygen is a universal electron acceptor. Do not denitrify or fix molecular nitrogen. All species are chemoorganotrophs that are able to grow on a mineral medium containing a seawater base, D-glucose, and NH₄Cl. Na⁺ is an absolute requirement for all species; the minimal concentration necessary for optimal growth ranges from 75 to 200 mM. All species utilize D-glucose, acetate, succinate, DL-β-hydroxybutyrate, lactate, glycerol, and L-α-alanine. All species grow at 35°C. No species has an extracellular lipase, gelatinase, or chitinase. No species is able to utilize

H₂ as the sole source of energy and CO₂ as the sole source of carbon. All species lack an arginine dihydrolase system. Found in marine habitats. The G+C contents of the DNAs range from 52 to 68 mol%, as determined by buoyant density. The type species is *Deleya aesta*.

Further descriptive information. Light and electron micrographs showing the general cell morphology and flagellation of representative strains of species of *Deleya* have been published previously (4, 6). There may be difficulty in determining the type of flagellar arrangement in *Deleya marina* since this species has multitrichous flagella which tend to bend backward toward the cell, giving arrangements which may be interpreted as lateral or peritrichous flagellation. References 4 and 6 should be consulted for a discussion of this problem.

The appearance of the colonies of species of *Deleya* is not distinctive. All are cream colored and convex with entire edges.

Species of *Deleya* are able to utilize 47 to 85 different organic compounds as sole sources of carbon and energy. These include pentoses, hexoses, disaccharides, sugar acids, sugar alcohols, fatty acids, dicarboxylic acids, tricarboxylic acid cycle intermediates, amines, and a number of simple aromatic compounds (see above; Table 1). Aromatic compounds are utilized via the β-ketoadipate pathway, which involves the *o* cleavage of diphenolic compounds (4, 21). D-Glucose and D-fructose are utilized via the Entner-Doudoroff pathway (1, 17). In the case of the latter sugar, the initial reactions appear to involve the conversion of D-fructose to fructose 1-phosphate via a D-fructose:phosphotransferase system, 1-phosphofructokinase, and a pyrophosphate-dependent 6-phosphofructokinase (17).

Species of the genus *Deleya*. The physiological and nutritional characteristics of the species, as well as their type strains, are presented above and in Table 1. Selected properties which distinguish among the species are presented in Table 2. Below are the new species combinations.

TABLE 2—Continued

Utilization of:										
Aconitate	Mannitol	δ -Aminovalerate	L-Histidine	L-Tyrosine	DL-Kynurenine	Ethanolamine	Benzylamine	Putrescine	Sarcosine	Allantoin
—	+	—	—	—	—	—	—	—	—	—
+	+	(4)	(4)	+	—	—	—	+	—	+
(5)	—	+	+	+	+	—	(5)	+	+	(5)
(13)	(12)	+	(12)	+	—	(13)	—	+	+	+
+	+	—	—	+	—	—	—	—	(6)	—

Deleya aesta comb. nov. (basonym, *Alcaligenes aestus*). Motile by means of peritrichous flagella. Utilizes 47 to 53 organic compounds, including hexoses and disaccharides but not pentoses. Only species of *Deleya* that is able to utilize suberate. The G+C content of the DNA is 57 to 58 mol%, as determined by buoyant density. The type strain is strain 134 (= ATCC 27128).

Deleya pacifica comb. nov. (basonym, *Alcaligenes pacificus*). Motile by means of peritrichous flagella. Utilizes 55 to 60 organic compounds, including D-glucose and D-fructose but no other hexose or disaccharide. Only species of *Deleya* that is able to utilize DL-kynurenine. The G+C content of the DNA is 67 to 68 mol%, as determined by buoyant density. The type strain is strain 62 (= ATCC 27122).

Deleya cupida comb. nov. (basonym, *Alcaligenes cupidus*). Motile by means of peritrichous flagella. Utilizes 69 to 85 organic compounds, including pentoses, hexoses, and disaccharides. Only species of *Deleya* that is able to utilize L-arabinose, D-mannose, saccharate, and glycolate. The G+C content of the DNA is 60 to 63 mol%, as determined by buoyant density. The type strain is strain 79 (= ATCC 27124).

Deleya venusta comb. nov. (basonym, *Alcaligenes venustus*). Motile by means of peritrichous flagella. Utilizes 52 to 76 organic compounds, including D-glucose, D-fructose, and disaccharides but no additional hexoses or any pentoses. Able to grow at 4°C. The G+C content of the DNA is 52 to 55 mol%. The type strain is strain 86 (= ATCC 27125).

Deleya marina comb. nov. (basonym, *Pseudomonas marina*). Motile by means of two to five flagella which are present at one pole of the cell. Utilizes 35 to 47 organic compounds, including D-ribose, D-glucose, D-galactose, and D-fructose but no other pentose, hexose, or disaccharide. Able to grow at 4°C. The G+C content of the DNA is 62 to 64 mol%. The type strain is strain 219 (= ATCC 25374).

Differentiation from phenotypically similar genera. Species of *Deleya* are found in marine environments and, therefore, need to be distinguished from the described marine species of

Pseudomonas and *Alteromonas* (4, 6; P. Baumann, M. Gauthier, and L. Baumann, in *Bergey's Manual of Systematic Bacteriology*, 9th ed., in press). The presence of peritrichous flagella differentiates most of the species of *Deleya* from these polarly flagellated genera. All species of *Deleya*, including the polarly flagellated organism *D. marina*, differ from the two described marine species of *Pseudomonas*, *Pseudomonas doudoroffii* and *Pseudomonas nautica*, by their ability to utilize D-glucose, D-gluconate, and glycerol, properties absent in the latter two species. All species of *Deleya* accumulate poly- β -hydroxybutyrate, a trait absent in *Alteromonas*. Species of *Deleya* do not produce an extracellular gelatinase or lipase; this distinguishes them from all *Alteromonas* species except *Alteromonas communis* and *Alteromonas vaga*, two species which are sufficiently different from the other *Alteromonas* species to warrant removal from this genus (12). Species of *Deleya* can be readily distinguished from terrestrial *Pseudomonas* and *Alcaligenes* species by their requirement for at least 75 mM NaCl for optimal growth rate and yield.

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