Proposal That the Species *Vibrio anguillarum* Bergman 1909, *Vibrio piscium* David 1927, and *Vibrio ichthyodermis* (Wells and ZoBell) Shewan, Hobbs, and Hodgkiss 1960 Be Combined as a Single Species, *Vibrio anguillarum*

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The characteristics of seven strains identified as *Vibrio anguillarum*, *Vibrio piscium* var. *japonicus*, or *Vibrio ichthyodermis* are compared with those in the original descriptions of these taxa. A proposal is made to combine all strains as a single species, *Vibrio anguillarum* Bergman.

The implication of vibrios as the causal organisms of diseased conditions in fish was first recognized by Bergman (4), who isolated from eels an organism which resembled the cholera vibrio and which he called *Vibrio anguillarum*. David (5) isolated an organism from carp and named it *Vibrio piscium*, using the argument that, as it was from freshwater fish, it was a different species from *V. anguillarum*. Subsequently, Wells and ZoBell (14) isolated a polarly flagellated rod from diseased marine fish, proposing the name *Achromobacter ichthyodermis*, a correct taxonomic assignment at that time. No reference was made by Wells and ZoBell to the work of either Bergman or David. ZoBell and Upham (15) proposed that *A. ichthyodermis* should be included in the genus *Pseudomonas*.

In 1950, Hodgkiss and Shewan (6) isolated an organism from a diseased plaice which, on comparison with the information in the 6th edition of *Bergey's Manual of Determinative Bacteriology*, they concluded was *Pseudomonas ichthyodermis*. Later Shewan, Hobbs, and Hodgkiss (11) suggested that the organism belonged in the genus *Vibrio*.

Other fish-pathogenic organisms belonging to the genus *Vibrio* have been isolated from cod by Bagge and Bagge (1), who concluded that their organism was a strain of *V. anguillarum*; from rainbow trout by Hoshina (7), who named

his organism *V. piscium* var. *japonicus*, as it was not identical to David's original description of *V. piscium*; and from finnock by Smith (12), who showed that her organisms were similar to Bagge and Bagge's strain of *V. anguillarum*. Furthermore, Smith (12) suggested that the Hoshina (7) strains were nearer to *V. anguillarum* than to *V. piscium*.

During a comprehensive study of vibrios and related organisms (2, 3) and the routine checking of cultures held in the National Collection of Marine Bacteria, it has become clear that the three species *V. anguillarum*, *V. piscium* var. *japonicus*, and *V. ichthyodermis* are phenotypically similar. No original isolates from Bergman (4), David (5), or Wells and ZoBell (14) are available, but cultures from Hodgkiss and Shewan (6), Bagge and Bagge (1), Hoshina (7), and Smith (12) have all been compared. The results are given in Table 1, along with information on *V. anguillarum* (4), *V. piscium* (5), and *A. ichthyodermis* (14).

Bergman and David's results are not identical with those obtained for the strains held in the NCMB, but as only a very limited amount of information can be gleaned from these papers and because the methods used for certain tests, e.g., carbohydrate breakdown, are not comparable to ours, their data are of limited value.

To our knowledge, no original strains exist for *V. anguillarum* Bergman 1909, *V. piscium* David 1927, or *A. ichthyodermis* Wells and

ZoBell 1934. Until a large number of strains can be examined and a suitable neotype selected, we suggest that the following strains are useful representatives of *V. anguillarum*: NCMB 6 = ATCC 19264 = Bagge and Bagge strain; NCMB 407 = strain PL 1 of Hodgkiss and Shewan; NCMB 571, a strain from Hoshina; and NCMB 828 = ATCC 14181 = strain 4063 from Smith.

We agree with the recommendation of Ross et al. (9) that *V. anguillarum* should be included in the 8th edition of *Bergey's Manual*.

***Vibrio anguillarum* Bergman 1909.** [Subjective synonyms: *Vibrio piscium* David 1927; *Achromobacter ichthyodermis* Wells and ZoBell 1934; *Pseudomonas ichthyodermis* (Wells and ZoBell) ZoBell and Upham 1944; *Vibrio piscium* var. *japonicus* Hoshina 1957]; *Vibrio ichthyodermis* (Wells and ZoBell) Shewan, Hobbs, and Hodgkiss 1960.]

anguillarum L. noun *anguilla* eel; gen. pl. *anguillarum* of eels.

Short rods, axis straight or curved, sides parallel, ends rounded, occurring singly and in pairs, pleomorphic, 0.5 to 0.7 by 1.0 to 2.0 μ m. Motile by means of polar flagella, usually monotrichous (Fig. 1), but lophotrichous forms may occur. Gram-negative.

Nutrient agar colonies: Off-white to buff, translucent or opaque, circular, convex, entire margin, smooth, shiny, 1.0 to 2.0 mm in diameter. Colony variation can occur within individual strains.

Horse blood agar: Abundant greyish growth, usually beta-hemolytic.

Nutrient broth: Good growth with off-white pellicle and uniform turbidity. Thickness of pellicle and density of turbidity varies from strain to strain.

Growth at temperatures from 5 to 30 C, generally no growth at 37 C (Bergman records growth at 38 C), optimum usually 20 to 25 C. Growth in nutrient broth without added NaCl and with up to 5% NaCl. Growth at pH 6 to 9; no growth at pH 5.

Insensitive to penicillin, but sensitive to streptomycin, chloramphenicol, aureomycin, terramycin, tetracycline, erythromycin, neomycin, novobiocin, polymyxin B, and the vibriostatic compound 0/129 (2:4-diamino-6:7-diisopropyl pteridine).

Indole produced.

Acetylmethylcarbinol usually produced; 2:3 butanediol usually positive (Bullock's method).

Methyl red test negative.

Fig. 1. *Vibrio anguillarum* strain NCMB 6. Twenty-four hours on sea water agar at 20 C. Negatively stained with phosphotungstic acid. $\times 20,000$.

Ammonia produced from peptone but not from urea.

Nitrites produced from nitrates.

Trimethylamine oxide reduced to trimethylamine.

Citrate not utilized as sole carbon source.

Gelatin, starch, and casein hydrolyzed.

Carbohydrate metabolism fermentative.

Acid but no gas produced from glucose, fructose, galactose, mannose, sucrose, maltose, trehalose, mannitol, sorbitol, dextrin, glycogen, and starch. Acid may or may not be produced in cellobiose, rhamnose, glycerol, inositol, and salicin. No acid from lactose, arabinose, xylose, ribose, sorbose, raffinose, or dulcitol.

Alkaline reaction in Møller's arginine medium, but no lysine or ornithine decarboxylases are produced.

Deoxyribonucleic acid base ratio: 44.5 ± 1.5 moles per cent guanine plus cytosine.

Habitat: Water, marine and fresh. Cause of ulcerous lesions in marine and freshwater fish.

TABLE 1. Comparison of *Vibrio anguillarum*, *Vibrio piscium* var. *japonicus*, and *Vibrio ichthyodermis* with originally published information on *V. anguillarum* Bergman 1909, *V. piscium* David 1927, and *Achromobacter ichthyodermis* Wells and ZoBell 1934

Test	<i>Vibrio anguillarum</i> (Bergman 1909)	<i>Vibrio anguillarum</i> (3 strains)	<i>Vibrio piscium</i> (David 1927)	<i>Vibrio piscium</i> var. <i>japonicus</i> (2 strains)	<i>Achromobacter</i> <i>ichthyodermis</i> (Wells and ZoBell 1934)	<i>Vibrio ichthyodermis</i> (2 strains)
Morphology	Short curved rods, 1.0–3.0 × 0.3–0.5 μm	Short rods, curved or straight, sides parallel, ends rounded, occur- ring singly and in pairs, pleomorphic	Curved or <i>f</i> -shaped rods	Short rods, straight or slightly curved, sides parallel, ends rounded, occurring singly and in pairs, pleomorphic	Rods 0.2–1.3 × 3.0– 5.0 μm occurring singly, in pairs, and short chains, encapsulated, pleomorphic	Short rods, straight or slightly curved, sides parallel, ends rounded, occurring singly and in pairs, pleomorphic
Gram stain	Negative	Negative	Negative	Negative	Negative	Negative
Motility		+	+	+	+	+
Flagella		One polar	One polar	One polar	Tuft polar	One polar
Colony	Dull greyish-yellow iri- descent by transmitted light	Off-white, translucent convex, circular, smooth, shiny, 2.0– 3.0 mm diameter		Off-white, opaque or translucent, circular, convex, 1.0–2.0 mm diameter	Glistening, convex, circular, 2.0–4.0 mm diameter	Off-white to buff, translucent or opaque, circular, convex, 1.0–2.0 mm diameter
Growth in liquid medium	Turbid, fine pellicle, crystalline precipitate	Good growth, thin pel- licle, slight turbidity, small deposit	Slight turbidity, thin pellicle	Good growth, thin pellicle, moderate turbidity, small deposit		Good growth, thin pel- licle, moderate or slight turbidity
Temperature range	5–38 C Optimum 25–35 C	5–30 C No growth at 37 C	Optimum between 8 and 20 C	5–30 C No growth at 37 C	4–30 C Optimum 20–25 C No growth at 37 C	5–30 C No growth at 37 C
Growth in broth with added NaCl		0.0–5.0%		0.0–5.0%		0.0–5.0%
Sensitivity to Penicillin		–		–		–
Novobiocin		+		+		+
Polymyxin B		+		+		+
0/129		+		+		+
Oxidase		+		+		+
Catalase		+		+		+
Indole production	+	+	+	+	+	+
Methyl Red		–		–		–
Voges-Proskauer		+		+		+

Ammonia from peptone		+		+	+	+
Nitrate reduction	+ To nitrite	+ To nitrite	—	+ To nitrite	+ To nitrite	+ To nitrite
H ₂ S production	—		+		—	
Trimethylamine oxide reduction		+		+		+
Citrate utilization		—		—		—
Hemolysis		β	—	β		β
Starch hydrolysis		+		+	+	+
Gelatin hydrolysis	+	+	+	+		+
Casein hydrolysis		+		+		+
Milk	Coagulated acid peptonized		Not coagulated by fresh isolates			
Glucose metabolism		Fermentative		Fermentative		Fermentative
“Sugar” media						
Glucose	—	Acid		Acid	Acid	Acid
Fructose		Acid		Acid		Acid
Galactose		Acid		Acid		Acid
Mannose		Acid		Acid		Acid
Lactose	—	—		—	—	—
Sucrose	—	Acid		Acid	Acid	Acid
Maltose	—	Acid		Acid		Acid
Arabinose		Variable	No comparable results	Weak acid		—
Xylose		—		—		—
Dulcitol		—		—		—
Glycerol		Acid (variable)		Acid	—	Acid
Inositol		—		—		—
Mannitol		Acid		Acid	Acid	Acid
Sorbitol		Acid		Acid		Acid
Salicin		—		—		—
Dextrin		Acid		Acid		Acid
Starch		Acid		Acid		Acid
Glycogen		Acid		Acid		Acid
Møller's (1955)						
Arginine reaction		Alkaline		Alkaline		Alkaline
Lysine reaction		—		—		—
Ornithine reaction		—		—		—
Moles % GC		44.5 (Sebald and Véron; 1 strain)				44.7 (Véron and Sebald; 1 strain)

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