Taxonomic Study of "Corynebacterium suis" Soltys and Spratling: Proposal of Eubacterium suis (nom. rev.) comb. nov.†

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The name "Corynebacterium suis" Soltys and Spratling 1957 was not included on the 1980 Approved Lists of Bacterial Names and has no current nomenclatural standing. This commonly occurring swine pathogen was studied to determine its taxonomic status. It is an anaerobic, gram-positive, catalase-negative, nonmotile, nonsporulating, short to medium-sized, rod-shaped organism that grows optimally at pH 7.0 to 8.0 and 37°C. Of 27 substrates tested, this bacterium fermented only maltose, glycogen, and starch. This organism is urease positive but is negative in other common biochemical tests. Growth in peptone-yeast extract-maltose medium is not enhanced by Tween 80, heme, or menadione and is inhibited by bile. Rhamnose and lysine are the major cell wall components, whereas mannose, glutamic acid, and alanine are the minor components in the cell wall of this organism. Acetate, ethanol, and formate are the major metabolic products of maltose fermentation. No detectable levels of propionate are produced. Major amounts of type b cytochrome and minor amounts of type c cytochrome appear to be present in cell extracts. It is susceptible to penicillin G, ampicillin, erythromycin, tetracycline, cephalothin, and clindamycin. The deoxyribonucleic acid of this organism has a guanine-plus-cytosine content of 55 mol%. These data indicate that this organism does not belong in the genus Corynebacterium but rather in Eubacterium. Therefore, the name Eubacterium suis (nom. rev.) comb. nov. is proposed for it, and strain Soltys 50052 (= ATCC 33144) is designated the type strain.

† Journal article 9148 from the Michigan Agricultural Experiment Station.
MATERIALS AND METHODS

**Bacterial strain.** A culture of "*C. suis*" strain Soltys 50052 was obtained from M. A. Soltys, Ontario Veterinary College, Guelph, Ontario, Canada.

**Media.** The basal medium used in this study was the modified prereduced anaerobically sterilized peptone yeast extract (PRAS-PY) medium described by Holdeman et al. (15). Minerals 1 and 2 (4 ml each) of Caldwell and Bryant (4) were used in place of the salts solution, and the vitamin K-hemin solution was deleted. The pH was adjusted, carbohydrates or other substrates used in the biochemical studies were added to this basal medium in the concentrations recommended by Holdeman et al. (15). An oxygen-free CO₂ gas phase was used, unless specified otherwise. 1-L cysteine hydrochloride hydrate was added to the medium immediately before heating. The mixture was boiled under CO₂ in a round-bottomed flask (until the resazurin was decolorized), stoppered, and allowed to cool, and a sterile, CO₂-equilibrated 8% (wt/vol) sodium carbonate solution was added (5 ml/100 ml of medium). The medium was then dispensed into screw-capped Hungate tubes (3.5 ml/tube; Belco Glass Co.) or rubber-stoppered test tubes (18 by 150 mm; 10 ml/tube) and autoclaved at 15 lb/in² for 15 min at 121°C. Solid medium was prepared by incorporating 2% agar (Difco Laboratories) into the above-mentioned medium. The compositions of all other media were exactly as previously described (15). All incubations were at 37°C, except where indicated otherwise. The pH values of the cultures were determined with a pH meter and a combination electrode. Growth in liquid medium was estimated by determining the absorbance at 600 nm of triplicate tubes (18 by 150 mm) with a Bausch & Lomb Spectronic 20 spectrophotometer.

**Culture maintenance.** Slants of PRAS-PY-maltose (PYM) medium were each inoculated with a loopful of an actively growing culture in PYM broth, incubated at 37°C, and stored at 4°C. Subcultures were made in the same slant medium once every 4 weeks. Purity was checked periodically by examining Gram-stained smears and wet mounts with a Zeiss phase-contrast microscope and by streaking plates of PRAS-supplemented brain heart infusion agar or Trypticase soy agar plates supplemented with 5% sheep blood. Brain heart infusion agar plates were incubated anaerobically in a GasPak jar (BBL Microbiology Systems) under CO₂, and Trypticase soy agar plates were incubated aerobically.

**Morphologic studies.** Wet mounts of PYM broth cultures, as well as the water of syneresis from PYM slant cultures, were observed for motility with a Zeiss phase-contrast microscope. For electron microscopic studies, cells were fixed in 2.5% glutaraldehyde and 1% OsO₄, dehydrated, and embedded in Epon 812. Cell preparations were examined with a Philips model 300 electron microscope.

**Biochemical testing and gas chromatographic analyses.** An actively growing culture in PYM (A₅₄₀ of 0.5) was used for inoculating various liquid and solid biochemical test media. All of the resulting cultures were incubated for at least 48 h after inoculation. Volatile and nonvolatile acid end products in PYM were determined after 48 h of incubation, as described previously (37). A model 15C-3 Dohrmann gas chromatograph equipped with a Resoflex column was used. The column temperature was 120°C, and the helium (carrier gas) flow rate was 120 cm³/min. A 50-ml PYM culture was distilled by using the procedures of Neish (35) for the determination of alcoholic end products. These end products were analyzed by using a Varian model 2440 gas chromatograph equipped with an H₂ flame ionization detector and Porapak Q column packing. The temperature of the column was 170°C, and the N₂ (carrier gas) flow rate was 30 ml/min.

**Determination of temperature for optimal growth.** For the determination of the temperature at which optimal growth occurred, PYM broth was prepared as described above except that phosphate buffer (pH 7) was added to the medium in place of sodium carbonate to a final concentration of 0.02 M before the pH was adjusted. Also, an N₂ gas phase was used instead of CO₂. Each tube was inoculated with one loopful of a young culture (A₅₄₀, 0.2), and the tubes were incubated at 25, 30, 37, and 43°C. Growth was recorded after 72 h. The mean A₅₄₀ of triplicate tubes was used to report growth at each temperature.

**Determination of pH for optimal growth.** Samples (10 ml) of PYM buffered at pH 5, 6, 7, 8, 8.2, and 8.5 were used to determine the pH for optimal growth. Acetate, phosphate and trihydroxymethylaminomethane (Tris) buffers were added as appropriate in place of sodium carbonate to give final concentrations of 0.01, 0.02, and 0.025 M, respectively. N₂ was used as the gas phase instead of CO₂. Each medium was inoculated with one loopful of a young culture (A₅₄₀, 0.2), and the A₅₄₀ was recorded every 12 h for 72 h.

**Cell wall analysis and DNA base composition.** The cell wall composition of strain Soltys 50052 was determined by C. S. Cummins (Virginia Polytechnic Institute and State University Anaerobe Laboratory, Blacksburg) using procedures described previously (8). John Johnson (Virginia Polytechnic Institute and State University Anaerobe Laboratory) determined the guanine-plus-cytosine (G+C) content of deoxyribonucleic acid (DNA) by the thermal melting point method (20, 26). *Escherichia coli* B DNA was used as the standard.

**Cytochromes.** For cytochrome analyses, strain Soltys 50052 was grown in 3 liters of PRAS-PY starch (PYS) medium supplemented with 0.25 mg of hemin per 100 ml of medium and 5 mg of ferrous sulfate per 100 ml of medium. About 100 ml of a culture grown in PYS for 24 h was used as the inoculum. After incubation for 72 h, the bacteria were harvested by centrifugation at 16,300 × g for 15 min at 4°C. washed six times with 4 volumes of 0.02 M phosphate buffer (pH 7), and suspended in the above-mentioned buffer (1.0 g [wt. weight] per ml), and a few crystals of sodium bicarbonate were added to reduce the extract in a sample
FIG. 1. (A) Phase-contrast photomicrograph of strain Soltys 50052 grown in PYM medium for 24 h. (B through D) Thin-section electron micrographs of strain Soltys 50052 grown for 36 h. Bar = 0.2 μm. Abbreviations: CW, cell wall; CM, cytoplasmic membrane; OC, outer coat; M, mesosome-like membranous organelle; EOA, electron-opaque area.

cuvette, and its spectrum was compared with that of an air-oxidized extract in the reference cuvette. All spectral analyses were performed in 1-ml cuvettes (light path, 10 mm) at room temperature with a Varian model 634S double-beam recording spectrophotometer connected to a Sargent-Welch model SR recorder.

The modified procedures of Jacobs and Wolin (19) were used for heme extraction and characterization. A freeze-dried cell extract containing at least 140 mg of protein was thoroughly mixed with 40 ml of cold acetone in a homogenizer and centrifuged at 15,000 × g for 15 min at 4°C. This acetone wash was repeated once, and the protoheme in the washed pellet was extracted with 40 ml of cold acetone containing 1% (vol/vol) 2.4 N HCl. This extraction procedure was repeated once more, and the extracts were pooled and dried under a vacuum. The dried residue was then suspended in a solution containing 3.5 ml of pyridine and 3.5 ml of 0.2 N KOH, and the difference spectrum of the alkaline pyridine hemochrome was determined as described above.

To detect the heme of cytochrome c, the pellet remaining after acid acetone extraction was mixed with pyridine and KOH as described above, and this suspension was analyzed spectrally.

Antimicrobial susceptibility testing. The disk diffusion method of Wilkins et al. (45) and the broth disk method of Wilkins and Thiel (46) were used for antimicrobial susceptibility testing.

RESULTS

Morphology and staining characteristics. Cells of strain Soltys 50052 were gram positive, although they easily decolorized, especially in old cultures, and often had a beaded appearance; they were not acid fast. No spores were observed, and the organism did not survive heating at 80°C for 10 min. Cells were nonmotile, slender, pleomorphic, and rod shaped and measured 0.5 by 1 to 3 μm (Fig. 1A); they were often found
Ultrastructure studies. Cell membrane, cell wall, and fringe-like outer coat layers were clearly seen in thin-section electron micrographs (Fig. 1B and D and 2A). The cytoplasmic membrane was tightly associated with the cytoplasm, as is typical of most gram-positive organisms. At high magnifications (Fig. 2C) the cell walls of many cells had a multilayered appearance, as previously reported for Actinomyces and Eubacterium species (2, 11). Large electron-opaque areas were observed in many cells, especially at the poles. The nature of these structures is not known. Many rudimentary branching cells were seen. For example, Fig. 1B shows two rounded, budding cells at an angle to the long horizontal cell. Although the septa in this figure are not at right angles to the longitudinal axis of the cell and the completed septa are curved, the most frequent type of cell division appeared to be by the formation of septa at right angles to the longitudinal axis of the cell (Fig. 2B). In this case septum formation was initiated by invagination of a portion of the cytoplasmic membrane at the division plane on either side of the cell, and these invaginations became transformed into round or oval membranous structures resembling mesosomes (Fig. 1D). Ingrowth of these structures and joining of the opposing mesosomes (Fig. 2A) seemed to result in complete septum formation (Fig. 2B). Mesosome-like membranous organelles were often observed in cells at sites other than the division plane (Fig. 1B and 2B). These intracytoplasmic membranous elements appeared to be continuous with the cytoplasmic membrane. Undefined membranous structures, apparently formed by invagination of the cytoplasmic membrane, were also occasionally seen in the cytoplasm.

Cultural characteristics. Colonies on blood agar plates that were incubated anaerobically for 48 h were white, circular, and granular and had entire to slightly irregular margins. A dense, slightly raised region in the center of each colony gave them a "fried-egg" appearance. After incubation for 3 days at 37°C, an indefinite "hazy" beta-hemolysis around the colonies was apparent, and most colonies were 0.5 to 2.0 mm in diameter. After 1 week, colonies often attained a diameter of 3 to 5 mm and were flatter, and the central raised region observed earlier became nearly indistinguishable from the rest of the colony. Colonies on anaerobic PYM agar were similar to those described above, although they appeared to be smoother than those growing on blood agar plates. Initially, no growth was observed on plates cultivated aerobically. However, after numerous subcultures barely discernable pinpoint colonies were detected after incubation in air or under 6% CO₂ for 7 days.

PYM broth supported moderately good
growth of this organism \((A_{600}, 0.6)\). Growth in PYM broth was not enhanced by adding Tween 80, hemin, or menadione, and bile was inhibitory.

**Effect of pH and temperature on growth.** Strain Soltys 50052 appeared to have a broad pH optimum (between pH 7 and 8), and growth decreased substantially at pH values less than 7 and greater than 8 (Table 1).

The temperature for optimal growth was 37°C \((A_{600}, 0.58)\), although good growth was also obtained at 30°C \((A_{600}, 0.52)\) and 43°C \((A_{600}, 0.46)\). Growth was not detected at room temperature after 72 h.

**Biochemical characteristics.** Of the carbohydrates tested, strain Soltys 50052 fermented only maltose, glycogen, and starch during 48 h of incubation (Table 2). Xylose and ribose were attacked after 14 days of incubation. Lactate, pyruvate, and threonine were not metabolized. This organism was strongly urease positive but was negative for the other commonly tested biochemical characteristics (Table 2). These results were confirmed by L. V. Holdeman at the Virginia Polytechnic Institute and State University Anaerobe Laboratory. The results reported here are in agreement with those of Soltys (41), who performed a limited number of tests and showed that maltose was fermented by all strains of "C. suis" and that lactose, salicin, mannitol, fructose, and galactose were not fermented by any strain; furthermore, the strains tested were positive for urease but failed to produce indole or liquefy gelatin. However, Soltys reported an alkaline reaction after 7 days of incubation in litmus milk, whereas we did not observe any change in the milk medium.

Since metabolic products are important in classifying anaerobic bacteria (15, 28), the fermentation products of this organism were determined. Ethanol, formate, and acetate were the major products (Table 2), lactate and succinate were found only in trace amounts, and propionate, butyrate, and butanol were not found.

**Cell wall composition.** The major sugar component of "C. suis" cell walls was rhamnose; a small amount of glucosamine and a trace amount of mannose were also present. The major diamino acid found was lysine; small amounts of glutamic acid and alanine were also found.

**Cytochrome analyses.** Previously, Meyer and Jones (27) established that cytochromes are relatively important in bacterial taxonomy. The dithionite-reduced versus air-oxidized difference spectrum (Fig. 3) of cell extracts of strain Soltys 50052 grown in PYS supplemented with 0.002% (wt/vol) hemin showed \(\alpha, \beta, \text{and } \gamma\) absorption maxima at 562, 530, and 430 nm, respectively, a pattern characteristic of a type \(b\) cytochrome (18). The absorption maxima of the pyridine hemochrome derivative of the protoheme were at 558, 525, and 423 nm, confirming the presence of a type \(b\) cytochrome (Fig. 4). In contrast, the pyridine hemochrome of the residue left after acid acetone extraction showed absorption maxima at 552, 523, and 417 nm (Fig. 5), a pattern characteristic of a type \(c\) cytochrome. Our results indicated that a type \(b\) cytochrome is the major cytochrome of "C. suis" and that this cytochrome completely masks a type \(c\) cytochrome present in crude cell extracts. The presence of the type \(c\) cytochrome became obvious only when the pyridine hemochrome of the mesoheme in the acid acetone residue was examined.

**G+C content of DNA.** The DNA base composition of this organism is 55 mol% G+C.

**Antibiotic susceptibility.** Strain Soltys 50052 was susceptible to penicillin, ampicillin, erythromycin, tetracycline, cephalothin, and clindamycin as determined by the disk diffusion and broth disk methods (Table 2). These results were later confirmed by L. V. Holdeman at the Virginia Polytechnic Institute and State University Anaerobe Laboratory.

**DISCUSSION**

At the time that Soltys and Spratling (42) named "C. suis," it was a common practice to assign arbitrarily any gram-positive, nonsporeforming diphtheroid organism to the genus *Corynebacterium*. According to *Bergey's Manual of Determinative Bacteriology*, 8th ed., the genus *Corynebacterium* (38) includes those coryneform organisms from humans or other animals which are aerobic or facultatively anaerobic and nonsporeforming and which are characterized by cell walls containing arabinose and galactose as the major sugar components and meso-diaminopimelic acid as the major diamino acid. Furthermore, it has been shown recently that strains of *Corynebacterium diphtheriae*, the type species of the genus, and a
closely related species, *Corynebacterium pseudotuberculosis*, produce major amounts of acetate, propionate, and formate and variable amounts of other acids as products of carbohydrate metabolism (37). In contrast, strain Soltys 50052 is anaerobic, has rhamnose and lysine as its major cell wall components, and produces acetate, formate, and ethanol but not propionate as major end products of carbohydrate metabolism. Therefore, it appears that this organism does not belong in the genus *Corynebacterium*.

*Haemophilus vaginalis* (21), which was recently reclassified as *Gardnerella vaginalis* (13), is a gram-positive, coccoid rod-shaped bacterium which carries out fermentative metabolism of sugars and produces acetic acid as a major product; also, lactic and formic acids are often produced. Although this organism is generally believed to be facultatively anaerobic, Malone et al. (25) recently isolated some obligately anaerobic strains which are biochemically similar or identical to the facultatively anaerobic strains. Most strains ferment maltose and starch producing acid but not gas. The cell walls of this organism contain lysine, not diaminopimelic acid, as the major diamino acid and 6-deoxytartronic acid but no gas. The cell walls of this organism contain lysine, not diaminopimelic acid, as the major diamino acid and 6-deoxytartaric acid. Therefore, it appears that this organism does not belong in the genus *Corynebacterium*.
FIG. 3. Dithionite-reduced versus air-oxidized difference spectrum (solid line) and air-oxidized versus air-oxidized difference spectrum (broken line) of a cell extract of strain Soltys 50052 containing 15 mg of protein per ml.

FIG. 4. Dithionite-reduced versus air-oxidized difference spectrum (solid line) and air-oxidized versus air-oxidized difference spectrum (broken line) of a pyridine hemochrome from an acid acetone extract of strain Soltys 50052. The acid acetone extract from 140 mg of cell protein was suspended in 7 ml of pyridine-KOH.

G. vaginalis DNA is 42 ± 1 mol%, whereas that of strain Soltys 50052 DNA is 55 mol%. Thus, it is apparent that "C. suis" is different from G. vaginalis.

Douglas and Gunter (10) and Moore and Cato (29) showed that the human pathogen C. acnes and related "anaerobic coryneforms" produce major amounts of propionate and acetate as end products of carbohydrate metabolism and therefore actually belong in the genus Propionibacterium (30). Furthermore, the cell walls of propionibacteria typically contain 3-linked diaminopimelic acid and galactose as the major diamino acid and sugar components, respectively (20). We found that strain Soltys 50052 is quite different from propionibacteria in its metabolic end products, its cell wall composition, and its biochemical characteristics and thus cannot be classified as a member of the genus Propionibacterium.

Our results show that strain Soltys 50052 does not belong in Actinomyces, Bifidobacterium, or Clostridium (15). Unlike bifidobacteria, this strain does not produce lactic acid as a major product. It is similar to Actinomyces in being gram positive, anaerobic, nonmotile, and non-acid fast, in having diapheroid morphology, and in containing lysine in its cell wall, and in containing cytochromes (7, 40, 43). However, in contrast to Actinomyces, it does not produce succinic acid (in the presence of CO₂) or lactic acid as a major product, and its products do not change in the presence of CO₂ (Wegienek and Reddy, unpublished data). It is also quite different from Actinomyces in its biochemical characteristics (40). Members of the genus Clostridium
### TABLE 3. Characteristics that differentiate strain Soltys 50052 from non-butyrate-producing Eubacterium species

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<thead>
<tr>
<th>Products</th>
<th>Glycogen</th>
<th>Lactic acid</th>
<th>Lactic acid</th>
<th>Ethanol</th>
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<th>Butyric acid</th>
<th>Formic acid</th>
<th>Isobutyric acid</th>
<th>Isovaleric acid</th>
<th>Propionic acid</th>
<th>Pyruvic acid</th>
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<tr>
<td><strong>Organism</strong></td>
<td><strong>Glycogen</strong></td>
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<td><strong>Lactic acid</strong></td>
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All organisms except strain Soltys 50052 were grown in peptone-yeast extract-glucose broth. Strain Soltys 50052 was grown in peptone-yeast extract-maltose medium. Abbreviations: A, acetic acid; B, butyric acid; C, formic acid; D, isobutyric acid; E, lactic acid; F, propionic acid; L, lactic acid; P, pyruvic acid; S, succinic acid; E, ethanol. The products in parentheses are produced by only some strains.

**Symbols:**
- (+), positive reaction or final pH of 5.5 or lower;
- (w), weak acid (pH 5.6 to 6.0); c, curd; d, digest.

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**Data from Holdeman and Moore (16).**

**Data from Holdeman and Moore (17).**

**Data from Moore et al. (31).**
are generally gram-positive sporeforming rods, are "usually motile," are not known to contain cytochromes except in rare instances (12), and therefore are different from strain Soltys 50052.

The genus *Eubacterium* (16) includes a rather diverse group of gram-positive, obligately anaerobic (oxygen sensitivity varies among species, as well as among strains within a species), nonsporeforming, rod-shaped, uniform or pleomorphic, motile or nonmotile, saccharolytic or non-saccharolytic chemoorganotrophs which do not produce major amounts of propionate, lactate, or succinate ( singly or in combination) but instead produce varied mixtures of other organic acids from carbohydrates or peptones. Based on these characteristics, strain Soltys 50052 appears to belong to the genus *Eubacterium*. In addition, similar to most eubacteria, it is catalase negative and grows optimally at pH 7.0 and 37°C.

Based on existing data, strain Soltys 50052 can be differentiated from the 37 currently recognized species of *Eubacterium* (15, 16). Some characteristics that are helpful in differentiating strain Soltys 50052 from eight eubacterial species which do not produce butyrate are given in Table 3. Unlike most of the species listed, strain Soltys 50052 ferments glycogen and starch but not glucose or fructose and does not curdle or digest milk. It is also strongly urease positive, a characteristic shared by only two other currently recognized members of the genus. It contains rhamnose as a major sugar component of the cell wall, a characteristic also reported for one other species, *Eubacterium saburreum*; however, information on the cell wall sugar component(s) of other eubacteria is not available. Similarly, although nine species have been shown to contain meso-diaminopimelic acid as the major cell wall diamino acid, this information is lacking for the rest of the species. In contrast, strain Soltys 50052 contains lysine as the major diamino acid. The DNA base ratios of only a few species of this genus have been determined; these range from 31 to 45 mol% G+C, values which are considerably lower than the value (55 mol%) found for strain Soltys 50052. Since only a small number of organisms have been examined for the G+C content of the DNA, the importance of this characteristic in the taxonomy of *Eubacterium* remains to be determined.

Based on the results of this investigation, we propose that "Corynebacterium suis" Soltys and Spratling (42) be transferred to the genus *Eubacterium*. The name "Corynebacterium suis" originally proposed for this organism was not included on the Approved Lists of Bacterial Names (39) and currently has no nomenclatural standing. Therefore, we propose that *C. suis* be transferred to the genus *Eubacterium* as *Eubacterium suis* (nom. rev.) comb. nov. The type strain is Soltys 50052 (= ATCC 33144).

*Eubacterium suis* (nom. rev.) comb. nov. Slen- dred, nonmotile, pleomorphic rods, 1 to 3 by 0.5 μm, arranged singly, in pairs (often found at an angle to each other or in palisades), or in small clusters. Gram positive, but rather easily decolorized, especially in old cultures. Not acid fast and non-sporulating; does not survive heating at 80°C for 10 min. Capsules not observed by capsule staining; however, a fringelike outer coat external to the cell wall is seen in thin-section electron micrographs.

Colonies on anaerobic blood agar plates are 0.5 to 3.0 mm in diameter after 48 h, white, circular, and granular and have entire to slightly irregular margins. Colonies often show slightly raised centers, giving a fried-egg appearance. After 1 week, colonies are 3 to 5 mm in diameter and flatter. Growth is barely discernible after incubation for 7 days under 6% CO₂ or air.

Peptone-yeast extract-starch broth supports excellent growth. Optimal pH, 7 to 8; no growth occurs at pH 5.0 or less. Optimal temperature, 37°C; temperature range for growth, 30 to 43°C; no growth occurs at 22 to 23°C.

Anaerobic: metabolism is strictly fermentative. Maltose, starch, and glycogen are fermented. Acetate, ethanol, and formate are the main products from maltose fermentation. Adonitol, amygdalin, arabinose, cellobiose, dulcitol, erythritol, esculin, fructose, galactose, glucose, glycerol, inositol, inulin, lactose, mannitol, mannose, melezitose, melibiose, raffinose, rhamnose, salicin, sorbitol, sucrose, trehalose, lactate, pyruvate, and threonine are not fermented. Strongly urease positive. Does not produce catalase, indole, acetyl methylcarbinol, hydrogen sulfide, lipase, or lecithinase; ammonia is not produced from peptone; esculin and gelatin are not hydrolyzed; meat and milk are not digested; nitrates are not reduced.

Major amounts of type b cytochrome and minor amounts of type c cytochrome are synthesized.

Cell wall sugars are rhamnose and mannose; the diamino acid of the peptidoglycan is lysine. The G+C content of the DNA is 55 mol%.

Originally isolated from cases of cystitis and pyelonephritis and cases of metritis in pregnant sows (41, 42). Not isolated from healthy sows, but frequently recovered from urine and semen of apparently healthy boars. Sows can be infected artificially by intrarenal injection of live organisms plus 5% saponin (41). No demonstrable exotoxin is produced.

Type strain: Soltys 50052 (= ATCC 33144).

ACKNOWLEDGMENTS

We thank M. A. Soltys for furnishing strain 50052 for this work. We are very grateful to C. S. Cummins for determining
the cell wall composition, L. V. Holdeman for confirming our results for biochemical characteristics and antimicrobial susceptibility patterns, J. L. Johnson for the G+C determination, S. Pankratz for taking the electron micrographs, and M. J. Allison for a critical review of the manuscript.

REPRINT REQUESTS
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