STATUS OF THE GENERIC NAME ZOOGLOEA
AND ITS SPECIES

An Aid to the Formulation of an Opinion

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Crabtree and McCoy (1967) isolated in pure culture five floc-forming strains of bacteria from the activated sludge of five sewage plants. After careful characterization, the organisms were identified as Zoogloea ramigera Itzigsohn and one of these strains was proposed as the neotype strain of Zoogloea ramigera Itzigsohn. Three additional isolates were identified as Zoogloea filipendula Beger.

Certain nomenclatural problems relating to the validity and legitimacy of the generic name Zoogloea and its species were enumerated by Crabtree and McCoy (1967) and, in light of the requests made of the Judicial Commission of ICNB, it appeared appropriate to formulate a more detailed account of the nomenclatural history of the genus and its species.

Zoogloea Cohn 1854, 123. In a lengthy article, "Studies on the Development of Microscopic Algae and Fungi," Cohn (1854) described organisms which were embedded in gelatinous masses. Although he felt they were related to the genera Sphaerotilus and Cryptococcus, he believed with regard to the behavior of the free cells that a separate genus should be recognized for which he proposed the name Zoogloea with the single species Zoogloea termo. The following is a translation of Cohn's original Latin description of the genus:

Cells very small, rod-shaped, colorless; hyaline jelly in spherical mucilaginous lumps, resembling a cluster of grapes, at first assembled as in a membrane, later individually separated, moving to and fro in the water.

Cohn gives the etymology of the name Zoogloea in a footnote:

ζῶον, animal, and γλοιός, gelatin or jelly.

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The Latin description of the single species and a list of synonyms are then given. The translation follows:

Zoogloea termo with free, motile, straight cells, equaling 1/2000-1/700". Palmella infusionum Ehrenberg, Infusionsthierchen p. 526, Micraloa teres von Flotow. Cryptococci spec.? - Bacterium termo Dujardin, Vibrio lineola Ehrenberg.

Cohn(1854) also refers to Figure 9 of Table 15 at the end of his article. The following is a translation of the German description which accompanies the drawing (p. 246):

Fig. 9. Zoogloea termo mihi, spherical-grapelike, gelatinous-slimy mass in standing infusions, multiplication much like Palmella through the formation of new spherical lobes from which extremely small bodies (swarm cells) are later freed, more like vibrios, and are to be designated as Bacterium termo Dujardin.

Later in his discussion, Cohn (1854) makes the following statements concerning the "Vibrionien" (bacteria) and Zoogloea termo (page 130):

1. The vibrios all appear to belong in the Plant Kingdom, being obviously related to the algae.
2. The absence of color and their presence in decaying infusions place the vibrios in the group of the water fungi (Mycophyceae).
3. Bacterium termo is the motile swarm-form of the genus Zoogloea, related to Palmella and Tetraspora.

Finally, on page 132, Cohn noted a close relationship between Zoogloea termo and Zoogalactina immetrofa [sic] Sette (Serratia marcescens) based upon his observation of the gelatinous masses formed on boiled potato, and indicated there might even be generic identity.

The following conclusions may be drawn from a study of Cohn's paper (1854):

1. The name Zoogloea Cohn 1854 was effectively published.
2. The validity of the name Zoogloea Cohn 1854 is determined by the single named species Zoogloea termo Cohn 1854.

3. The genus Zoogloea includes the species Bacterium termo Dujardin [sic] as indicated by his choice of the specific epithet termo and by the list of synonyms following the species description. Apparently the new name was necessitated by Cohn's recognition of the growth of the organism in jelly-like masses.
4. The basionym of Zoogloea termo is obviously Bacterium termo.

Modern consensus regards Bacterium termo Dujardin [sic] as not identifiable and thus a nomen nudum. Buchanan (1925, 213-230) presented a very complete discussion of the history of Bacterium termo and the attempts to fix its identity. If the premise is acceptable that B. termo (Zoogloea termo) is not identifiable, then the generic name Zoogloea Cohn 1854 is not validly published, inasmuch as its type species (the only species described) is not identifiable.

Zoogloea ramigera Itzigsohn 1868, 30. Itzigsohn (1868), in a paper which was presented by Braun at a meeting in 1867 and subsequently published in the Sitzungs-Berichte der Gessellschaft Naturforschender Freunde (Berlin 1868), refers to Cohn's Zoogloea termo found among decaying algae. Itzigsohn described a second species which formed conspicuous jelly-like masses several "lines" thick. This he named Zoogloea ramigera, differentiated from Cohn's species by growing out in dendritic branches from the more or less spherical gelatinous base. The cells were not motile while embodied in the gelatine, but later with favorable environmental conditions a swarm appeared as a result of the sudden liberation of cells, first from the edge and later from the entire body. Itzigsohn does not indicate whether he himself isolated Z. termo.

The name Zoogloea ramigera Itzigsohn is both validly published and legitimate. The remainder of this paper also points out that with the exception of Scheibler (1878) no investigator who isolated a zoogloea form recognized Z. termo.

Rabenhorst (1868) listed and illustrated Zoogloea Cohn 1857 [sic] in his treatise on the algae of Europe. The description differs very little from that of Cohn. The species name was cited as Z. termo (Müller) Cohn, thus recognizing Monas termo Müller as the basionym. Rabenhorst (1868) also concluded that Zoogloea was a fungus.

Zoogloea pulmonis equi Bollinger 1870, 585. Bollinger (1870) very tentatively proposed the name Zoogloea pulmonis

equi for microorganisms occurring in slimy masses in pneumonitis of the horse. These, he believed, should be included in Zoogloea Cohn. The name may be regarded as not validly published. It has not been accepted by later authors.

Cohn (1872) later did not recognize or use the name Zoogloea termo. Zoogloea is not used in a strict generic sense but only to designate a growth form common to bacteria of several genera. Cohn (1872, 141) terms Zoogloea a form genus. His classification of bacteria (page 146), with four tribes and six genera, does not include a genus Zoogloea. In Table III (page 223) the legend for several figures, "Zoogloaeform" is used to designate growth forms in the genus Micrococcus and in Bacterium termo and Bacterium lineola.

Cohn (1875) did not recognize a genus Zoogloea in his more comprehensive classification. He later (page 143) stated that the cloudy flocs termed Gliacoccus by Billroth (1874) had been termed Zoogloea 20 years earlier. Billroth (1874, 7) stated that Coccoglia or Gliococcus [sic] were to be regarded as growth forms of his Coccobacteria septica and were synonymous with Zoogloea. Opinion 25 of the Judicial Commission placed all names of taxa proposed by Billroth in the list of nomina rejicienda.

Koch (1877, 414) in the first published photographs of bacteria included two (Table XIV, figs. 1, 2) with the legend Zoogloea ramigera Itzigsohn. The photographs show the same characteristics as those of Crabtree and McCoy (1967).

Scheibler (1878) incorrectly ascribed the viscous masses sometimes developing in syrups during the manufacture of beet sugar to growth of Zoogloea termo.

Zoogloea beigeliana Eberth acc. to Trevisan 1879, 146. Trevisan listed the name as a synonym of Chlamydotomus beigelii Trevisan and ascribes Z. beigeliana to Eberth 1873. Examination of Eberth's paper failed to show the use of this name. Eberth (1873) described an organism which formed thick crusts in the hair. Trevisan apparently interpreted these as zoogloea masses; Eberth proposed no names of genera or species. Zoogloea beigeliana is not validly published (12d).

Flügge (1886, 312) discards Bacterium termo as a mixture of species. Zoogloea ramigera Itzigsohn is recognized (page 399).

Winogradskya Trevisan 1889, 12. Trevisan in a preliminary listing of bacterial taxa proposed the new generic name Winogradskya with the single species Winogradskya ramigera

(Itzigsohn) Trevisan (basionym: Zoogloea ramigera Itzigsohn). He described the genus as follows:

Cylindrical rods and filaments collected in much-branched zoogloea-like families, included within a thin gelatinous capsule. Spores unknown.

Trevisan in De Toni and Trevisan (1889) again included W. ramigera (Itzigsohn) Trevisan and listed Zoogloea termo Cohn as a synonym of Bacterium termo (Müller) Ehrenberg. Opinion 13 of the Judicial Commission (1954, 154) designated the generic name Winogradskya illegitimate as a later synonym of Zoogloea.

Stutzer and Hartleb (1897, 237) gave a lengthy description of an organism they regarded as Zoogloea ramigera. It had a complicated life history (production of spores and mycelia were emphasized). There seems ample evidence that they studied mixed cultures.

Kolkwitz (1909, 150) listed the genus Zoogloea Cohn which he felt should be rejected. The species Z. ramigera was recognized and listed. He published two drawings showing typical morphology.

Kolkwitz (1911) listed Zoogloea ramigera as an accepted species. He also described three organisms which he designated nomina ad interim. The provisional names proposed are:

1. Zoogloea compacta Kolkwitz 1911, 373. Formed microscopically small gelatinous clumps, often with Z. ramigera. Cells rod-like.
2. Zoogloea carnea Kolkwitz 1911, 373. Large macroscopically visible, flesh-colored, gelatinous masses on the walls of the sewage ditches. Cells short, rod-like, 1.5 μ thick.
3. Zoogloea uva Kolkwitz 1911, 373. Appears on roots, stems, etc., in pea to cherry size forms, with grape-like structure. Rods usually long and more than 1 μ thick.

Kolkwitz' three tentative species are not validly published (International Code of Nomenclature of Bacteria, 1966, Rule 12c).

Johnson (1914, 124) listed three varieties of the species Zoogloea ramigera Itzigsohn, using as subspecific epithets for each the same species names which Kolkwitz (1911) used for his three species nomina ad interim. Description is limited to a discussion of morphology with a picture (page

123) and drawings (pages 123, 129). The new varieties are:

Zoogloea ramigera var. compacta Johnson 1914, microscopically small gelatinous masses packed among the type form; short rods.

Zoogloea ramigera var. carnea Johnson 1914, as flesh-colored masses on the sides of sewers; cell 1.5 μ thick.

Zoogloea ramigera var. uva Johnson 1914, on stalks and roots of submerged plants in subglobular masses varying in diameter from 1/4" to 3/4"; cells long and somewhat over 1 μ thick.

These subspecific names appear to be validly published and legitimate.

Buchanan (1918, 43) did not recognize the genus Zoogloea Cohn since it was based upon an insufficiently described species. Later (1925, 531) he regarded the name as probably "invalid" as not based on pure cultures.

Bacterium zoogloae ramigerae Blösch 1918, 60. This author described Zoogloea ramigera Itzigsohn in detail. He made an attempt to base his description on pure cultures which he isolated, with great difficulty, from the vegetation of a creek into which sewage and city drainage water emptied. Blösch's description of Z. ramigera follows:

Rods 1 μ wide and 2-3 μ long, rarely filamentous with definite septa, possessing a single polar flagellum, enclosed in a capsule. Cells form a dextran compound which produces the antler-like or branched zoogloal form; Gram-negative; good growth in nutrient broth, hay infusion and yeast water; poor growth on nutrient agar and in peptone water; NH_3 from peptone and asparagine; nitrates reduced; does not fix nitrogen; attacks cellulose poorly; obligate aerobe; minimum temperature 2-3°C, optimum temperature 25°C, maximum temperature 37°C; carbohydrates utilized for growth.

He further concluded, after a comparison of Sphaerotilus natans Kützing and Cladotrix dichotoma Cohn with his pure cultures of Zoogloea ramigera Itzigsohn, that there was no relationship between them. In his discussion of the classification of Zoogloea ramigera, Blösch (on the basis of the lack of spore formation) placed Zoogloea in the subgroup "Bacterium" according to the nomenclature of Mez (1898). For

this reason he proposed a new binary combination Bacterium zoogloaeae ramigerae. This name is illegitimate (Rule 24b; see also Opinion 4).

Pseudomonas zoogloaeae ramigerae (Blösch) de' Rossi 1927, 981. The description given is quite similar to that of Blösch (1918). In a footnote de' Rossi stated that on the basis of the characteristics of Bacterium zoogloaeae ramigerae Blösch, he transferred it to the genus Pseudomonas. Pseudomonas zoogloaeae ramigerae (Blösch) de' Rossi is illegitimate (Rule 24b).

Zoogloea filipendula Beger 1928, 145. Beger investigated gelatinous masses found in water from wells. He dissolved the slime with dilute HCl and noticed the odor of sulfuric acid, indicating the presence of sulfide, but he was not able to demonstrate the presence of amorphous sulfur. He felt that the gelatinous masses were "Bakterienzoogloeen" which differed from Zoogloea ramigera, Z. compacta, Z. carnea and Z. uva on the basis of the morphology of the slime masses. He proposed the species name Zoogloea filipendula with the following characteristics (no attempt was made to secure pure cultures):

Numerous cocci embedded in a gelatinous mass about 8 μ long, also rods about 2 μ long, and strange bodies assumed to be algae. It differs from the previously described forms by its solid clumps and "gelatinous berries," by its distinct gelatinous stalks and its skin-like structure on which the "berries" sit (similar to the nodules hanging from the thin roots of Ulmaris filipendula).

A picture (page 144) is included which may better explain the described morphology. Zoogloea filipendula Beger is a validly published and legitimate name.

Zoogloea ramigera Kruse emend. Butterfield [sic] is listed in Bergey et al. 1939, 627. The description given is that of Butterfield (1935). An examination of Kruse in Flüggé (1896, 68) failed to show the use of the binary combination Zoogloea ramigera or any description of the species. Butterfield's paper (1935) reveals that he believed previous descriptions of Z. ramigera were not adequate, and that he would tentatively assume that the zoogloal organism which he had now more fully described, was a variety of Z. ramigera named by earlier workers.

Breed et al. (1948) list Zoogloea ramigera in Appendix II

(page 150) in the family Pseudomonadaceae. The description is the same as that given in Bergey et al. (1939). Hucker and Pederson in the 6th edition of Bergey's Manual (1948, 348) in an Appendix to the genus Leuconostoc, which includes species that probably belong in that genus, list Zoogloea termo Cohn but include no description.

Bacterium ramigerum (Itzigsohn) Krasil'nikov 1949, 432. Krasil'nikov cited Blösch (1918) as using the binary combination Bacterium ramigerum. Blösch used the name Bacterium zoogloeeae ramigerae. His description does not expand that of Blösch; however, flagellation is described as peritrichous and not polar. The use of the generic name Bacterium renders this combination illegitimate according to Opinion 4 of the Judicial Commission (1954).

Lackey in the 7th edition of Bergey's Manual (1957) listed the genus Zoogloea in the family Pseudomonadaceae. Two species are recognized, Zoogloea ramigera Itzigsohn and Zoogloea filipendula Beger. Lackey credits Cohn with the genus description but does not recognize the type species (by monotypy) Zoogloea termo Cohn, since she feels it is unrecognizable. Lackey recommends that Z. ramigera be accepted as the type species of the genus Zoogloea Cohn.

Prévot (1961) lists Zoogloea Cohn as a genus incertae sedis. Zoogloea ramigera (Itzigsohn) Blösch 1918 [sic] is then listed and described according to Blösch (1918). Prévot regards Z. filipendula Beger as an insufficiently described species and includes Beger's (1928) description.

Unz and Dondero (1964) reported the isolation of 200 cultures from typical colonies of Zoogloea ramigera using micromanipulation to isolate single cells from the zoogloeoal masses.

The Judicial Commission is asked to determine the nomenclatural status of the generic name Zoogloea and the species names Zoogloea termo and Zoogloea ramigera. The following suggestions are made:

1. The generic name Zoogloea Cohn 1854 was not validly published because Cohn (1872) regarded it as the name of a growth form and not of a nomenclatural genus. It was not recognized by Cohn in the list of genera included in any of his several classifications of bacteria. (Rule 12c(1)).
2. Zoogloea termo Cohn 1854 was identified by Cohn as identical with Bacterium termo Dujardin [sic], a nomen specificum rejiciendum.

3. Zoogloea Itzigsohn 1868 was validly published as a generic name and is placed in the list of nomina generum conservanda with the type species Zoogloea ramigera Itzigsohn 1868.
4. The Wisconsin strain (ATCC 19623) of Zoogloea ramigera Itzigsohn as proposed by Crabtree and McCoy (1967) is recognized as the neotype strain.
There are extant no strains studied by Itzigsohn.

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