STAPHYLOCOCCUS PYOGENES ROSENBACH

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In a recent paper, Cowan (4) presents an interpretation of the rules in the International Bacteriological Code of Nomenclature in support of the recognition of Staphylococcus aureus Rosenbach as the correct binomial for the name of the pus-forming staphylococcus. It is believed that the interpretation of the rules that he has presented needs further study, and that a closer study of the facts will show that the binomial Staphylococcus pyogenes (originally preferred by Cowan because of its appropriateness) is also the binomial that should be used because it is legitimate under the rules in the Bacteriological Code of Nomenclature.

As various editions of Bergey's Manual have been issued, opportunities for careful studies of the literature have presented themselves; This is particularly true of the years since the 6th edition of Bergey's Manual was published (1). It is the purpose of those in charge of editing the Manual to abide by the Rules in the Code of Nomenclature, with certain definite exceptions. a) In some cases it has been found that a strict interpretation of the Rules would cause us to use names that have priority but which have never been generally used. To introduce them in Bergey's Manual before appropriate action has been taken by the Judicial Commission would produce confusion in the literature. For example, Streptococcus nocardii Trevisan has not been used for the mastitis streptococcus (Streptococcus agalactiae Lehmann and Neumann) although the former binomial has clear priority. Recently the International Judicial Commission on Bacteriological Nomenclature agreed that Trevisan's name Streptococcus nocardii, never having come into general use, should be placed on the list of nomina rejicienda. b) In some cases where it has been found that a generic name is an illegitimate homonym of a generic name previously used in botany or protozoology, the illegitimate name has been continued in use in Bergey's Manual rather than to introduce a series of new binomials that would be new combinations. Such changes in nomenclature are preferably left to students of the particular group in question. These policies have been

followed in order to support two important principles of all codes of nomenclature. The primary aim of such codes is to provide stability in nomenclature; but a second, and likewise important aim, is to avoid the useless creation of new names.

In preparing the manuscript for the 7th edition of Bergey's Manual, which has now been sent to press, we, like Cowan, have again reviewed the status of the names Micrococcus Cohn, 1872 (3), and Staphylococcus Rosenbach, 1884 (11). While Micrococcus Cohn has priority over Staphylococcus Rosenbach, and may be used as the generic name for all mass-forming micrococci as was done in the 6th edition of Bergey's Manual, it has been realized that the use of the generic name Micrococcus for the pus-forming cocci causes the elimination of the commonly-used generic name Staphylococcus and the commonly-used binomial Staphylococcus pyogenes. A further study of the micrococci was therefore stimulated, whereupon several facts not previously fully recognized were discovered.

The micrococci include quite a number of species that have been studied carefully in recent years, that are very different in character from the pus-forming staphylococci. For example, there are certain micrococci found in soil that are active denitrifiers, producing N_2 and N_2O gases from nitrates. Some of these are obligate halophiles that are not able to live in brines of lower concentration than 4 or 5 per cent. Some of these require brines of 12 to 16 per cent for optimum growth. There are even red micrococci that will not grow in brines lower than 18 per cent. Some related red micrococci are motile, as are occasional strains of certain yellow micrococci. Some micrococci are able to grow at temperatures below freezing and are now being studied because they occur in foods preserved by freezing.

Organisms of these types are so different from the pathogenic staphylococci that it seemed possible to find a satisfactory basis for separating the genus Micrococcus Cohn, type species Micrococcus luteus Cohn, from Staphylococcus Rosenbach, type species Staphylococcus pyogenes Rosenbach. Such a basis has been reported by Winslow, Rothberg, and Parsons (15) and has been developed further by Evans, Bradford, and Niven (6).

The true micrococci either do not attack glucose at all, or utilize it in their metabolism with the liberation of small

amounts of CO₂ that may give a faint acid reaction. The true micrococci are such strict aerobes that they cannot grow anaerobically even when given as favorable a carbon source as glucose. On the other hand, the pus-forming staphylococci are able to ferment glucose anaerobically, and frequently other substances.

Such studies as have been made also indicate that the common white skin staphylococcus known as Staphylococcus epidermidis albus Welch (12) (see also Gordon, 7) can ferment glucose anaerobically. Further studies may show that more than these two species should be placed in the genus Staphylococcus, but in the manuscript that has been sent to press only these two species are recognized in the genus Staphylococcus.

Those who have not had occasion to study the literature do not realize that about 500 names have been given to purported species of micrococci or staphylococci. Many of the descriptions are almost exact duplicates, and almost all should be reviewed before acceptance. It takes 33 pages in the 6th edition of Bergey's Manual merely to give the bibliographical record of the names of these species. These organisms are common in their natural habitats but are listed in the appendix to Genus Micrococcus in the Manual because the original work with them has not been adequately evaluated.

Two noteworthy attempts have been made to bring some order out of this confusion. The work done by Winslow and Rogers was reported in two papers (13,14) and then was summarized in their book (16) discussing the systematic relationships of the Coccaceae. Unfortunately, this book never received wide distribution. Only 13 species of the micrococci (mass-forming cocci) were accepted by the Winslows.

The Winslows' work was used by Hucker (8) in his still more extensive studies carried out at the New York State Agricultural Experiment Station, and at Yale University where Prof. Winslow was available for consultation. In his work, Hucker recognized 15 species out of the hundreds that had been described previously.

These monographic studies form the basis of the classification of the genus Micrococcus in the 6th edition of Bergey's Manual. In the arrangement presented in the 6th edition of the Manual, pyogenic staphylococci were recognized as two varieties of the species Micrococcus pyogenes.

Following the usage that had developed during the years, Staphylococcus pyogenes citreus Passet was incorrectly described as a species of the lemon-yellow micrococci, distinct from Staphylococcus pyogenes. More recently, a further study has been made of the status of the species.

While Cowan (4) was concluding that he was wrong in having previously accepted Staphylococcus pyogenes Rosenbach as the correct name for the type species of the genus Staphylococcus, we had concluded that under the rules Staphylococcus pyogenes Rosenbach was the correct binomial to use for the species which would include the orange and white staphylococci as well as the lighter yellow cultures of pyogenic cocci that Passet (10) named Staphylococcus pyogenes citreus. Cowan has given us a photostatic copy of the most important pages from the Rosenbach publication. He points out, for example, that the first names proposed by Rosenbach (11) for the pus-forming staphylococci (p.18) occur in the following sentence: "Zur Bezeichnung der beiden Arten schlage ich vorläufig bis die Botaniker diese Wesen mit passenden Bennungen in das allgemeine System eingereiht haben werden, nach der charakteristischen Farbe der Kulture die Staphylococcus flavus oder aureus und Staphyl. albus vor."

There are two words in this sentence that deserve thought and careful study. One is the word "Arten" which English-speaking persons, especially those interested in taxonomy, normally give the technical meaning "species;" the other word is "vorläufig," which may be translated as "preliminary" or "provisional."

In checking the meaning of "Art" in a German dictionary, it was discovered that the word "Art" is a common German word. While it may be given the technical meaning "species" this is not the usual meaning of the word. Rosenbach did not intend to name two "species" as many think, but is merely speaking of two "sorts" or "kinds" of pus-forming cocci. A German-speaking friend was consulted and he, without any suggestion on my part, translated "Arten" as "sorts of." He felt that the meaning "species" was rare and unusual. Rosenbach, a clinician not trained in botanical taxonomy does not indicate that he was describing two "species."

Cowan (4) speaks of Staphylococcus pyogenes aureus and Staphylococcus pyogenes albus as trinomials, forgetting that this is the correct form to use for varietal names. An example of the correct way in which to write subspecies or

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varietal names is given in the Bacteriological Code (2) under Rule 7. Varietal names of subspecific names may be correctly written as Staphylococcus pyogenes subsp. aureus, Staphylococcus pyogenes var. aureus, or even as Staphylococcus pyogenes aureus.

A careful reading of Rosenbach's description of the staphylococci that he isolated from aseptically drawn pus, indicates that he was describing two sorts of these staphylococci; one that grew with an orange color, and the other that grew without showing chromogenesis. As Cowan points out, he did not in any place in his publication use Staphylococcus pyogenes without the addition of the varietal epithets. He, however, indicates that he is not familiar with the procedures used by botanists. At that time there was no such rule in codes of nomenclature as that now given in the last paragraph of Rule 7 (2) which states that "The subspecific epithet of the subspecies containing the type of the species shall be the same as that of the species." Rosenbach did the very natural thing for anyone not trained in the modern technical requirements of codes of nomenclature and designated the orange variety as aureus and the white variety as albus.

Before turning to other evidence that supports this interpretation of Rosenbach's intent, brief mention should be made of the reason no mention is made in Bergey's Manual of Staphylococcus flavus Rosenbach as a possible name for the orange to yellow colored staphylococcus. This is because of Rosenbach's use of the word "vorläufig." Preliminary or provisional names suggested by an author but not accepted by him are not validly published and have no standing whatever from the standpoint of nomenclature (2; Rule 12, 4th par.). Dozens, yes hundreds, of binomials have been ignored in Bergey's Manual that occur in the literature but which are not validly published. Authors frequently list synonyms that are not validly published, never having been used by the person to whom they are ascribed.

It is significant that German workers contemporary with Rosenbach accepted Staphylococcus pyogenes as the binomial proposed by him for the species under discussion. Thus, Passet (10) apparently is the first to have actually used Staphylococcus pyogenes without an attached varietal name. His work has likewise been very much misunderstood. Many subsequent authors have described lemon-yellow micrococci under the name Staphylococcus pyogenes citreus or Staphylo-

coccus citreus that clearly are not the Staphylococcus pyogenes citreus that Passet had in front of him. Passet studied the staphylococci present in aseptically drawn pus as did Rosenbach. He proposed the name Staphylococcus pyogenes citreus merely as a varietal name to be applied to organisms that formed lighter yellow colonies that were mixed with the darker yellow (aureus) colonies, as shown in his figure. He speaks of the darker yellow colonies as being more orange colored and the lighter yellow colonies as being more lemon colored. In further studies of the organism in the yellow colonies he found it to be pathogenic for rabbits, guinea pigs, and white mice, as also were the organisms in the orange and white colonies. He also gives other characters which show that his Staphylococcus pyogenes citreus was a variety of Staphylococcus pyogenes.

Passet presents the names for these pus-forming staphylococci in a section beginning on page 8 of his book. This section bears the title "Staphylococcus pyogenes aureus, albus, citreus." The first sentence of this section reads:

"Der Staphylococcus pyog. findet sich im Eiter der Menschen und Thiere am Häufigsten einzeln oder als Doppelkokkus."

In other words, Passet accepts the thought that Rosenbach was merely indicating two sorts of pus-forming staphylococci belonging to the species Staphylococcus pyogenes.

Lehmann and Neumann (9), who had a much clearer understanding of taxonomic principles and procedures than did Rosenbach, likewise accept pyogenes as the specific epithet proposed by Rosenbach, using it in the binomial Micrococcus pyogenes (Rosenbach) Lehm. and Neum. Under this species they recognize three varieties: α aureus (Rosenbach) Lehm.; β citreus (Passet) Lehm. and Neum.; γ albus (Rosenbach) Lehm. and Neum.

It seems clear that Germans understood Rosenbach's work as one that proposed a description of a species which showed variation in its chromogenesis as indicated by the subspecific epithets aureus and albus.

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CONCLUSION

It is recommended that the Judicial Commission recognize the valid and legitimate status of the generic name Staphylococcus Rosenbach 1884, for use wherever it is desired to subdivide the aerobic to facultatively anaerobic mass-forming cocci into two genera. The type species in this case would be Staphylococcus pyogenes Rosenbach. The culture recommended by Cowan, Shaw, and Williams (5) might well serve as the type culture for this type species.

It is recommended that Staphylococcus pyogenes aureus, Staphylococcus pyogenes albus, and Staphylococcus pyogenes citreus be accepted as names indicating varieties of the species Staphylococcus pyogenes without insisting that the name of the type variety be changed as required by Rule 7.

If the interpretation of the facts presented here is regarded by the Judicial Commission as correct, these recommendations would preserve for us in suitable fashion the generic and specific names that have been most generally used throughout bacteriological literature. While usage is not definitely recognized as a basis for establishing names under either the most recent Botanical or Bacteriological Codes, it forms, nevertheless, a sound basis by which to determine whether generic or specific names should be placed on lists of nomina conservanda. This is already recognized in some of the decisions rendered by the Judicial Commission.

REFERENCES

1. Breed, R. S., E. G. D. Murray, and A. P. Hitchens. Bergey's Manual of Determinative Bacteriology, 6th ed. Baltimore, Md. The Williams and Wilkins Co. 1948.
2. Buchanan, R. E., R. St. J. Brooks, and R. S. Breed. International Bacteriological Code of Nomenclature. Jour. Bact., 55:287-306. 1948.
3. Cohn, F. Untersuchungen über Bakterien. Beitr. Biol. Pflanz. 1:127-224. 1872.
4. Cowan, S. T. Specific epithet for the type species of Staphylococcus. Internatl. Bull. Bact. Nomen. and Taxon. 5:133-139. 1955.

5. _____, C. Shaw, and R.E.O. Williams. Type strain for Staphylococcus aureus Rosenbach. Jour. Gen. Microbiol. 10:174. 1954.
6. Evans, J., W.L. Bradford, Jr., and C.F. Niven, Jr. Comments concerning the taxonomy of the genera Micrococcus and Staphylococcus. Internatl. Bul. Bact. Nomen. and Taxon. 3:129. 1953.
7. Gordon, M.H. Bacterial test whereby particles shed from the skin may be detected in the air. Rept. Local Govt. Bd. London. 34th Ann. Rept. for 1904-05, 387-400. 1906.
8. Hucker, G.J. et al. Studies on the Coccaceae. New York Agr. Exp. Sta. Tech. Bulls. 99, 100, 101, 102, 103, 118, 134, 136, 141, 142, 143, 144, 167, 190, and 275. From the standpoint of the present discussion, the most important of these bulletins are "IV. Studies of the classification of the micrococci. Tech. Bull. 102. 1924," and "XVIII. The enterotoxin producing micrococci. Haynes, Wm. C. and G.J. Hucker. Tech. Bull. 275. 1945."
9. Lehmann, K.B. and R.O. Neumann. Bakt. Diag., 1 Aufl. Bd. 2. München (J.F. Lehmann Verlag). 1896.
10. Passet, J. Untersuchungen über die Aetiologie der eiterigen Phlegmone des Menschen. Berlin (Fisher's Verlag). 1885.
11. Rosenbach, F. G. Mikro-Organismen bei den Wund-Infektions-Krankheiten des Menschen. Wiesbaden (J. F. Bergmann's Verlag). 1884.
12. Welch, W.H. Amer. Jour. Med. Sci. Phila. N.S. 102: 441. 1891.
13. Winslow, C.-E.A., and Anne F. Rogers. A revision of the Coccaceae. Science N.S. 21:669-672. 1905.
14. _____, _____. A statistical study of generic characters in the Coccaceae. Jour. Inf. Dis. 3:485. 1906.
15. _____, William Rothberg, and Elizabeth'I. Parsons. Notes on the classification of the white and orange staphylococci. Jour. Bact. 5:145-167. 1920.
16. _____, and A. Rogers Winslow. The systematic relationships of the Coccaceae. New York, John Wiley and Sons, 300 pp. 1908.