MORAXELLA
SOME PROBLEMS OF TAXONOMY
AND NOMENCLATURE

S. D. Henriksen

Kaptein W. Wilhelmsen og Frues
Bakteriologiske Institutt, Oslo
University and Rikshospitalet
Oslo, Norway

The genus Moraxella as treated in the 7th edition of Bergey's Manual (1957) comprises only 3 species, M. lacunata, M. liquefaciens and M. bovis. In addition to these, various other organisms have been described as Moraxella species. It is the purpose of this paper to examine the case for or against admission of some of these organisms to the genus as well as to discuss some questions of nomenclature.

In a previous paper (Henriksen 1952) it was shown that, in addition to morphology, the oxidase reaction, penicillin sensitivity and preference for a humid atmosphere could be used as criteria in the classification of Moraxella. Further experience has confirmed the usefulness of these criteria, in particular the two former, and has further indicated that some strains of Moraxella are sensitive to other antibiotics which are mainly active on Gram-positive bacteria and on Neisseria, viz. erythromycin and bacitracin. In addition to this it may be pointed out that all species of Moraxella recognized so far, and some which may deserve recognition, appear to have been isolated exclusively from mucous membranes of man or animals.

Nothing needs to be said in this place about M. lacunata or M. liquefaciens, as their recognition as separate taxa can be taken for granted. As for M. bovis, early descriptions (Jones and Little 1923) as well as the cytological studies of Murray and Truant (1954) indicate that it is morphologically a typical Moraxella. Barner (1952) found that this organism shows some degree of sensitivity to penicillin, bacitracin, chloramphenicol, dihydrostreptomycin and terramycin. A study of 4 strains (strains 8561, 9425 and 9426 from the National Collection of Type Cultures in London and strain 10900, one of Barner's strains, from the American Type Culture Collection) confirmed that these

strains are morphologically indistinguishable from Moraxella duplex var. nonliquefaciens (Lwoff 1939). Furthermore, they all showed a strong oxidase reaction with dimethylparaphenylenediamine, and tests by the disk method of Ericsson, Högman and Wickman (1954) showed that they were all highly sensitive to bacitracin, erythromycin, streptomycin, chloramphenicol and oxytetracycline. Two strains were highly sensitive to penicillin (inhibition zones of 31 mm and 34 mm), the other two moderately sensitive (zones of 25 and 28 mm). Two strains were highly sensitive and two resistant to sulphathiazole. There can be no doubt that this organism should be included in Moraxella, and that fact that it produces haemolysis on blood agar in contrast to the other species, justifies its claim for separate recognition.

The diplobacillus described by Scarlett (1916) and named Moraxella duplex var. nonliquefaciens by Lwoff (1939) has not yet been included in Bergey's Manual, but there can hardly be any doubt that this organism is just as worthy of recognition as any other Moraxella. It has been shown (Henriksen 1958, Kaffka 1959) that this organism is a very common inhabitant in the upper respiratory tract of man, and that it possesses all the characteristics of Moraxella, including typical morphology, oxidase reaction and penicillin sensitivity. It differed from other Moraxellae in failing to liquefy coagulated serum and gelatin, and therefore should be recognized as a separate species.

Lwoff (1939) recognized an additional variety of M. duplex, the variety josephi, likewise originally described by Scarlett (1916). This organism was Gram-positive, only a single strain was studied, it has never been encountered again, and the original description is rather sketchy. There can be no good reason to maintain this organism as a separate species or variety, unless it should be rediscovered.

Audureau (1940) described a new species, Moraxella lwoffii, divided into the varieties brevis and bacteroides, and later Piéchaud, Piéchaud and Second (1951, 1956) added still another variety, var. glucidolytica, later raised to the rank of species, M. glucidolytica, apparently identical with Bacterium anitratum of Schaub and Hauber (1948). It was shown in a previous paper (Henriksen 1952) that representative strains of these species showed little resemblance to Moraxella. Brisou and his collaborators (Brisou 1953,

1957a, 1957b, 1958; Bourlat 1953; Brisou and Morichaud-Beauchant 1952; Brisou, Morichaud-Beauchant and Giminez 1953; Brisou and Prévot 1954) arrived at similar conclusions and classified these organisms in Pseudomonadaceae, tribus Achromobactereae, genus Acinetobacter under the names A. lwoffii and A. anitratum. It is felt that this re-classification settles the dispute about the relationship of these organisms to Moraxella, as well as the question about the validity of the tribe Mimeae of De Bord.

Audureau (1940) also described a new variety of M. lacunata var. atypica, which differed from M. lacunata in failing to liquefy serum. Since otherwise only morphological criteria, which have proved unreliable in other cases, were used, it may be suggested that this organism should be re-examined before its relationship to Moraxella is determined.

Flamm (1956) described a strain of diplobacilli, isolated from spinal fluid, which he considered a new species of Moraxella, M. saccharolytica. The description indicates that this strain resembled Moraxella morphologically and possessed several additional Moraxella characteristics (oxidase reaction, penicillin sensitivity), but it differed from other Moraxellae in decomposing certain sugars with development of an acid reaction. The antibiogram showed by the strain was rather unusual with sensitivity to penicillin, polymyxin and supronal, and resistance to streptomycin, chloromycetin and tetracyclines. Apart from some hesitation in recognizing a new species on the basis of a single strain, it appears that this may be a new species, and that the name proposed by Flamm is correct. The strain should, however, be deposited in one of the type culture collections, unless this has already been done.

Finally Flamm (1957) described still another strain from a case of meningitis, believed to be a new species, M. polymorpha. This organism appeared to be a typical Moraxella in most respects, but it was characterized by a very marked pleomorphism and refused to grow in broth without the addition of serum. As for pleomorphism, this is a common characteristic of Moraxella. Thus pleomorphic strains of M. nonliquefaciens have been described by Murray and Truant (1954) and by the author (1958). In view of the fact that it appears that the strain did grow on plain nutrient agar without serum, it is felt that the need for

serum in broth can not be worthy of taxonomic recognition. Murray and Truant (1954) described a strain which showed unusual nutritional requirements in early cultures, but later was adapted to simple media. It seems probable that Flamm's strain may have been a slightly unusual strain of M. nonliquefaciens.

In conclusion, the organisms described as M. lacunata, M. liquefaciens, M. bovis, M. duplex var. nonliquefaciens and, with some hesitation, M. saccharolytica should be placed in different taxa in the genus Moraxella. M. lwoffii with the varieties brevis, bacteroides and glucidolytica do not belong in this genus. M. lacunata var. atypica should be re-examined before it is accepted, and M. polymorpha is considered to belong to M. duplex var. nonliquefaciens.

Turning to questions of taxonomy and nomenclature, none of the early names used in the original descriptions appear to be legitimate, and the first successful attempt to group and name these organisms is due to Lwoff (1939). In the absence of previous valid names, it would appear that the names proposed by Lwoff are valid and remain so, unless definite action is taken to change his system of classification.

Three different courses of action seem to be possible. First one might follow Lwoff's proposal and maintain the two species M. lacunata and M. duplex, the latter subdivided into the varieties liquefaciens and nonliquefaciens. The variety josephi should not be recognized, but var. bovis should be added as a new variety, as suggested by Lwoff. M. saccharolytica could be added as a third species as proposed by Flamm, since the faculty of decomposing sugars may be of some taxonomic significance. The rules of nomenclature and reasons of priority would appear to be in support of this alternative. On the other hand the division of bacterial species into varieties is not very common, and no practical advantage is gained by considering these organisms as varieties of the same species and not as separate species. Furthermore, it is difficult to understand why greater taxonomic significance should be attached to the need for serum (actually probably only a question of neutralization of some toxic component of the usual media) than to the faculty of digesting solid proteins.

Second, one might consider all the Moraxellae recognized so far (with the possible exception of M. saccharolytica) as

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a single species, M. lacunata with the varieties liquefaciens, nonliquefaciens and bovis. There may be little to be said in support of this plan, except that it is simple and takes the close similarity of the Moraxella strains into consideration. The differences may be rather slight to justify separation into different species.

Third, one might give all these organisms the rank of species, M. lacunata, M. liquefaciens, M. nonliquefaciens, M. bovis and M. saccharolytica. This may be the simplest solution and the one that is in the closest conformity to the usual principles and customs of classification. It meets the practical need for separation of different organisms in different taxa, without making any distinction between the relative taxonomic significance of different types of criteria. And it would always be possible to change the system at some later date, if future studies should show that this was desirable. But, in view of what has been said above, it is felt that this course of action could only be taken if the International Committee formally decides to do so and to set previous proposals for the classification of this group aside. It is the opinion of the present author that such action would be desirable.

SUMMARY

It is proposed that the genus Moraxella should be divided into the species M. lacunata, M. liquefaciens, M. nonliquefaciens and M. bovis, and that the recognition of M. saccharolytica as a new species should be considered.

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