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Letters to the Editor

Public health and patient safety concerns merit retention of Lyme borreliosis-associated spirochetes within the genus *Borrelia*, and rejection of the genus novum *Borreliella*

Lyme borreliosis (also called Lyme disease) is the most common arthropod-borne bacterial disease of humans in North America, Europe, and Asia. For example, an estimated 300,000 people become infected each year in the USA, and, according to health insurance data, over 200,000 cases of Lyme borreliosis occur every year in Germany (Müller et al., 2012; Nelson et al., 2015; Radolf et al., 2012; Schwartz et al., 2017; Stanek and Strle, 2003; Steere, 2001; Sykes and Makiello, 2017). In recent years, there have been substantial expansions of the range of the tick vector in North America, leading to increased incidence of human infections (Khatchikian et al., 2015; Stone et al., 2017).

Symptoms of Lyme borreliosis can vary widely among patients and may include characteristic skin lesions, arthritis, meningitis, radiculoneuritis, facial nerve paralysis, ocular involvement, and atrioventricular nodal block (Forrester and Mead, 2014; Hegerova and Olson, 2014; Kuchynka et al., 2015; Pinto, 2002; Robinson et al., 2015; Stanek and Strle, 2003; Steere, 2001). Failure to treat this infection during the early stages of infection can result in later clinical manifestations that may be more difficult to treat, such as Lyme arthritis and acrodermatitis chronica atrophicans. A missed or delayed diagnosis of Lyme carditis might even contribute to patient mortality (Forrester and Mead, 2014; Koene et al., 2012; Shenthar et al., 2014; Stanek and Strle, 2003; Steere, 2001; Yoon et al., 2015).

After its discovery during the early 1980s, the causative agent of Lyme borreliosis was named *Borrelia burgdorferi* (Burgdorfer et al., 1982; Johnson et al., 1984). Subsequent investigations led to its division into several genospecies, e.g., *B. burgdorferi* (sensu stricto), *B. afzelii, B. garinii*, and others. Also existing within the genus *Borrelia* are agents of avian spirochetosis (*B. anserina*, the type species of the genus); soft tick-borne relapsing fever (*B. hermsii, B. duttonii*, and others, vectored by argasid ticks); louse-borne relapsing fever (*B. recurrentis*); *B. miyamotoi*, the agent of a disease that is distinct from Lyme borreliosis but vectored by the same tick species of the *Ixodes ricinus-persulcatus* species complex; and a large number of *Borrelia* genospecies with unknown human pathogenicity that are tick-transmitted and associated with tortoises, snakes, echidnas, and other vertebrates (Cutler et al., 2017). The chromosomes of the Lyme borreliosis agents are largely syntenic with those of the tick-borne relapsing fever *Borrelia* species, with the same gene orders and only 21 protein-coding genes (out of approximately 840) being specifically present only in one or the other group (Adeolu and Gupta, 2014; Pettersson et al., 2007). In addition, the type species of the genus *Borrelia*, *B. anserina*, lacks three genes that are contained by every other sequenced member of the genus, namely *glpA, glpF*, and *glpK* (Elbir et al., 2017). Moreover, the majority of *Borrelia* species have yet to be characterized at a genomic level, so the extent of diversity among these bacteria is not known.

A proposal was recently presented to split the spirochetes that cause Lyme borreliosis, and others within an undefined range of genomic similarity, into a new genus, *Borreliella* (Adeolu and Gupta, 2014). Other members of the genus *Borrelia* were to remain in the original genus. We note that the revised nomenclature does not invalidate the previously established nomenclature; for example, the same bacterium can validly be called either *Borrelia burgdorferi* or *Borreliella burgdorferi*.

As with many other bacteria, it is difficult to decide how different two organisms have to be before they are placed in separate species or genera. Arguments based on genetic similarities and differences can be made for and against the division of *Borrelia* (Barbour et al., 2017; Margos et al., 2017). However, changing the name of a pathogenic microorganism is not permitted if it poses a risk to public health and patient safety (*nomen periculosum,* as per Rule 56a of the International Code of Nomenclature of Prokaryotes) (Parker et al., 2015). Following this guidance, we describe safety concerns pertaining to changing the genus name of Lyme borreliosis-causing spirochetes:

1 Lyme borreliosis and *Borrelia* are thoroughly intertwined in medical references. It is imperative that physicians and other care givers receive prompt and accurate information when diagnosing and treating patients. New information on treatment recommendations or diagnostic tests is frequently published. From discovery onward, all publications on Lyme borreliosis describe the causative bacteria as members of the genus *Borrelia*. Only the paper on renaming the genus (Adeolu and Gupta, 2014), and fewer than ten others, even mention the word "*Borreliella.*"
2 Throughout the world, countless databases store diagnostic and treatment information. Search algorithms are usually based on keyword matches in order to retrieve the requested information. Thus, a search for *Borreliella* will likely fail to identify information that uses the name *Borrelia*, and vice versa. There is significant potential that such a failure could lead to diagnostic confusion and sub-optimal patient treatment, increasing the possibility of poor outcomes for patients. Overcoming this problem would require replacement of every database and/or access program throughout the world, which is not a practical solution. The possible risk to human health far outweighs any benefit of the proposed bacterial species name change.
3 In some countries, payment for the delivery of diagnostic testing services and clinical care to patients is highly dependent upon the use of standardized, precise disease codes and procedural codes (e.g. ICD-10, CPT in the USA). Such coding in hospitals, clinics, health care systems and insurance companies is indeed based on the terminology "*Borrelia.*" Inconsistencies in coding and related descriptors in computer systems, along with debates about whether or not *Borreliella burgdorferi* is the same causative agent as *Borrelia burgdorferi*, present genuine risks of confusion, denial of claims, and delay in proper insurance coverage. Consequently, access to diagnosis and treatment may be compromised, which could endanger the patient's health.

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4 Government regulations differ around the world. Similarly, health insurance coverages and procedures vary extensively. A diagnostic test or treatment regimen with approved use for treating infections by *Borrelia burgdorferi* sensu lato may not automatically be accepted for *Borreliella burgdorferi*. In such cases, a patient may be denied treatment or misdiagnosed. Again, this potential threat to human health needs to be of primary concern.
5 Lyme borreliosis is considered to be a professional risk in many countries for persons working in forested or grassy areas. Specific diagnosis and treatment are often covered by professional insurance programs; debates about *Borreliella* as being the same as *Borrelia* has the potential to delay proper insurance coverage and, consequently, diagnosis and treatment. This endangers the patient's health and – by consequence – further employment.

In summary, a change of the genus name of spirochetes that cause Lyme borreliosis from *Borrelia* to any other name is likely to create great confusion and has the potential to harm patients.

We urge the responsible authorities to establish the following names (that are now listed in the List of Prokaryotic Names with Standing in Nomenclature) as nomen periculosa and reject their validations: *Borreliella burgdorferi*, *Borreliella garinii*, *Borreliella bavariensis*, *Borreliella carolinensis*, *Borreliella japonica*, *Borreliella kurtenbachii*, *Borreliella sinica*, and *Borreliella spielmanii*, as well as any other application of the genus name *Borreliella*. For those same reasons, we urge government, business, and medical authorities, as well as scientists and clinicians, to use only the original genus name *Borrelia* for Lyme borreliosis-associated spirochetes.

This letter was cosigned by:

Patricia V. Adem M.D.
Department of Pathology, New York Medical College, Valhalla, NY, USA.
Armin Alaedini Ph.D.
Department of Medicine, Columbia University Medical Center, New York, NY, USA.
Paul M. Arnaboldi Ph.D.
Department of Microbiology and Immunology, New York Medical College, Valhalla, NY, USA.
Paul G. Auwaerter M.D.
Fisher Center for Environmental Infectious Diseases, Johns Hopkins University School of Medicine, Baltimore, Maryland, MD, USA.
Johan S. Bakken M.D., Ph.D.
Department of Family Medicine, University of Minnesota, Duluth, MN, USA.
Aleksandra Barac M.D., Ph.D.
Clinic for Infectious and Tropical Diseases, Clinical Centre of Serbia, Faculty of Medicine, University of Belgrade, Belgrade, Serbia.
Nicole Baumgarth D.V.M., Ph.D.
Center for Comparative Medicine, University of California, Davis, CA, USA.
Anna Beltrame Ph.D.
Centro per le Malattie Tropicali, Ospedale Sacro Cuore - Don Calabria, Negrar (Verona), Italy.
Jon S. Blevins Ph.D.
Department of Microbiology and Immunology, University of Arkansas for Medical Sciences, Little Rock, AR, USA.
Nathalie Boulanger Ph.D.
French Reference Center on *Borrelia*, Strasbourg Hospital and University of Strasbourg (Head of Lyme borreliosis research group), France.
John A. Branda M.D.
Department of Pathology, Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA.
Catherine A. Brissette Ph.D.
Department of Biomedical Sciences, University of North Dakota, Grand Forks, North Dakota, USA.
Dustin Brisson Ph.D.
Department of Biology, University of Pennsylvania, Philadelphia, PA, USA.
Isabel Lopes de Carvalho Ph.D.
Instituto Nacional de Saude Doutor Ricardo Jorge, Lisboa, Portugal.
Nyles W. Charon Ph.D.
Department of Microbiology, Immunology, and Cell Biology, West Virginia University, Morgantown, West Virginia, USA.
Croxatto Antony Ph.D.
Institute of Microbiology, Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne, Switzerland.
Sally Cutler Ph.D.
Stratford Campus School of Health Sport and Bioscience, University of East London, London, UK.
Thomas J. Daniels Ph.D.
Dept. of Biological Sciences, Fordham University, Bronx, NY, USA.
Marketa Derdakova Ph.D.
Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia.
Rick Dersch M.D.
Universitätsklinikum Freiburg, Abteilung für Neurologie und Neurophysiologie, Neurozentrum, Freiburg, Germany.
Ram B. Dessau, M.D., Ph.D.
Department of Clinical Microbiology, Slagelse Hospital, Denmark.
Maria Diuk-Wasser Ph.D.
Department of Ecology, Evolution and Environmental Biology, Columbia University, 1200 Amsterdam Ave., New York, NY, USA.
Helmut Eiffert M.D., Ph.D.
Universitätsmedizin Göttingen, Institut für Medizinische Mikrobiologie, Göttingen, Germany.
Randi Eikeland M.D.
Norwegian Advisory Unit for Tick Borne Diseases, Sørlandet Hospital, Norway.
David G. Ellis
SmartGene, Inc., Raleigh NC 27624 – 9543, USA.
Stefan Emler M.D.
SmartGene Services, EPFL Innovation Park, Lausanne, Switzerland.
Henry M. Feder Jr. M.D.
Family Medicine, University of Connecticut Medical Center & Pediatrics, Connecticut Children's Medical Center, CT, USA.
Erol Fikrig M.D.
Section of Infectious Diseases, Department of Internal Medicine, Yale University School of Medicine, New Haven, CT, USA.
Howard Hughes Medical Institute, Washington DC, USA.
Michael Freitag MPH
Abteilung Allgemeinmedizin, Department für Versorgungsforschung, European Medical School Oldenburg – Groningen, Carl von Ossietzky Universität Oldenburg, Oldenburg, Germany.
Neil S. Goldberg M.D.
Dermatology Private Practice, White Plains, NY, USA.
Maria Gomes-Solecki D.V.M.
Department of Microbiology, Immunology, and Biochemistry, University of Tennessee Health Science Center, Memphis, TN, USA.
Gilbert Greub M.D., Ph.D.
Institut de microbiologie de l'Université de Lausanne, Département des laboratoires, Lausanne, Switzerland.
Peter Herzer M.D.
Rheumatology, Medical Care Centre MEDICOVER München, München, Germany.
Heidelore Hofmann M.D.
Klinik für Dermatologie und Allergologie, TU München, München, Germany.
Thomas G.T. Jaenson Ph.D.
Department of Organismal Biology, Uppsala University, Uppsala, Sweden.
Reinhard Kaiser M.D.

Neurology, Helios Klinikum Pforzheim, Pforzheim, Germany.

Vivian Kjelland Ph.D.

Department of Natural Sciences, Faculty of Engineering and Science, University of Agder, Kristiansand, Norway & Research Unit, Sørlandet Hospital Health Enterprise, Kristiansand, Norway.

Uwe Koedel Ph.D.

Neurologische Klinik Großhadern, Klinikum der Universität München, München, Germany.

Wilhelm Kohlhepp M.D., Ph.D.

Scharnhorststraße, Berlin, Germany.

Peter Kraiczy Ph.D.

Institut für Medizinische Mikrobiologie und Krankenhaushygiene, Klinikum der Goethe-Universität, Frankfurt/Main, Germany.

Andreas Krause M.D.

Abteilung Rheumatologie und Klinische Immunologie, Immanuel Krankenhaus Berlin, Berlin, Germany.

Reto Lienhard M.Sc.

ADMed Microbiologie, Laboratoire Microbiologie, La Chaux-de-Fonds, Switzerland, and Part of CNRT (Swiss Reference Center forTick transmitted disease) for Lyme Borreliosis Diagnostic, Switzerland.

Sally Mavin M.D.

National Lyme borreliosis testing service laboratory, Microbiology department, Raigmore Hospital, Inverness, Scotland, UK.

Robert B. Nadelman M.D.

Division of Infectious Diseases, New York Medical College, Valhalla, NY, USA.

Raquel Escudero Nieto Ph.D.

Laboratorio de Referencia e Investigación en Patógenos Especiales, Centro Nacional de Microbiología-Instituto de Salud Carlos III, Majadahonda, Madrid, Spain.

Lise E. Nigrovic M.D., M.P.H

Division of Emergency Medicine, Boston Children's Hospital, Boston, MA, USA.

Sheila M. Nolan M.D., M.S.C.E.

Division of Pediatric Infectious Diseases, New York Medical College, Valhalla, NY, USA.

Ana Cláudia do Souto G. Norte PhD.

MARE - Marine and Environmental Sciences Centre, Department of Life Sciences, Faculty of Sciences and Technology, University of Coimbra, Coimbra, Portugal.

John Nowakowski M.D.

Division of Infectious Diseases, New York Medical College, Valhalla, NY, USA.

Sofia Núncio Ph.D.

Instituto Nacional de Saude Doutor Ricardo Jorge, Lisboa, Portugal.

Charlotte OskamBBiomedSc, M.Sc., Ph.D.

Vector & Waterborne Pathogens Research Group, School of Veterinary & Life Sciences (Medical & Molecular Sciences), Murdoch University, Murdoch, WA 6150, Australia.

Charles Pavia Ph.D.

Dept. of Biomedical Sciences, NYIT College of Osteopathic Medicine, Old Westbury, NY, USA.

Mary M Petzke Ph.D.

Department of Microbiology and Immunology New York Medical College Valhalla, New York, NY, USA.

Hans-Walter Pfister M.D.

Neurologische Klinik Großhadern, Klinikum der Universität München, München, Germany.

Didier Raoult M.D., Ph.D

Aix Marseille Université, URMITE, UM63, CNRS 7278, IRD198, Inserm 1095 ; IHU Méditerranée Infection, Marseille, France.

Ira Schwartz Ph.D.

Dept. of Microbiology and Immunology, New York Medical College, Valhalla, NY, USA.

Eugene D. Shapiro M.D.

Departments of Pediatrics, of Epidemiology of Microbial Diseases, and of Investigative Medicine, Yale University, New Haven, CT, USA.

Sunil K. Sood M.D.

Professor of Pediatrics, Cohen Children's Medical Center, Northwell Health, Zucker School of Medicine at Hofstra/Northwell, USA.

Hein Sprong Ph.D.

National Institute of Public Health and Environment (RIVM), Laboratory for Zoonoses and Environmental Microbiology, BA Bilthoven, Netherlands.

Klaus Stark M.D.

Gastrointestinal Infections, Zoonoses and Tropical Infections, Infectious Disease Epidemiology, Robert Koch Institute, Berlin, Germany.

Allen C. Steere M.D.

Division of Rheumatology, Allergy and Immunology, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA.

Franc Strle M.D.

Department of Infectious Diseases, University Medical Center Ljubljana, Ljubljana, Slovenia.

Klemen Strle Ph.D.

Division of Rheumatology, Allergy, and Immunology, Massachusetts General Hospital, Harvard Medical School, MA, USA.

Veronika Taragel'ova Ph.D.

Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia.

Marie-Lise Tritten Arber Microbiologiste FAMH

ADMED Microbiologie, La Chaux-de-Fonds, Switzerland.

Jean I. Tsao Ph.D.

Departments of Fisheries and Wildlife and of Large Animal Clinical Sciences, Michigan State University, East Lansing, MI, USA.

Yngvar Tveten Chief Consultant

Telemark County Hosptial, Skien, Norway.

Reinhard Wallich Ph.D.

Klinikum der Universität Heidelberg, Institut für Immunologie, Heidelberg, Germany.

Hendrik Wilking M.Sc.

Gastrointestinal Infections, Zoonoses and Tropical Infections, Infectious Disease Epidemiology, Robert Koch Institute, Berlin, Germany.

Susan J. Wong Ph.D.

Wadsworth Center, New York State Department of Health, Albany, NY, USA.

X. Frank Yang Ph.D.

Department of Microbiology and Immunology, Indiana University School of Medicine, Indianapolis, IN, USA.

Declarations of interest

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Brian Stevenson[a,b,*]
[a] *Department of Microbiology, Immunology, and Molecular Genetics, University of Kentucky, Lexington, Kentucky, 40536-0298, USA*
[b] *Department of Entomology, University of Kentucky, Lexington, Kentucky, 40546-0091, USA*
E-mail address: brian.stevenson@uky.edu (B. Stevenson)

Volker Fingerle
German National Reference Centre for Borrelia, Bavarian Health and Food Safety Authority, Oberschleissheim, Germany
E-mail address: Volker.Fingerle@lgl.bayern.de (V. Fingerle)

Gary P. Wormser
Division of Infectious Diseases, New York Medical College, Valhalla, NY, USA
E-mail address: GWormser@nymc.edu (G.P. Wormser)

Gabriele Margos
German National Reference Centre for Borrelia, Bavarian Health and Food Safety Authority, Oberschleissheim, Germany
E-mail address: Gabriele.Margos@lgl.bayern.de (G. Margos)

* Corresponding author at: Department of Microbiology, Immunology, and Molecular Genetics, University of Kentucky, Lexington, Kentucky, 40536-0298, USA.