

Otto Müller's *Surirella* taxa (Bacillariophyta) from East Africa, based on a historical collection kept at the Botanic Garden and Botanical Museum Berlin-Dahlem (B)

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At the beginning of the 20th century, Otto Müller described over 100 new freshwater diatom taxa from algae samples, collected during the German “Nyassa-See- und Kinga-Gebirgs-Expedition” in East Africa. He published valuable drawings and wrote detailed descriptions of these microalgae, but subsequent authors regarded many of these African taxa to be synonyms or infraspecific of European species. In the last two decades renewed attention to the diatom flora of East Africa has made it evident that Müller’s taxa have to be reinvestigated, in terms of both light as well as scanning electron microscopy, in order to evaluate possible new or endemic species. This was recently done for his *Surirella* taxa, a typical component of the African Great Lakes diatom flora of which many species are endemic to this area. Additional data, originating from material of later periods in the same region (e.g. Lakes Tanganyika, Malawi, Victoria, Edward), was incorporated in the investigation to study the variability in valve morphology and the African distribution of each species. Otto Müller’s samples thus provide the means to study historical African diatom diversity as a baseline for modern biodiversity assessment. Type information and the English description for taxon have been published in international journals and online at the AlgaTerra Information System [www.algaterra.org], a site developed and updated by the Botanic Garden and Botanical Museum Berlin-Dahlem (BGBM). High resolution digital photographs of the *Surirella* taxa will also be available in the future on the API website [www.aluka.org].

Key words: Algae, Diatoms, Historic Collections, East Africa

Introduction

The end of the 19th and beginning of the 20th century was characterized by the launching of several important scientific expeditions to East Africa and the East African Great Lakes area during which microscopic freshwater algae were collected. This period

was preceded by the Livingstone mission to the shoreline of Lake Nyassa (= Lake Malawi), resulting in the first publication dealing with tropical African algae (Dickie 1879). The most important historical expeditions, from an algological point of view, were the “Nyassa-See und Kinga-Gebirgs-Expedition der Hermann- und Elise-geb. Heckmann-Wentzel-Stiftung” (1897-1898) (Schmidle 1900, 1902; Müller 1903, 1904, 1905, 1912), and “The Third Tanganyika expedition conducted by Dr. Cunningham” (1904-1905) (West 1907). Some decades later two Belgian expeditions, the “Exploration du Parc National Albert Park, Mission H. Dumas” (1935-1936) and the “Exploration hydrobiologique du lac Tanganika” (1946-1947) were organized, resulting in the collection of additional algae material, not only from lakes already sampled before, but also from new places, such as Lakes Kivu and Edward (Conrad 1949, Frémy 1949, Hustedt 1949, Pascher 1949 and Van Meel 1954).

Some of these historical algae collections are still kept at European institutions, for example the Müller Collection acquired during the German expedition of 1897-1898 is kept at the Botanic Garden and Botanical Museum Berlin-Dahlem (B), the G.S. West Collection derived from the British expedition of 1904-1905 at the British Natural History Museum (BM), and the diatom collection from the 1935-1936 expedition at the Friedrich Hustedt Diatom Collection (BRM), housed in the Alfred-Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

In addition to the historically important expeditions mentioned above, algae were also collected on smaller scale expeditions: for example from Lake Victoria at the beginning of the 20th century by Agassiz (1908) and Schröder (1910). Ostenfeld and Schröder himself studied the algal composition resulting in several publications (e.g. Ostenfeld 1908, 1909; Schröder 1911, 1912). The material and microscope slides are kept at the Museum Botanicum Hauniense (C), Copenhagen, Denmark.

Several species epithets (e.g. *Aulacoseira agassizii* (Ostenf.) Simonsen, *Melosira schroederi* Wołosz., *Nitzschia ostefeldii* Hust., *Surirella fuellebornii* O. Müll.) and generic names (e.g. *Schroederiella africana* Wołosz.) of East African algae are dedicated to these early algae collectors.

The present paper deals with biologically important aquatic organisms, the diatoms (Bacillariophyta) which are unicellular micro-algae with a siliceous exoskeleton (frustule). Because of their exoskeleton, diatoms remain well preserved, both in sediments and in permanent collections. In order to establish a baseline for their occurrence and thus their distribution pattern, and to understand their endemism in Africa, this paper stresses the importance of algae collections, for both their historical value and their usefulness as a scientific tool. As the earliest East African diatom taxa have been described by Otto Müller, this study focuses on one genus, *Surirella*, and the re-evaluation of the taxa Müller described.

Sampling and preservation of diatoms: a non-technical account

A difference exists between collecting large organisms such as “higher plants”, and microscopic algae. Plants are collected in the field and pressed between paper, in most



Fig. 1. The Botanical Museum Berlin-Dahlem (B). A) After its destruction in 1943; the herbarium was kept in the wing on the right hand side (photo: BGBM). B) After its restoration in 1987 (photo: I. Haas, BGBM 2003); the herbarium is now kept underneath the central area in the front of the picture; today the wing on the right hand side contains the library.

cases newspaper. The drying process continues in the laboratory in an oven which is especially necessary in tropical wet regions so as to avoid the sampled material becoming moldy or rotten due to high humidity. For preservation purposes, the collected plants are fixed on special herbarium sheets. A sheet contains a single specimen (= one “plant”). If the specimen is the base for a new species description (nomenclatural type), the herbarium sheet is labeled in a special way – it is put in a red folder or marked in red – following a well-established tacit convention between several herbaria; the labelling must follow the International Code of Botanical Nomenclature, ICBN (McNeill *et al.* 2006).

Microscopic algae, on the other hand, are collected by taking water samples that can be concentrated using a phytoplankton net whose mesh width varies between 10 and 28 μm . This method is ideal for collecting free-living organisms where the plankton concentration is low. The attached species are scraped off the substratum (stones, pebbles, plants, and so on). The sampled material is not dried between papers but a fixative, often diluted formalin, is added to the wet sample. The preservation method can be in a “wet collection” and/or on permanent microscope slides, depending on the group of algae. As diatoms are microscopic unicellular organisms containing silica in their cell wall, cleaning of the material is needed. This cleaning comprises an oxidation process to remove organic matter, not only in the organism itself, but also in the total sample. Cleaned material is mounted on microscope slides in a resin (e.g. Naphrax) with a high refractive index (1.78). The slide contains, in most cases, a large number of individuals belonging to several species. The position of a certain diatom on the slide can be indicated by a small ring on the cover glass, or notation of the coordinates on the X and Y axes as indicated on the microscope stage micrometer. In the past diatoms were often isolated and a small number of individuals belonging to the same species were the only individuals present in the microscope slide. This process is only possible for “larger” diatoms (diatom dimensions range from about 5 μm (= 0.005 mm) to around 0.5 mm). Besides the microscope slides most herbaria maintain a “wet collection” which can be very useful for taxonomic studies as the ultra-structure of the taxa can be studied by means of SEM (Scanning Electron Microscopy).

Since diatoms, and most other algal groups, have been traditionally treated as plants (currently classified in the Chromista), the process of assigning a name must also follow the ICBN (McNeill *et al.* 2006).

Otto Müller’s diatom taxa from East Africa

Otto Müller (1837-1917), by profession a book publisher in Berlin, wrote 41 papers on diatoms, six of which dealt with material from East Africa (Jahn 2002). He described new genera (*Rhopalodia* and *Gomphocymbella*) and more than 100 new diatom species, of which 25 belong to the genus *Surirella*. The main East African material he studied was collected by F. Fülleborn and W. Goetze during the German East Africa expedition at the end of the 19th century to Lake Malawi (= Lake Nyassa) and the vicinity. Other samples originated from diverse places, such as Lake Victoria (collected by F. Stuhlmann in 1882 and A. Borgert in 1904), the Kilimanjaro area (collected by G. Volkens in 1892). The ma-

terial Müller used for his description of the new East African taxa was deposited at the Botanic Museum of Berlin-Dahlem (B). Unfortunately, large parts of the buildings of the museum were destroyed in 1943 during World War II (Fig. 1) including most of the herbarium. Important nomenclatural types, which serve as calibration for organism names as they form the basis upon which a species is described, is an indispensable tool for taxonomists, were lost to science.

Some years ago, a problem arose for one of us (C. C.) during the study of diatoms from the northern basin of Lake Tanganyika: a diatom, a *Surirella* species, was observed resembling the description and drawing of *Surirella malombae* O. Müll., described from Lake Malombe, located downstream of the discharge of Lake Malawi. Hustedt (1942) had synonymized this species with *S. nyassae* O. Müll., a species described from Lake Malawi. However, the material observed from Lake Tanganyika did not fit the dimensions and other taxonomic characteristics of *S. nyassae* O. Müll. sensu Hustedt. The only way to know the exact identity of *S. nyassae* and *S. malombae* was to study the original material the species were described from (Fig. 2). This seemed to be an impossible task since the material had been destroyed in 1943.

In the early 1990's another member of the team (R. J.) discovered a number of historical flasks in the basement of the Botanical Museum Berlin-Dahlem. What had seemed to be an impossibility became reality: these flasks contained material sampled at the turn of the 19th century in East Africa (Jahn 1996). Fortunately, the samples Fülleborn collected on August 17, 1899 in Lake Malawi and on February 17, 1900 in Lake Malombe, and which were used by Müller to describe *S. nyassae* and *S. malombe*, were amongst these. This allowed the authors to make new permanent microscopic slides and to designate types of both species, in this case lectotypes. The study of both samples, microscope slides as well as SEM investigations, led us to conclude that the two species described by Müller are indeed two different species (Cocquyt & Jahn 2007a). Moreover, the species observed in Lake Tanganyika does not belong to one of these, but is a different entity and was described as *Surirella chepurnovii* Cocquyt & Jahn (Cocquyt & Jahn 2007a).

Not all the *Surirella* species described by Müller from East Africa could be traced back to a specimen. This was the case when the diatom was described from a sample which was not among the rediscovered flasks e.g. *Surirella panganensis* O. Müll. (Cocquyt & Jahn 2005). In some cases the original sample was found, but no organism resembling the description and drawing of Müller was observed in the newly made microscope slides. The original drawing of Müller then is designated as the lectotype. *Surirella fasciculata* O. Müll. can be used as an example. This species was described from a sample collected in Lake Ngozi, a brackish water crater lake on Mountain Ngozi on the northern edge of Konde-land, Tanzania. As we have found this species in one of the other historic samples (collected in a basin near the hot spring of Utengule, Beya Mountain, Tanzania), collected during the same period, this microscopic slide was designated as type, in this particular case an epitype (Cocquyt & Jahn 2007c).

To make Müller's East African diatoms more easily accessible to modern researchers, his original German descriptions were translated, the names lectotypified, and the

taxonomy discussed based on modern light microscopy and scanning electron microscopy photographs whenever possible; diatom names were changed to comply with modern taxonomy and classification schemes, or the rules of the ICBN (McNeill *et al.* 2006) when necessary. In addition, to facilitate access to names and taxonomic information, this information was made available via the AlgaTerra Information System on the Internet (Jahn & Kusber 2007, Kusber & Jahn 2007).

Otto Müller's East African *Surirella* taxa as a tool for future research

The historical collection allowed us to study species diversity in East Africa and to describe two new species: *Surirella chepurnovii* and *Surirella olungensis* Cocquyt & Jahn (Cocquyt & Jahn 2007a, 2007c). All East African species described by O. Müller belonging to the genus *Surirella* have recently been re-investigated (Cocquyt & Jahn 2005, 2007a, 2007b, 2007c, 2007d) (Table 1).

In addition, the diatom community structure at the end of the 19th and beginning of the 20th century can be reconstructed for the water body from which the sample was collected; even though the sample may represent a temporal representation of the diatom community. This allows for the possibility of studying changes in diatom composition between the past and the present. In European countries, such as Germany, comparisons of historical and recent samples have improved the Red List of Diatoms as a tool for environmental research (Lange-Bertalot 1996).

Of the 17 taxa that were described by Otto Müller from diverse habitats at the turn of the 19th century, only one taxon (*S. fuellebornii*) is currently a common element of the East African diatom flora of the three large lakes, i.e. Lake Malawi, Lake Victoria and Lake Tanganyika. On the other hand, one taxon (*S. nyassae*) is common in Lake Malawi and Lake Victoria, while another species (*Surirella malombae*) is only common in Lake Victoria. The latter two species are absent in Lake Tanganyika where *Surirella engleri* is the most common *Surirella* species. The other taxa are less common and two species (*S. panganiensis*, *S. turbo*) have never been recorded since their description from their type locality. This indicates that either these species may have disappeared altogether due to habitat change, or that a thorough study of the type locality and analogous waterbodies is needed in order to recollect them. Nevertheless, this indicates that East Africa supported, and may still support, a great diversity of *Surirella* species which can serve as a baseline from which diatom biogeography and endemism can be understood.

Changes in the diatom composition in Africa can also lead to the detection of environmentally vulnerable taxa, which is the case for many *Surirella* species. From the more than 300 *Surirella* species reported from the African continent (Cocquyt, unpublished data), 28 have a distribution restricted to Lake Tanganyika (Cocquyt 2000). A number of these species are threatened with extinction or are already extinct due to anthropogenically induced changes in the lake. For example, the higher sedimentation rate caused by deforestation is one of the major problems (Cohen *et al.* 1993).

An intensive investigation of the East African *Surirella* taxa, including morphometric studies of different species, is the basis for the study of speciation and radiation within

these diatoms. Whereas preliminary cladistic analyses were conducted on a section of these species (Cocquyt et al. 2006), genetic information is needed to support the results, and to conclude whether or not the speciation and radiation within the Surirellaceae followed the same scenario as that reported for haplochromine Cichlids (as described in Salzburger et al. 2002). As the diatoms are part of the diet of these fish a similar scenario could be an obvious statement.

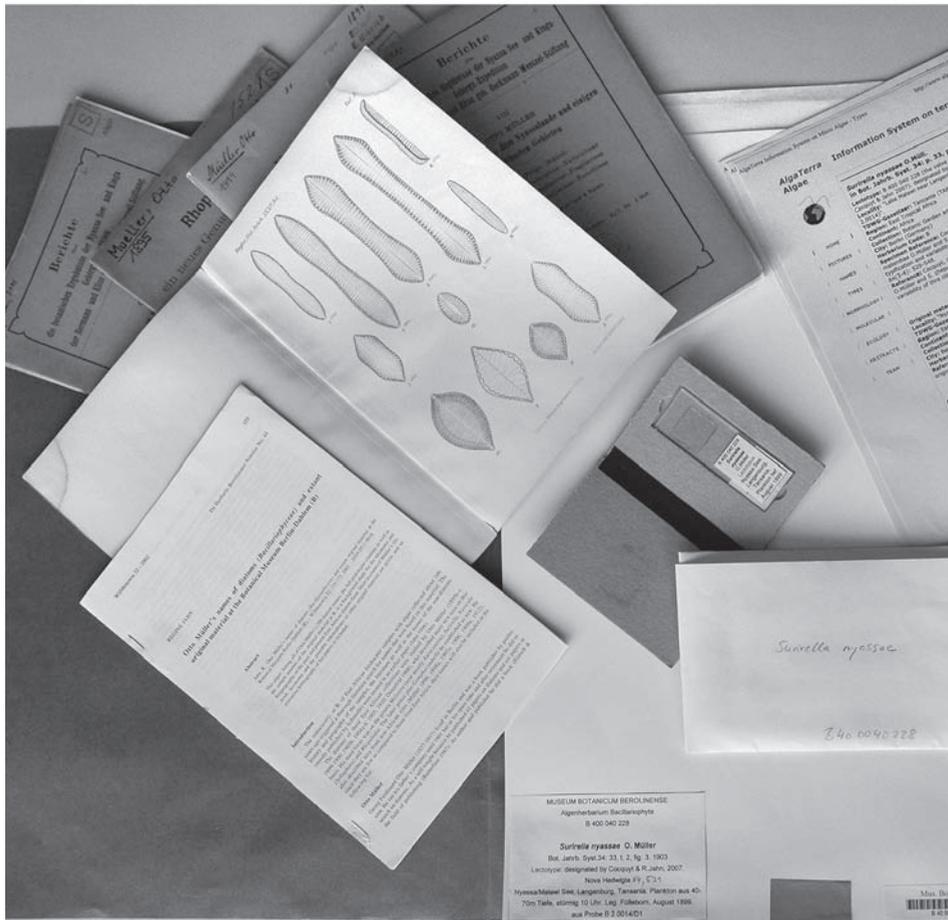


Fig. 2. Research materials for identifying and typifying diatom taxa at B. Center: the type slide and envelope of the herbarium sheet of *Surirella nyassae* O. Müll.; at left: reprints of O. Müller's papers opened at the drawings of *S. nyassae* (Müller 1903) plus a recent inventory of Müller's names (Jahn 2002); at right: print out of AlgaTerra database records on *S. nyassae*, available via the Internet (Jahn & Kusber 2008).
Photo: I. Haas, BGBM.

Link between Otto Müller's East African historical collection and heritage for Africa

In 2006-2007, the "Pilot project on the digitization of African micro-algae types and typical specimens: the diatom family Surirellaceae" was implemented thanks to funding by the Andrew W. Mellon Foundation. Besides the National Botanic Garden of Belgium and the Botanic Garden and Botanical Museum Berlin-Dahlem, a South African partner was included, namely DH Environmental Consulting, at Helderberg, represented by B. Harding and J. Taylor. The latter, associated with the North-West University at Potchefstroom, was the scientist responsible for the South Africa collections (Cocquyt *et al.* 2007).

This pilot project was part of the larger African Plants Initiative Program (API) which aims at collecting all data on African plants from leading herbaria and botanic gardens around the world by supplying a comprehensive database of high-resolution images of all African type specimens (more information can be found on www.aluka.org). The African Surirellaceae types will thus be returned in the form of digital images to the African countries where the original samples were collected.

This study demonstrates the necessity of collections and the importance of safe guarding the archives for research and the study of global change. This stored information is of the utmost importance as it can serve as a baseline for understanding biodiversity changes especially when the information is made available not only in scientific journals but also via the Internet. This creates added value for scientific colleagues in African countries where research infrastructure is often in a relatively early stages of development.

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List of the *Surirella* taxa described from East Africa (Müller 1903, 1904), their new names, new combinations and synonyms (in parenthesis) as re-evaluated by Cocquyt & Jahn (2005, 2007a, 2007b, 2007c, 2007d).

- *Surirella africana-orientalis* Cocquyt & R.Jahn. (= *S. constricta* var. *africana* O. Müll., *S. constricta* var. *maxima* O. Müll.)
- *Surirella brevicostata* O. MÜLL.
- *Surirella crawfordii* Cocquyt & R.Jahn (= *S. fuellebornii* var. *tumida* Hust.)
- *Surirella engleri* O. Müll. (= *S. engleri* f. *genuina*, f. *recta* O. Müll., f. *angustior* O. Müll., f. *subconstricta* O. Müll., *S. engleri* var. *constricta* O. Müll., f. *sublaevis* O. Müll.)
- *Surirella fasciculata* O. MÜLL.
- *Surirella friedelhinziae* Cocquyt & R.Jahn (= *S. fuellebornii* var. *elliptica* O. Müll.)
- *Surirella fuellebornii* O. Müll. (= *S. fuellebornii* f. *genuina*, f. *recta* O. Müll., f. *subconstricta* O. Müll., *S. fuellebornii* var. *constricta* O. Müll.)
- *Surirella kusberi* Cocquyt & R.Jahn (= *Surirella bifrons* var. *intermedia* O. Müll.)
- *Surirella likomensis* Cocquyt & R.Jahn (= *S. bifrons* var. *tumida* f. *minor* O. Müll.)
- *Surirella linearis* var. *elliptica* O. Müll.
- *Surirella margaritacea* O. Müll.
- *Surirella malombae* O. Müll. (= *S. malombae* f. *acuta* O. Müll.)
- *Surirella nyassae* O. Müll. (= *S. nyassae* var. *sagitta* O. Müll.)
- *Surirella ovalis* var. *apiculata* O. Müll. (= *S. ovalis* var. *apiculata* f. *minor* O. Müll.)
- *Surirella panganiensis* O. Müll.
- *Surirella tumida* (O. Müll.) Cocquyt & R.Jahn (= *Surirella bifrons* var. *tumida* O. Müll.)
- *Surirella turbo* O. Müll.

