

Introduction to the Reexamination of the Haeckel and Ehrenberg Radiolarian Collections

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Abstract Over 4,500 radiolarian species were described by C. G. Ehrenberg (1795–1876) and E. Haeckel (1834–1919) in the 19th Century. Inadequate knowledge of these taxa, which even today form a large fraction of described names for radiolarians, has long hindered the development of radiolarian research. The papers in this volume provide the first major, albeit incomplete, review of these names using the original preserved materials. The Ehrenberg Collection has been kept in the Museum für Naturkunde, Berlin, and has recently been restored and made accessible for research. Several places in Britain and Germany were visited to locate Haeckel's scattered radiolarian collections. Only a small fraction of Haeckel's original materials are still preserved (in Jena, Germany) although the Natural History Museum in London still holds a nearly complete set of original Challenger Expedition plankton and sediment samples. For the benefit of future research on Haeckel's taxa, we summarize here how to access and interpret these collections. In addition, we have resolved most of the publication dates of Ehrenberg's papers, providing a list of the correct dates, based primarily on the printing dates given in the original journal volumes. Citation of these in recent literature has often been confused, which complicates locating original descriptions, and adversely affects determining priority of names under International Code of Zoological Nomenclature (ICZN).

Key words: Ehrenberg, Haeckel, Legacy Collection, Radiolaria.

Introduction

The history of radiolarian research is long and has been marked by many changes in emphasis and activity over the decades. One constant theme however has been the highly incomplete and unstable state of radiolarian taxonomy, particularly for Cenozoic material. This has in part been due to the inability of more recent workers to re-examine and thus formally revise the extensive but very preliminary taxonomic work of the two great founders of radiolarian systematics: C. G. Ehrenberg (1795–1876) and E. Haeckel (1834–1919).

Ehrenberg was the first worker to describe significant numbers of radiolarians, together with numerous other groups of living and fossil microorganisms, particularly diatoms. Often referred to as the founder of micropaleontology, Ehrenberg's primary interests were to document the diversity of microscopic life forms, describe the complexity of their structure, and to try and understand their basic patterns of distribution in nature. As detailed in the papers in this volume (Ogane *et al.*, 2009; Suzuki, 2009; Suzuki *et al.*, 2009a, 2009b) Ehrenberg described over 70 genera and more than 500 species of radiolarians, including a many of the most commonly oc-

curring Cenozoic genera and species. Ehrenberg's descriptions and drawings, although meticulous for the standards of his time, are often insufficient for today's more detailed knowledge of microorganisms, and review of his material is much needed. Algologists have begun this process for many of Ehrenberg's diatom and other algal species (see www.algaterra.org), but until now no similar attempt has been made for radiolarians.

Haeckel, although primarily known for his promotion of Darwin's theory of evolutionary biology and his 'Monism' philosophy, was also an extremely productive taxonomist of both radiolarians and other groups of organisms such as cnidarians. Haeckel described over 700 genera and over 4,000 new species of radiolarians. Some of these came from Mediterranean plankton (see Sakai *et al.*, 2009 for details), but the majority were described in his great monograph based on materials of the *Challenger* deep-sea expedition. Unlike Ehrenberg, who was largely content to create taxonomy at the genus and species level only, Haeckel (probably because of his interest in documenting the hierarchy of evolutionary descent), erected a complex system of higher level taxa for radiolarians. This system was, by his own admission, highly artificial. By splitting species into multiple categories based on arbitrary higher level criteria, it created numerous distinct taxonomic names for con-specific forms, and thus a major challenge for taxonomic revision by later workers. These two workers together introduced thousands of genus and species level names for Cenozoic or Recent material, names which still dominate the modern Cenozoic-Recent taxonomic literature. Despite decades of work by radiolarian specialists, many of these taxa are still badly in need of review and revision.

History of Ehrenberg and Haeckel Materials

Unfortunately, both Haeckel and Ehrenberg worked in universities located what became East Germany. Economic and political restrictions meant that neither local nor international study of these collections was possible. Without any way to re-examine materials, much of radiolarian systematics was left in a limbo, which only became possible to change with the collapse of communism and the reunification of East with West Germany at the beginning of the 1990s.

Ehrenberg, rather unusually for his time, had always maintained detailed records of the material he studied, and was careful to preserve both the original samples and the microscopic preparations themselves (on mica discs, as glass slides were then still expensive and of variable quality). In this work he was assisted by his daughter Clara, and after Ehrenberg's death Clara carefully documented the material before its official donation to the Berlin university. The collection was moved into the new Museum für Naturkunde (Natural History Museum) soon after its opening in 1889. The collection however did not receive any special curation, and with Germany's financial and social problems in the early part of the 20th Century became neglected. Although the importance of the collection was recognized by Museum staff during the East Germany years, resources were seriously inadequate and the collection was difficult to access and little used. In the mid 1990s, the senior author was appointed as the first curator to the Ehrenberg collection, and was able to carry out the needed basic curation work to make the collection accessible again for scientific research (Lazarus, 1998; Lazarus and Jahn, 1998).

In the late 1990's the senior author also began a new search for the long missing Haeckel materials. This search (Lazarus, 2000) was able to determine that only a limited set of original Haeckel material was still left at his university: the original slides used for Haeckel's early studies of radiolarian plankton from the Mediterranean Sea near Messina. Some of the remaining material had apparently been sent by Haeckel shortly before his death to a scholar for additional re-

search in Berlin, but no records exist of this material any more and it must be presumed to be lost. Haeckel also gave away at least some of the material he had used in his studies as gifts to relatives. Specifically, he gave a set of a dozen original (mostly *Challenger*) plankton slides plus a partial set of his mass-produced 'teaching' slides to a favorite niece. These slides have survived and are now held privately by her descendants, the Benn family. The authors have recently been able, through the generosity of the Benn family, to examine this material and photograph the radiolarians contained in it (archive available at the Berlin Museum website). Importantly the material, being held privately rather than in a recognized repository, is not suitable for new systematic studies. No taxa though were seen in these slides that are not also present in other, similar plankton slides held in Museum repositories, so the restricted usability of the material does not present a problem.

The bulk of the Haeckel radiolarians still available for study is contained in the material of the original *Challenger* expedition, held by the Natural History Museum in London and stored partially in the main Kensington facility and partially in external storage facilities, e.g. Wandsworth (Lazarus, 2000). These materials consist of several components—original plankton slides prepared on the *Challenger* itself, deep-sea sediment samples from the *Challenger* Expedition, and radiolarian 'teaching slides' prepared in large quantities and sold commercially by Haeckel as part of his efforts to raise funds to found a new evolution museum in Jena. The plankton slides and teaching slides are stored in the Natural History Museum in London, in the Department of Palaeontology; the sediment samples are in the Wandsworth facility and are curated by the Museum's Department of Geology. The plankton slides are often labeled with radiolarian taxa names in Haeckel's own hand, but are not marked specifically to indicate the presence of type specimens (Lazarus, 2000). Although previous workers, most notably Nigrini (then Clark), had examined some of these materials in the late 1960s and 1970s, the material at that time was assumed to be of at best secondary importance, as it was then thought that original type material from Haeckel may still have survived in Jena and East Berlin.

Haeckel's students, e.g. Dreyer, also may have used some of Haeckel's original materials for their own studies, but, despite attempts to trace such materials in Germany by the senior author, there is no evidence that any of these materials, if they had existed, now survive. Nor would it be likely that such materials, even if found, would be marked in ways that allow identification of unambiguous type specimens. It is therefore recommended to treat the remaining material in Jena and London as the basis for all future Haeckel radiolarian typification work.

The lack of marked type specimens is in general one of the major problems in resolving uncertainties in these two authors' taxonomic legacy: neither one designated type specimens, either in their publications or in the materials they studied. For Ehrenberg, this is natural as the concept of the type specimen had not yet in his time been developed, but is less excusable for Haeckel, as designating types had become common taxonomic practice during the period in which he carried out his own work. Fortunately, Ehrenberg's methods for preparing and labeling materials, together with the accuracy of his drawings, normally allow workers to identify the actual specimen used by him to illustrate new species (see discussion and results by Ogane *et al.*, 2009; Suzuki, 2009; Suzuki *et al.*, 2009a, 2009b, this volume). For Haeckel's taxa, there is no alternative but to choose a new lectotype specimen from, wherever possible, topotype material to fix his species names. For some of Haeckel's taxa, single picked specimens make this process fairly clear (see Sakai *et al.*, 2009, this volume) but for the most part only mixed strewn slides or unprocessed sediment samples are available for this purpose. In the papers in this volume, specimens suitable for type fixation have been found for the large majority of Ehrenberg's species. For the much

larger number of species described by Haeckel we have only been able to re-illustrate those forms found in a selection of the plankton slides (see Aita *et al.*, 2009, this volume). The numerous taxa described by Haeckel from sediment samples remain a challenge for the future.

The current project was formed in 2004 as an international collaboration between European curators and Japanese taxonomists in the hope that by combining curatorial knowledge, taxonomic expertise and sufficient manpower, real progress could be made on the difficult legacy of Ehrenberg's and Haeckel's radiolarian taxonomy. The work of the project has been described in detail in Tanimura *et al.* (2006). The goal of this project has not been to attempt to formally revise the entire corpus of Cenozoic radiolarian taxonomy, an enormous task for which we are neither fully qualified, nor have the resources to achieve. Instead we have simply attempted to make these hitherto largely inaccessible collections accessible to the community of radiolarian taxonomists, primarily by imaging using modern digital technologies the forms encountered on the slides and making them available via new plates, and in the future, an online archive. It remains for individual taxonomists to carry out the needed formal revisions for taxa within their own special area of expertise, drawing on the imaged specimens presented in this volume.

A note on the publication dates of Ehrenberg's papers

Ehrenberg published virtually all of his primary species descriptions in either the Monatsbericht (monthly report) or Abhandlung (proceedings) of the Prussian Academy of Sciences (now part of the Berlin-Brandenburg Academy of Sciences-BBAW). Except in some the earliest volumes, each volume of these two serial publications is marked with two different dates. The first date is the year of activities that the publication covers, such as when the paper was first presented orally to academy members, while the second date, often one or two years later, is the date when the volume with the written paper was actually published. Ehrenberg and other authors occasionally sent preprints of their papers to colleagues or other institutions, and the presence of these preprints in the library of the Natural History Museum in London have led some previous authors (e.g. Nigrini, 1967) to conclude that Ehrenberg's papers were effectively published in the year that they were orally presented. However, distribution of such preprints was purely a personal activity and not one practiced by the Academy at any time (pers. comm. to DBL by Anne Jobst, archivist, and librarians of the Berlin-Brandenburg Academy of Sciences, 2009), and such sporadic and informal distribution does not constitute publication under the rules of the ICZN. The correct publication dates for general citation and in particular for taxonomic priority purposes remain the latter date of actual formal publication of the printed volume. For the early volumes that lack a separate date indicating printing, there is no other information preserved to our knowledge that would allow setting the date independently of the date provided for initial oral presentation. We have checked both with the Berlin-Brandenburg Academy of Sciences (the successor to the Prussian Academy of Sciences) and the German Federal Library (the Staatsbibliothek) and no authoritative records of actual printing dates have been preserved. Thus for these volumes we suggest using the sole available date-year of initial presentation (Table 1).

Resources for working with Ehrenberg and Haeckel Radiolarian Taxa

Ehrenberg

The Ehrenberg Collection at the Museum für Naturkunde in Berlin (<http://www.museum.huberlin.de/pal/microp/ehrenmp.asp?lang=1>) maintains extensive online documentation, including

Table 1. Correct published year of Ehrenberg' radiolarian papers with special reference of year in Radrefs.

Journal Abbr.	Correct Year	Year in Radrefs	Title as printed in the original paper, except for "Ue"	Title of Published Volume	Page range
Abh. Königl. Akad. Wiss. Berlin	1839	1838	Über die Bildung der Kreidelfelsen und des Kreidemergels durch unsichtbare Organismen	Abhandlungen der Königlich Akademie der Wissenschaften zu Berlin, Jahre 1838	59 147
Ber. Königl. Preuß. Akad. Wiss. Berlin	1840	1840	Hierauf 274 Blätter von ihm selbst ausgeführter Zeichnungen von eben so vielen Arten in dem 1838 erschienenen grösseren Infusorienwerke noch nicht abgebildeter Infusorien	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1840	197 219
Abh. Königl. Akad. Wiss. Berlin	1841	1839	Über noch jetzt zahlreich lebende Thierarten der Kreidebildung und den Organismus der Polythalamien	Abhandlungen der Königlich Akademie der Wissenschaften zu Berlin, Jahre 1839	81 174
Ber. Königl. Preuß. Akad. Wiss. Berlin	1842	1842	Über einen plastischen Kreidemergel von Ägina aus mikroskopischen Organismen und über die Möglichkeit, durch mikroskopische Untersuchung des Materials den Ursprung gewisser alter ächtgriechischer Kunstdenkmalier aus gebrannter Erde (Terracotten) mit bisher unbekannter Sicherheit zu bestimmen	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1842	263 268
Abh. Königl. Akad. Wiss. Berlin	1843	a 1843	Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nord-Amerika	Abhandlungen der Königlich Akademie der Wissenschaften zu Berlin, Jahre 1841	291 446
Ber. Königl. Preuß. Akad. Wiss. Berlin	1843	b 1843	Über den Gehalt an unsichtbar kleinen Lebensformen aus einigen von Hrn. Prof. Koch aus Constantinopel eingesandten Proben der Meeres-Ablagerungen im Marmara-Meer und im Bosporus	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1843	253 257
Ber. Königl. Preuß. Akad. Wiss. Berlin	1844	a 1844	Über 2 neue Lager von Gebirgsmassen aus Infusorien als Meeres-Absatz in Nord-Amerika und eine Vergleichung derselben mit den organischen Kreide-Gebilden in Europa und Afrika	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1844	57 97

Table 1. (Continued).

Journal Abbr.	Correct Year	Year in Radrefs	Title as printed in the original paper, except for "Ue"	Title of Published Volume	Page range
Ber. Königl. Preuß. Akad. Wiss. Berlin	1844	b	1844 Einige vorläufige Resultate seiner Untersuchungen der ihm von der Südpolreise des Captain Ross, so wie von den Herren Schayer und Darwin zugekommenen Materialien über das Verhalten des kleinsten Lebens in den Oceanen und den grössten bisher zugänglichen Tiefen des Weltmeeres	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1844	182 207
Ber. Königl. Preuss. Akad. Wiss. Berlin	1844	c	1844 Untersuchungen über die kleinsten Lebensformen im Quellenlande des Euphrats und Araxes, so wie über eine an neuen Formen sehr reiche marine Tripelbildung von den Bermuda-Inseln	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1844	253 275
Ber. Königl. Preuß. Akad. Wiss. Berlin	1844	d	1844 Über einen deutlichen Einfluss des unsichtbar kleinen organischen Lebens als vulkanisch gefritzte Kieselmasse auf die Massenbildung von Bimstein, Tuff, Trass, vulkanischem Conglomerat und auch auf das Muttergestein des nordasiatischen Marekanits	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1844	324 344
Ber. Königl. Preuß. Akad. Wiss. Berlin	1844	e	1844 Eine Notiz des Hrn. Dr. Franz Schulz in Eildena aus einem Schreiben desselben an Hrn. v. Humboldt mit, worin derselbe seine Methode vorträgt, den Kieselerdegehalt der Steinkohlen so chemisch gereinigt darzustellen, dass er zur Erkennung mikroskopischer kieseliger Organismen, noch geeignet bleibt und machte dazu Bemerkungen	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1844	359 361
	1844	f	1844 On microscopic life in the ocean at the South Pole, and at considerable depths	Annals and magazine of natural history, including zoology, botany and geology, volume 14	169 181
Ber. Königl. Preuß. Akad. Wiss. Berlin	1845		1845 Neue Untersuchungen über das kleinste Leben als geologisches Moment	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1845	53 87

Table 1. (Continued).

Journal Abbr.	Correct Year	Year in Radrefs	Title as printed in the original paper, except for "Ue"	Title of Published Volume	Page range
Ber. Königl. Preuß. Akad. Wiss. Berlin	1846	1847	Über eine halbiolithische, von Herrn R. Schomburgk entdeckte, vorherrschend aus mikroskopischen Polycystinen gebildete, Gebirgsmasse von Barbados	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1846	382 385
Ber. Königl. Preuß. Akad. Wiss. Berlin	1847	1847	Über die mikroskopischen kieselschaligen Polycystinen als mächtige Gebirgsmasse von Barbados und über das Verhältniss der aus mehr als 300 neuen Arten bestehenden ganz eigenthümlichen Formengruppe jener Felsmasse zu den jetzt lebenden Thieren und zur Kreidebildung. Eine neue Anregung zur Erforschung des Erdlebens	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1847	40 60
Ber. Königl. Preuß. Akad. Wiss. Berlin	1854	a	Über das organische Leben des Meeresgrundes in bis 10800 und 12000 Fuss Tiefe	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1854	54 75
Ber. Königl. Preuß. Akad. Wiss. Berlin	1854	b	Systematische Charakteristik der neuen mikroskopischen Organismen des tiefen atlantischen Oceans	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1854	236 250
Ber. Königl. Preuß. Akad. Wiss. Berlin	1854	c	Weitere Ermittlungen über das Leben in grossen Tiefen des Oceans	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1854	305 328
	1854	d	Mikrogeologie	Book	
Ber. Königl. Preuß. Akad. Wiss. Berlin	1855	a	Über die weitere Entwicklung der Kenntniss des Grünsandes als grüner Polythalamien-Steinkerne, über braunrothe und corallothe Steinkerne der Polythalamien-Kreide in Nord-Amerika, und über den Meeresgrund aus 12,900 Fuss Tiefe	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1855	172 178

Table 1. (Continued).

Journal Abbr.	Correct Year	Year in Radrefs	Title as printed in the original paper, except for "Ue"	Title of Published Volume	Page range
Ber. Königl. Preuß. Akad. Wiss. Berlin	1855	b	Über ein europäisches marines Polygasterm-Lager und über verlarvte Polythalamien in den marinen Polygasterm Tripeln von Virginien und Simbirsk	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1855.	292 305
Ber. Königl. Preuß. Akad. Wiss. Berlin	1855	c	Die gelungene durchscheinende Färbung farbloser organischer Kieselerde für mikroskopische Zwecke	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1855	552 559
Ber. Königl. Preuß. Akad. Wiss. Berlin	1855	d	III. Nähere Bestimmung der Mischung des frischen Auswurfs des Schlamme-Vulkans von Poorwadadi auf Java	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1855	570 576
Ber. Königl. Preuß. Akad. Wiss. Berlin	1855	e	Über das Fortrücken des Supplementes zur Mikrogeologie und das mikroskopische Leben in den südlichen Staaten Nord-Amerikas	Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1855	779 783
Monat. Königl. Preuß. Akad. Wiss. Berlin	1856		Über 2 neue südamerikanische Gebirgsmassen aus mikroskopischen Organismen, eine aus Meeresorganismen in Chile und eine als mit gefritteten Süswasserorganismen gemischten vulkanischen essbaren Tuff aus Honduras in Centro-Amerika	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1856	425 431
Monat. Königl. Preuß. Akad. Wiss. Berlin	1858		Über die organischen Lebensformen in unerwartet grossen Tiefen des Mittelmeeres	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1857	538 570
Monat. Königl. Preuß. Akad. Wiss. Berlin	1859		Kurze Charakteristik der 9 neuen Genera und der 105 neuen Species des ägäischen Meeres und des Tiefgrundes des Mittel-Meeres	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1858	10 40
Monat. Königl. Preuß. Akad. Wiss. Berlin	1860		Über neue massenhafte Polycystinen als Meeresgrund aus 13200 Fuss Tiefe bei Zankebar	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1859	553 553

Table 1. (Continued).

Journal Abbr.	Correct Year	Year in Radrefs	Title as printed in the original paper, except for "Ue"	Title of Published Volume	Page range
Monat. Königl. Preuß. Akad. Wiss. Berlin	1861	a	Neue Zeichnungen der vermeintlich aus 19,800 Fuss Meerestiefe gehobenen Lebensformen, so wie neue Erläuterungen dieser Grund- und Wasserproben	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1860	588 592
Monat. Königl. Preuß. Akad. Wiss. Berlin	1861	b	Über die organischen und unorganischen Mischungsverhältnisse des Meeresgrundes in 19800 Fuss Tiefe nach Lieut. Brookes Messung	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1860	765 774
Monat. Königl. Preuß. Akad. Wiss. Berlin	1861	c	Über den Tiefgrund des stillen Oceans zwischen Californien und den Sandwich-Inseln aus bis 15600' Tiefe nach Lieut. Brooke	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1860	819 833
Monat. Königl. Preuß. Akad. Wiss. Berlin	1862	a	Beitrag zur Übersicht der Elemente des tiefen Meeresgrundes im Mexikanischen Golfstroms bei Florida	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1861	222 240
Monat. Königl. Preuß. Akad. Wiss. Berlin	1862	b	Über die Tiefgrund-Verhältnisse des Oceans am Eingange der Davisstrasse und bei Island	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1861	275 315
Monat. Königl. Preuß. Akad. Wiss. Berlin	1862	c	Über die vielfältigsten Grundhebungen zum Behufe der neuen nordatlantischen Telegraphenlinie	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1861	505 506
Monat. Königl. Preuß. Akad. Wiss. Berlin	1862	d	Über das mikroskopische Leben auf der Insel St. Paul im Süd-Ocean	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1861	1085 1102
Monat. Königl. Preuß. Akad. Wiss. Berlin	1873	a	Mikrogeologische Studien als Zusammenfassung seiner Beobachtungen des kleinsten Lebens der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluss	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1872	265 322
Abh. Königl. Akad. Wiss. Berlin	1873	b	Mikrogeologische Studien über das kleinste Leben der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluss	Abhandlungen der Königl. Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1872	131 399

Table 1. (Continued).

Journal Abbr.	Correct Year	Year in Radrefs	Title as printed in the original paper, except for "Ue"	Title of Published Volume	Page range
	1873	c	Massenhafte Gesteinsproben des Polycystinen-Kalkes	Sitzungsberichte der Gesellschaft Naturforschender Freude zu Berlin, 1873	19 24
Monat. Königl. Preuß. Akad. Wiss. Berlin	1874	a	Grössere Felsproben des Polycystinen-Mergels von Barbados mit weiteren Erläuterungen	Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Jahre 1873	213 263
	1874	b	Das unsichtbar wirkende Leben der Nordpolarzone am Lande und in den Meerestiefgründe bei 300 mal verstärkter Sehkraft, nach Materialien der Germania erläutert	Die zweite deutsche Nordpolarfahrt in den Jahren 1869 und 1870 unter Führung des Kapitän Karl Koldewey, Bd. 2	437 467
Abh. Königl. Akad. Wiss. Berlin	1876		Fortsetzung der mikrobiologischen Studien als Gesamt-Übersicht der mikroskopischen Paläontologie gleichartig analysirter Gebirgsarten der Erde, mit specieller Rücksicht auf den Polycystinen-Mergel von Barbados	Abhandlungen der Königl. Akademie der Wissenschaften zu Berlin, Jahre 1875	1 225

a database of the collection, scanned copies of Clara Ehrenberg's handwritten indices the collection, a full set of scans of the original drawings, photographs of the 'mica' preparations with labels, various other documents and copies of Ehrenberg's two major monographs (the *Infusionsthierchen*, 1838 and the *Mikrogeologie*, 1854). The latter volumes are largely syntheses of papers previously published in the *Monatsbericht* and *Abhandlungen*. These original articles can be obtained from the Academy (www.bbaw.de). It should also be noted that Ehrenberg's taxonomic work was by no means restricted to radiolarians, and indeed most taxonomists who work with Ehrenberg's materials today are algologists, particularly diatomists. These communities also maintain extensive information about Ehrenberg and his publications, and can be consulted for further information about his professional life and his science.

Haeckel

Haeckel's personal legacy is preserved in two institutions in Jena—the Ernst-Haeckel Haus, and the Phyletisches Museum, but, as also described in a paper in this volume (Sakai *et al.*, 2009), only a small amount of Haeckel's radiolarian materials have been preserved in these institutions. Only Haeckel's Messina material is stored in the Haeckel-Haus, and no primary materials are known to be stored in the Phyletisches Museum. The most important source of Haeckel radiolarian materials are those of the *Challenger* Expedition housed in the Natural History Museum, London in the departments of Palaeontology and Geology. The curators of these collections should be contacted for details of access. Haeckel's major publications, and most importantly his Challenger report, are available in scanned form online from a variety of sources, including the Biodiversity Heritage Library.

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