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PERSPECTIVE

HOW MANY SPECIES OF ALGAE ARE THERE?[1]

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Algae have been estimated to include anything from 30,000 to more than 1 million species. An attempt is made here to arrive at a more accurate estimate using species numbers in phyla and classes included in the on-line taxonomic database AlgaeBase (http://www.algaebase.org). Despite uncertainties regarding what organisms should be included as algae and what a species is in the context of the various algal phyla and classes, a conservative approach results in an estimate of 72,500 algal species, names for 44,000 of which have probably been published, and 33,248 names have been processed by AlgaeBase to date (June 2012). Some published estimates of diatom numbers are of over 200,000 species, which would result in four to five diatom species for every other algal species. Concern is expressed at the decline and potential extinction of taxonomists worldwide capable of improving and completing the necessary systematic studies.

Key index words: **algae; AlgaeBase; biodiversity; data sources; species concepts; taxonomy**

In the last few years, I have heard estimates of the number of living algae varying from 30,000 to over 1 million species, and one seminar presentation that "escaped" to the internet suggested that there may even be as many as 350 million algae, or about 20 times the number of all organisms on Earth. Such uncertainty is perhaps unsurprising because we are not even sure what an alga is; we are even more unsure what a species is; and it is not always clear whether we are discussing the species that have been described, or trying to predict what might be the total algal species diversity.

WHAT IS AN ALGA?

As all phycologists know, this is not an easy question to answer: generally algae are considered to be aquatic, oxygen-evolving photosynthetic autotrophs that are unicellular, colonial or are constructed of filaments or composed of simple tissues. Wishing for algal monophyly will not make it happen as algae are presently referred to four kingdoms: Bacteria, Plantae, Chromista, and Protozoa. For our purposes, algae are those organisms included in AlgaeBase (Table 1), which includes 15 phyla and 54 classes representing an incredible increase since I last took a university course in algae in the 1960s. Alga endings ("-phyceae") for class names are used except for some of the Protozoa.

WHAT IS A SPECIES?

A slightly jaundiced view is that a species is what a competent taxonomist says it is, but of course that is a circular argument and patently not good science. Kitcher (1984) referred to this as the "Cynical Species Concept." Wilkins (2002), for example, listed 26 species concepts, and there is a myriad of kinds of species: biospecies, cladospecies, compilospecies, ecospecies, microspecies, morphospecies, nothospecies, paraspecies, phenospecies, phylospecies, pseudospecies, quasispecies, semispecies, and so on. It therefore is no wonder that taxonomic algal neophytes can be confused.

May (2011) observed: "It is a remarkable testament to humanity's narcissism that we know the number of books in the US Library of Congress on 1 February 2011 was 22,194,656, but cannot tell you—to within an order-of-magnitude—how many distinct species of plants and animals we share our world with." This is not in the least "remarkable" in my opinion. Books are more or less discrete, tangible items, and generally readily identifiable, and with the resources of this outstanding library, it is possible to catalogue and to count such a huge number of entities, and thereby to arrive at such an accurate number, at least momentarily. Not so with species, I am afraid. And this is why taxonomy is most certainly not the equivalent of book cataloguing or even stamp collecting* (Johnson 2007).

Species concepts vary greatly throughout the kingdoms of life and between algal taxa, particularly classes. So in some classes of algae, we have

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*A particularly dismissive and cynical opinion attributed by many to Ernest Rutherford (1871–1937) who actually said: "All science is either physics or stamp collecting."

TABLE 1. Number of species of algae in each phylum and class of algae, with vernacular names (some coined by me) and species numbers in AlgaeBase in each class and in each phylum; estimated number of described species not in AlgaeBase, estimated number of species yet to be described.

Phylum (class)	Vernacular name(s)	In AlgaeBase classes	In AlgaeBase phyla	Described to date (estimate)	Undescribed (estimate)	Total (estimate)
Cyanobacteria	**Blue-green algae**		3,300	5,000	3,000	8,000
Cyanophyceae	Blue-green algae	3,300				
Rhodophyta	**Red algae**		6,131	7,000	7,000	14,000
Bangiophyceae	Bangiophytes	138				
Cyanidophyceae	Cyanidophytes	4				
Pophyridiophyceae	Porphyridiophytes	11				
Stylenomatophyceae	Stylonematophytes	25				
Rhodellophyceae	Rhodellophytes	5				
Florideophyceae	Florideophytes	5,948				
Glaucophyta	**Glaucophytes**	14		15	15	30
Charophyta	**Charophytes**		3,470	6,000	3,000	9,000
Charophyceae	Charophytes	690				
Coleochaetophyceae	Coleochaetophytes	18				
Klebsormidophyceae	Klebsormidophytes	39				
Mesostigmatophyceae	Mesostigmatophytes	14				
Zygnematophyceae	Zygnemophytes	2,709				
Chlorophyta	Chlorophytes		4,548	8,000	5,000	13,000
Bryopsidophyceae	Bryopsidophytes	520				
Chlorodendrophyceae	Chlorodendrophytes	43				
Chlorophyceae	Chlorophytes	2,292				
Dasycladophyceae	Dasycladophytes	50				
Mamiellophyceae	Mamiellophytes	16				
Nephroselmidophyceae	Nephroselmidophytes	26				
Pedinophyceae	Pedinophytes	22				
Pleurastrosphyceae	Pleurastrophytes	3				
Prasinophyceae	Prasinophytes	97				
Siphonocladiophyceae	Siphonocladiophytes	402				
Trebouxiophyceae	Trebouxiophytes	546				
Ulvophyceae	Ulvophytes	531				
Cryptophyta	Cryptophytes[a]		148	200	200	400
Cryptophyceae	Cryptophytes	148		550	250	800
Haptophyta	Haptophytes[a]		510			
Coccolithophyceae	Coccolithophorids	371				
Pavlovophyceae	Pavlovophytes	15				
Incertae sedis		124				
Cercozoa			12			
Chlorarachniophyceae	Chlorarachniophytes	12				
Ochrophyta	Ochrophytes[a]		11,571	12,500	8,500	21,000
Aureanophyceae	Aureanophytes	1				
Bacillariophyceae	Diatoms	8,397				
Bolidophyceae	Bolidophytes	14				
Chrysomoerophyceae	Chrysomerophytes	4				
Chrysophyceae	Chrysophytes	431				
Dictyochophyceae	Dictyochophytes	51				
Eustigmnatophyceae	Eustigmatophtes	35				
Pelagophyceae	Pelagophytes	12				
Phaeophyceae	Brown algae	1,792				
Phaeothamniophyceae	Phaeothamniophytes	33				
Picophagophyceae	Picophagophytes	4				
Pinguiophyceae	Pinguiophytes	6				
Placidiophyceae	Placidophytes	2				
Raphidophyceae	Raphidophytes	35				
Schizocladiophyceae	Schizocladiophytes	1				
Synchromophyceae	Synchromophytes	1				
Synurophyceae	Synurophytes	252				
Xanthophyceae	Xanthophytes	500				
Choanozoa	Choanoflagellates		79	150	150	300
Choanoflagellatea	Choanoflagellates	79				
Euglenozoa	Euglenoid flagellates		1,189	2,000	1,000	3,000
Bodonophyceae	Bodonozoans	32				
Euglenophyceae	Euglenozoans[a]	1,157				
Loukozoa	Loukozoans		3			
Jakobea	Jakobids	3				
Metamonada	Metamonads		5			

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TABLE 1. Continued

Phylum (class)	Vernacular name(s)	In AlgaeBase classes	In AlgaeBase phyla	Described to date (estimate)	Undescribed (estimate)	Total (estimate)
Trepomonadea	Trepomonads	5				
Myzozoa	Myzozoans		2,277	2,500	500	3,000
Dinophyceae	Dinoflagellates	2,270				
Perkinsea	Perkinsids	7				
Percolozoa	Percolozoans		3	3	3	6
Heterolobosea	Heterolobosids	3				
Totals		33,260		43,918	28,618	72,536

[a]The use of the suffix "-phytes" in these vernacular names and their included taxa (Chromista) should not be assumed to insinuate any relationship to those algae placed in the Rhodophyta, Chlorophyta, Charophyta, and Glucophyta (Plantae).

morphological species concepts dominating; in others, a mixture of morphological and molecular concepts; and in only a very few has there been any attempt further to apply a biological species concept. A notable exception in this regard has been the efforts of a few diatomists to apply what are essentially biological species concepts (see Mann 1999) that may result in huge numbers of microspecies of dubious utility. Most diatomists continue effectively to apply a morphospecies concept, particularly now that there are excellent tools for detailed examination of diatom frustules, and indeed the trend of "lumping" (synonymizing) diatom species together has been spectacularly reversed in recent decades. It has also been clear for some time now that cosmopolitan diatom species are not the rule and a considerable degree of endemism is apparent (e.g., Vanormelingen et al. 2008).

Despite the fact that a "species" is essentially a human construct and is not something that we should expect to be able to define precisely for all organisms, the morphological species concept and the age-old philosophical principle of "if it looks different, it *is* different" does work for most species. However, we need do decide how far we are willing to go in accepting species that are morphologically identical, but their lack of sexual interest in each other or their gene sequences tell us they are different. These so-called sibling or cryptic species make morphotaxonomic life very difficult and, perhaps, we should only accept new species when the authors provide characters by which they can be distinguished without recourse to extensive breeding programs or gene sequencing to identify them. I am indeed sanguine that one day soon simple DNA-based tools (something like a pregnancy- or blood-kit) will be available to identify species routinely, but until then we need morphological characters to assist us.

HOW MANY SPECIES OF ORGANISMS ARE THERE?

May (1998) reported estimates of 5–50 million species, including described and undescribed species, with other sources claiming as many as 100 million. Mora et al. (2011), using predictions based on asymptotic parametric regression models and multimodel averaging on the assignment of existing species to phyla, classes, orders and families, came up with a figure of 8.7 million species (±1.3 million SE, giving a range of 7.4–10 million), of which they say that about 1.2 million valid species (meaning taxonomically valid, a term widely used by zoologists) had been described. I must admit that I really do not fully understand the modelling parts and therefore cannot be critical of the methodology that they used, but their outcome that 86% of non-marine and 91% of marine species await description is very high, and certainly does not fit with what I know to be reasonable for the algae. Not surprisingly, these authors also show that, the higher taxonomic categories are "much more completely described than lower levels." Again, however, this might be true of animals and vascular plants, but for the algae it is likely that the extraordinary rate of discovery of higher level taxa in recent years will continue unabated.

With respect to described species, the situation is also not at all clear. Perhaps the best source of information on described species is Chapman (2009) who used a mixture of databases and expert opinion to come up with a figure of 1.9 million described species. In terms of cataloguing these species, the Catalogue of Life, an array of 115 taxonomic databases (including AlgaeBase), now numbers 1.4 million species, the vast majority of which are morphospecies, in other words, described on the basis of morphological observations. Of the 1.9 million species listed by Chapman (2009), insects account for >1 million, the beetles (Coleoptera) being the largest group of insects by far, numbering >400,000 species.

In the marine environment, a recent assessment (Appeltans et al. 2012), using most of the marine databases in the World Register of Marine Species, and with extensive expert assistance from 122 coauthors (including me) estimates that 225,000 eukaryotic marine species are taxonomically valid but 170,000 names represent synonyms. Expert opinion and statistics indicated that >0.7 million marine species exist, which is much, much fewer than the 2.2 million (±0.18 million SE) postulated by Mora

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PERSPECTIVE

et al. (2011), suggesting that their models are not reliable at least for marine organisms. The figures of Appeltans et al. (2012) indicate that, at most, 66%–75% of eukaryotic marine species remain to be described. These authors also show that as many as 70,000 species may already exist in marine collections (mostly zoological), and some 35,000 cryptic species, recognizable only by molecular means, still remain to be recognized.

Whatever the final number is, getting a complete list of all species requires funding, and while many government agencies and philanthropic foundations worldwide, particularly in the United States and Europe, have put money into nomenclatural and taxonomic databases, there has been a lack of vision and coordination, and a huge amount of duplication and petty politics. Considerable funding has gone to "aggregators" who collect names from the taxonomic and nomenclatural databases often called Global Species Databases (GSDs), very often to the detriment of the GSDs, which have, as a result, been starved of funding to finish the job, and to improve and verify the existing data. For some reason, many funders seem to think that the work of GSDs is done and needs no more funding, something that by any measure is patently untrue.

HOW MANY DESCRIBED SPECIES OF ALGAE ARE THERE?

Most of the reliable estimates of algal species, such as Chapman (2009) and Appeltans et al. (2012) and the IUCN Red List (2010), relied on AlgaeBase for their figures. So we should look for the current numbers there (as of June 2012). The figures in AlgaeBase are given in Table 1 for individual phyla and classes.

For the Cyanobacteria (blue-green algae) with a single class, Cyanophyceae, the current figure in AlgaeBase is 3,300 species, mostly equally distributed between marine and freshwater/terrestrial habitats. This is likely to be an underestimate; the difficulty, however, with the blue-green algae, as with other bacteria, the diatoms and the freshwater green algae, has always been in arriving at a consensus as to what a species is, and for many such algae, opinions ebb and flow between taxonomic "splitters" and "lumpers." The best taxonomic source for the Cyanophyceae is CyanoDB (see Web Resources below for links for this and other internet data sources), and although it is very clear from this comprehensive work that there are many problems with older names and concepts, much progress has been made in re-recognizing the huge biodiversity and beauty of the blue-green algae. I estimate that the number of described species is about 5,000, with about 3,000 undescribed species. Like the diatoms (see below), the blue-greens are turning out to be much less ubiquitous than formerly thought. By contrast, the oceanic blue-green *Prochlorococcus*, considered to be the most numerous organisms on earth with an estimated 10^{27} individuals that measure a mere 0.5–0.7 μm across, seems to be a single, ubiquitous species (*Prochlorococcus marinus* S.W.Chisholm, S.L.Frankel, R.Goericke, R.J.Olson, B.Palenik, J.B.Waterbury, L.West-Johnsrud et E.R. Zettler) found from 40° N to 40° S to 200 m in oligotrophic oceanic waters (Partensky et al. 1999).

For the Rhodophyta (red algae), currently with six classes, the figure of 6,131 species in AlgaeBase is about 85% of the actual number of described species (many of which are already included as uncertain names or synonyms). However, while most of the larger species have been described (and a majority of these belong to a single class, the Florideophyceae), sequencing and bar-coding is tending to suggest considerably more diversity than was formerly appreciated (e.g., Saunders and McDonald 2010, Milstein and Saunders 2012). So, there may be an equal number of undescribed rhodophytes, particularly in warmer seas. The red algae are predominantly marine.

The Glaucophyta (glaucophytes) is a very small phylum of about 15 marine species, and it is very difficult to assess how many species there are, and how many there might be. However, taking the red algae as a model, it is likely that about half are known and the total of described and undescribed taxa is about 30.

The Charophyta (including five classes of mostly freshwater/subaerial organisms, of which the charophytes and desmids are the best-known) numbers 3,470 species in AlgaeBase, of a probable total of about 5,000 species, and I estimate that about 3,000 species remain to be described. However, the degree of cryptic speciation in the desmids is very difficult to estimate, like the diatoms and blue-green algae, and may be very considerable.

The Chlorophyta (green algae with 12 classes, and probably even more remain to be discovered) currently includes 4,548 species. As more molecular work is done, species are tending to sort into marine vs. freshwater/subaerial classes, and the largest class, the Chlorophyceae, probably includes the most undescribed biodiversity and cryptic speciation in freshwater habitats. I estimate that about 5,000 chlorophytes remain to be described, notably in tropical and subtopical area.

The Cryptophyta (cryptophytes, occurring in marine and freshwater habitats) number 148 species in AlgaeBase (Table 1). The total number of described species is about 200, and there is probably an equal number of undescribed species.

The Haptophyta (coccolithophorids, haptophytes) includes two classes and quite a number of mostly marine species of uncertain class placement as yet, currently number 510 in AlgaeBase, which may be close to the actual number of described species, and there is probably relatively small number of undescribed species. Oceanic phytoplankton seems generally to be associated with low biodiversity, and

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phytoplankton biodiversity does not correlate with zooplankton biodiversity (Irigoien et al. 2004). What the coccolithophorids may lack in species number, they make up in individual numbers with annual coccolithophorid blooms from 1979 to 1984 averaging 1.4×10^6 km^2 (Brown and Yoder 1994), probably with individuals to rival those of *Prochlorococcus* described above.

The Ochrophyta (Heterokontophyta, heterokonts) currently with 18 classes, includes the brown algae, the diatoms, and the Xanthophyceae (Tribophyceae). Like the green algae, the higher level taxonomy of the ochrophytes is still in a state of some flux, but the classes are now tending to sort into primarily marine or primarily freshwater (and/or subaerial) organisms. Some authors, perhaps justifiably, include several classes of diatoms, but AlgaeBase is currently using only one, the Bacillariophyceae, mostly for reasons of integration with other databases. Of the 18 classes currently included in the Ochrophyta, 11 have 50 or less species described (Table 1), and only two (Bacillariophyceae and Phaeophyceae) have more than 1,500. The numbers of species in the brown algae (Phaeophyceae, an almost entirely marine class) seem to be fairly stable, although a lot of small filamentous browns are difficult to assess, and new entities are regularly turning up in tropical and subtropical areas.

The greatest difficulty within the Ochrophyta, and consequently the algae in general, is in assessing the numbers of diatoms. The Catalogue of Diatom Names has accumulated 62,000 names of genera, species, and infraspecific ranks. This is, however, a nomenclatural listing, as is Index Nominum Algarum and AlgaTerra, and these resources, perhaps sensibly, do not aspire to giving actual numbers of diatom and/or algal species. According to Mann and Droop (1996), there are likely to be >200,000 species of diatoms, of which they claim that 10% have been named, or about 20,000 extant species. Some 8,397 accepted species, supposedly about 50%, are in AlgaeBase. However, Mann and Droop's projections, which have become widely used by various sources, are based on a "fine-grained taxonomy" (Vanormelingen et al. 2008), and while the trend of lumping species among diatomists seems to have been firmly reversed, we still have no firm basis for accepting as large a number as 200,000. It is very clear, however, that the supposition that diatom species are in general ubiquitous and endemism is rare is not supported by recent studies (Vanormelingen et al. 2008). Therefore, as I have done with other algae, I have taken what is probably a conservative figure of 12,000 described species of diatoms, with a further 8,000 to be discovered. Of the non-diatom Ochrophyta, about 500 species have been described in the literature, but are not yet catalogued by AlgaeBase, and a further 500 probably remain to be discovered.

There is an increasing tendency not to include many of the Protozoa traditionally regarded as algae, such as the dinoflagellates and the euglenoid flagellates, and heterotrophic flagellates are often taxonomically orphaned or even placed in "unranked taxa." However, many of these organisms would otherwise become "orphaned," and many databases and checklists include them as algae.

The Choanozoa in AlgaeBase currently includes a mere 79 marine species, but it is likely there may be no more than 150 described species, and perhaps 150 undiscovered entities, but there do not seem to be many reliable published estimates. The Euglenozoa in AlgaeBase currently includes 1,189 freshwater and marine species and the total described is probably about 2,000 with perhaps an additional 1,000 undescribed species.

The Loukozoa, Metamonada and Percolozoa very poorly represented in AlgaeBase and species numbers, either described or undescribed, are simply impossible to estimate. The Myzozoa includes two algal classes, of which the Dinophyceae (dinoflagellates) is by far the largest and best-known. According to Taylor et al. (2008), some 4,500 species of dinoflagellates have been described, of which about 2,000 are extant. Of the living species, 87% are marine. AlgaeBase includes 2,277 extant dinoflagellate species, and this seems very close to the Taylor et al. (2008) estimate. The Centre of Excellence for Dinophyta Taxonomy site also estimates about 2,500 living species, and I have concluded that there are about 500 undescribed species.

To summarize, therefore, AlgaeBase currently documents 32,260 species of organisms generally regarded as algae of an estimated 43,918 described species of algae, or about 73%. Most of the species remaining to be treated in the database are marine and freshwater diatoms, and some phytoplanktonic organisms and freshwater chlorophycean algae are under-represented. I estimate that 28,500 algal species remain to be described, again mostly blue-green algae, diatoms and green freshwater algae. The total number of algal species is likely to be about 72,500, of which >20,000 will be diatoms.

Other than the names of 32,500 or so species, AlgaeBase includes a further 100,000 names and infraspecific names of algae, and Index Nominum Algarum "contains nearly 200,000 names of algae (in the broad sense)" at all taxonomic levels, but a percentage of the names in both of these databases are illegitimate or invalid nomenclaturally, or taxonomically invalid (synonyms), and many more are uncertain or confused in some way.

PROBLEMS

A particular difficulty with not knowing the numbers of algae in various groups with any certainty is that we cannot rigorously examine their conservation status. Although this is a universal problem in

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PERSPECTIVE

all taxa, it is particularly acute in the algae. Red Books are very rare for any algal group, except perhaps for the charophytes.

Gaining traction in determining final species numbers for algae depends of course on taxonomists, but, in the "developed" world, morphotaxonomy in any sense may shortly become more or less extinct as universities, museums, and other institutions that employed morphotaxonomists come under more and more financial constraints and other pressures. Some say that the taxonomic torch will be taken up by the "developing" countries, where much of the terrestrial and marine biodiversity is centred in any case, but many of these countries have so few resources that it will be a slow process. Perhaps the internet may obviate many of the disadvantages of trying to do taxonomic work in "developing" countries. Online nomenclatural and taxonomic databases, together with online libraries and, perhaps, most importantly, online herbaria (see Web Resources below) may be critical in discounting these disadvantages. Increasing use by countries with poor taxonomic resources is evident from the figures in Table 2, and this will further increase as broadband becomes pervasive and more reliable in such countries. Access to literature is also a major problem in the "developing" world: of the dozen or so exclusively or primarily phycological journals, only one, *Algae,* is entirely open-access. A sustainability model for the production of quality open-access journals is still only an aspiration.

TABLE 2. Top 25 countries (with individual visits and average number of page views) visiting AlgaeBase from 31 May 2011 to 1 June 2012 based on Google Analytics (http://www.google.com/analytics/).

Country	Individual visits	Page views (average)
United States	115,703	3.62
Brazil	38,991	6.2
Mexico	31,874	6.88
Spain	31,140	5.77
UK	27,622	3.77
France	26,969	4.24
Germany	23,145	4.61
Italy	22,226	4.8
India	21,219	3.2
Canada	21,195	3.59
Japan	19,804	3.91
Indonesia	19,428	2.55
Australia	16,303	4.52
Philippines	16,268	2.9
Portugal	13,687	5.43
South Korea	13,606	8.24
Turkey	12,712	6.8
Russia	11,613	7.89
Chile	10,919	4.86
Malaysia	10,286	3.57
Poland	8,393	3.69
Colombia	8,351	5.29
China	8,204	4.99
Thailand	7,795	4.64
Ireland	7,331	4.59

A cruel twist of fate is that by the time human societies have accumulated (or otherwise acquired) sufficient wealth to support taxonomists and other "non-productive" individuals, they have often begun to destroy the very things that taxonomists study.

SO, WHY WORRY?

We *should* worry about the decline in interest in taxonomy as our world needs it, if for nothing else other than effective communication. To those who think that it is just stamp collecting, I suggest that they completely miss the point of a basic human need to know the natural world, not just for its exploitation, but for its complexity and overwhelming beauty and harmony. In any event, cataloguing living organisms is not a mechanical thing: there is just as much philosophy and intellectual challenge as in any branch of science. It would also be a tragedy not to know the extent of our heritage before we wantonly destroy it.

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WEB RESOURCES

AlgaeBase: http://www.algaebase.org
AlgaTerra: http://www.algaterra.org
Bibliotheca Digital Real Jardín Botánico Madrid: http://bibdigital.rjb.csic.es
Biodiversity Heritage Library: http://www.biodiversitylibrary.org/
Catalogue of Diatom Names: http://researcharchive.calacademy.org/research/diatoms/names/index.asp
Catalogue of Life: http://www.catalogueoflife.org/annual-checklist/2012/info/about
Centre of Excellence for Dinophyta Taxonomy: http://www.dinophyta.org
CyanoDB.cz. On-line database of cyanobacterial genera: http://www.cyanodb.cz
EOL (Encyclopedia of Life): http://eol.org/
Gallica Bibliothèque Numérique: http://gallica.bnf.fr
GBIF (Global Biodiversity Information Facility): http://www.gbif.org
Herbaria United. UK and Irish Herbaria On-line: http://herbariaunited.org
ICN (International Code of Nomenclature for algae, fungi, and plants), formly ICBN (International Code of Botanical Nomenclature for algae): http://ibot.sav.sk/icbn/main.htm
Index Nominum Algarum: http://ucjeps.berkeley.edu/INA.html
IUCN (International Union for Conservation of Nature) Red List of Threatened Species: http://www.iucnredlist.org
JSTOR: http://www.jstor.org
JSTOR Plant Science: http://plants.jstor.org
The Linnean Collections: http://www.linnean-online.org
TOL (Tree of Life): http://tolweb.org/tree/
Wikispecies: http://en.wikipedia.orfg/wiki/Algae
WoRMS (World Register of Marine Species): http://www.marinespecies.org

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