

Checklist of the genus *Cosmarium* (Zygnematophyceae, Streptophyta) from Brazil

Abstract

Background: Despite the many problems involving taxonomy of the genus *Cosmarium*, the present checklist intends to provide an overview of the genus *Cosmarium* in the Brazilian territory, with respective references, in order to facilitate future ecological and taxonomical studies involving this ubiquitous genus. Several references containing *Cosmarium* records for Brazil are somewhat rare and difficult to access due to the great regionality of the publications. Very few studies are available online, thus complicating taxonomic inventories and analysis of their taxonomy. Checklist covers only taxonomic papers published until 2018 totalling 111 researches and discussion about studies of the genus in Brazil. Diversity of *Cosmarium* in Brazil is represented by 650 taxa, including species, varieties and taxonomic formae that were presently listed and referenced. Present status of the genus and some implications for its future studies in Brazil are discussed along the taxonomical context. Studies including taxonomic records of *Cosmarium* in Brazil covered just small geographic areas. It is fundamental to increase the commitment of the scientific community to primarily classical taxonomy coupled with ecofisiological and molecular studies in phylogenesis, still crucial and essential to reveal the desmid flora in Brazil and which should be constantly stimulated.

Keywords: desmid flora, desmidiales, microalgae, neotropical region, checklist

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Stefania Biolo, Carlos Eduardo de Mattos Bicudo

Núcleo de Pesquisa em Ecologia, Instituto de Botânica de São Paulo, Brazil

Correspondence: Stefania Biolo, Núcleo de Pesquisa em Ecologia, Instituto de Botânica de São Paulo, Caixa Postal 68041, 04045-972 São Paulo SP, Brazil, Email sbialo@gmail.com

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Introduction

Among the oldest and most specious desmid genera, *Cosmarium* Corda 1832 ex Ralfs 1848 embraces ca. 1,500 described taxa, comprising several hundred taxonomic varieties and forms.¹ Despite its substantial number of species, the genus appears in the Brazilian literature only in regional floras of very local and/or restrict environments, in which they usually are sporadically mentioned and mainly for the states São Paulo, Rio de Janeiro, Paraná and Amazonas.²

Moreover, several references containing *Cosmarium* records for Brazil are somewhat rare and difficult to access due to the great regionality of the publications. Very few studies are available online, thus complicating taxonomic inventories and analysis of their taxonomy. A great number of publications containing records of *Cosmarium* are aimed at ecological subjects, and are simple lists of the taxa identified by non-specialists for the ecological purpose of the paper. To complicate matters, taxonomic inventories very seldom include complete information on the specimens studied, such as description, measurements and illustration. Furthermore, many times the material examined was not preserved, thus making impossible its examination to confirm the identification.

Cosmarium is a very specious artificial genus, most probably of polyphyletic origin.³⁻⁵ Due to the disproportionate number of species included in the genus and its very much suspected artificiality, there are very few taxonomic revisions and floristic works published covering a broad area.⁶

Despite the many problems involving this genus' taxonomy, the present checklist intends to provide an overview of the genus *Cosmarium* in the Brazilian territory, in order to facilitate future ecological and taxonomical studies involving this ubiquitous genus; also, to contribute to algal floristic investigation, enhancing conception of this considerable genus' current overview to our country.

Methods

The present checklist covers all published data compiled from surveys that would include *Cosmarium* material recorded from periphytic, phytoplanktonic, metaphytic, phytohelmic and subaerophytic habitats in Brazil until 2018. The kind of work analysed was only taxonomic (proposition of new taxa or flora with description, dimensions and illustration of taxa). Such studies include an extensive literature and on online scientific databases such: SciVerse Scopus, ISI Web of Knowledge and SciELO; also the second author's private library at the "Instituto de Botânica", São Paulo, SP, Brazil; and complementary information from Google Scholar. Literature citations are given as complete as possible, in the chronological order.

Type materials were not checked, but publications of material were critically examined, and the nomenclature was included as it was published, except in the case of (1) synonyms, which were present in between parentheses; and (2) when symbols or Greek letters (* or α , β , etc.) were used, which were converted into the correct taxonomic level considered, according to McNeill et al.⁷ Invalid names, synonymized names to other genus, uncertain identifications and taxa in generic levels were not considered and not compiled; only specific and infraspecific level taxa were considered. Each taxa name cited in Results follows the number of each reference cited. Synonyms were according to Guiry & Guiry.⁸

Results

During analysis of research studies, a significant number of records have been found from ecological works and floristic surveys (lists) in Brazilian territory. Despite the somewhat high species richness recorded in all the studies, the vast majority of records were not followed by description, measurements and illustration that would allow their taxonomic confirmation, so were not here considered.

Systematic situation of the genus *Cosmarium* is according to Guiry⁹ as follows:

Phylum *Streptophyta*

Class *Zygnematophyceae*

Order *Desmidiiales*

Family *Desmidiaceae*

Cosmarium Corda 1832 ex Ralfs 1848

Analysis results in 111 studies of taxonomic and some floristic surveys and allowed compilation of 650 *Cosmarium* considerable records (including species, varieties, taxonomic formae and forma not named) in Brazil presented in the Table 1.

More than 200 new *Cosmarium* species, varieties and taxonomic formae were described from Brazilian material.^{9–24} Very few taxa in the Brazilian literature as a whole were represented by a large number of records. These records included a considerable fraction of rare taxa and the extreme use of the morphological concept of species, a fact that can be illustrated by the many species of both named of unnamed varieties and taxonomic formae described.

Discussion

Identification of *Cosmarium* is somewhat complicated. First of all, it is a very specious and artificial genus with a very probable polyphyletic origin, covering hundreds of varieties and taxonomic formae described on the essential basis of their morphology.⁴ Desmid taxonomy based on the “sole” vegetative cell morphology and cell wall decoration^{25,26} has so far provided very important and useful taxonomic data. It has been defended by Nemjová²⁷ and Šťastný & Kouwets²⁸ the use in the taxonomy of a group of general morphological characters clearly visible under optical microscopy and well-defined under electron microscopy.^{26,28} The tridimensionality of the desmid cell also allows observation of their cells in different views, the frontal (taxonomic view), the apical (vertical) and the lateral views, which denotes important taxonomic implications.²⁹ Consequently, classical taxonomy still remains essential and widely used for identification of *Cosmarium* species, varieties and taxonomic formae as well as other desmid genera worldwide. The idea of phylogenesis arose with the advances of molecular biology and led to the discussion of how valid the classical taxonomy is.^{3,4,30–34} However, taxonomic situation of *Cosmarium* based on phylogenetic relationships of molecular multigen studies, remains transitory especially in the species concept. Morphological concepts (despite of being artificial) are still universally applied,²⁷ so that all papers recording the occurrence of *Cosmarium* in Brazil were published using the morphological analysis of taxa, and those treated taxa taxonomically were considered in the present survey (Table 1).

Conclusion

The present study compiled every taxonomical data possible to provide the state of knowledge of the genus *Cosmarium* in Brazil, aiming at serving as the first steps toward a future review of the genus for the country and worldwide. Taxonomical diversity of *Cosmarium* in Brazil was significant according to this study and also revealed a large number of taxa described from Brazilian material. Regardless of the taxonomic records of *Cosmarium* that were restricted to relatively small geographical areas, the present situation requests an increasing

commitment of the Brazilian scientific community to pursue classical taxonomy of *Cosmarium*, since molecular biology information is presently totally absent in Brazil. Nevertheless, we have to always keep in mind the polyphasic concept of species. In other words, classical taxonomy coupled with ecofisiological and molecular findings are still crucial and essential to make public the Brazilian desmid flora.

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Conflict of interests

Authors declare that there is no conflict of interest.

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