Phytoflagellates from the Gulf of Gdańsk and surrounding waters (the Southern Baltic Sea)

Marcin Pliński
Konrad Wołowski
Paweł M. Owsianny

Phytoflagellates from the Gulf of Gdańsk and surrounding waters (the Southern Baltic Sea)

A key to the identification of the species

Gdańsk University Press
Gdańsk 2023

Reviewer
Dr. Irina Olenina

Technical editing
Justyna Zyśk

Cover and Title Pages Design
Maksymilian Biniakiewicz

Typesetting and Page Layout
Maksymilian Biniakiewicz

Index to names of the species
Marcin Pliński

The book is financed by
the Rector of the University of Gdańsk

ISBN 978-83-8206-591-6

Gdańsk University Press
ul. Armii Krajowej 119/121, 81-824 Sopot
tel. +48 58 523 11 37, tel. kom. +48 725 991 206
e-mail: wydawnictwo@ug.edu.pl
wydawnictwo.ug.edu.pl

Online bookstore: wydawnictwo.ug.edu.pl/sklep/

Printed and bound by
Zakład Poligrafii Uniwersytetu Gdańskiego
ul. Armii Krajowej 119/121, 81-824 Sopot
tel. +48 58 523 14 49

Contents

Introduction 7

Euglenophyta 15

Dinophyta 28

Cryptophyta 63

Haptophyta 69

Heterokontophyta 77

References 90

Line drawings and images of species 101

Phtotographs from a light and electron microscope SEM 223

Index to names of the species 252

Introduction

Flagellates is the name of a group of organisms which refers to either single-celled or colonial species that have one or more flagella on each cell. Within this group, Wettstein (1935) distinguished plant flagellates (Monadophyta) at the taxonomic rank of division which is phylogenetically heterogeneous and its composition includes systematic groups that are at different stages of development and are often very different from each other. This group is also often referred to as plant flagellates (Phytoflagellata). In the hierarchical taxonomy of organisms, such as the systems of Whittaker (1969) or Cavalier-Smith (2004), plant flagellates belong to the Protista kingdom. For practical reason, the systems proposed by Graham & Wilcox (2000), Wehr & Sheath (2003) and John et al. (2011) are used in this book. Therefore, species from the following divisions will be described in further sections of the book as: Euglenophyta, Dinophyta, Cryptophyta, Haptophyta and Heterokontophyta. Flagellate forms classified as green algae (Chlorophyta), such as prasinophyceans and chlorophyceans, are excluded from this book. They are described in a separate volume devoted to the division of green algae from the Southern Baltic (Pliński et al. 2022). As the taxonomic studies of the above-mentioned groups of flagellates are still in progress, only some of them have been either included in the identification key or indicated in this study.

Before the first descriptions of euglenoids were published (Ehrenberg 1830), they were considered also as a specific taxonomic group belonging to the plant kingdom. However, due to a large variety of feeding habits (the presence of non-green forms), they are also of interest to zoologists. Previous studies allow euglenoids to be classified either in the kingdom Protozoa, phylum Euglenozoa (Cavalier-Smith 1993, 1998) or in the division Euglenophyta, kingdom Protista (Corliss 1984). According to Margulis et al. (1990) they also have been classified in the phylum Euglenoida, class Euglenophyceae. Despite the development of molecular phylogenetics in the 21st century, taxonomic difficulties related to euglenoids could not be resolved unequivocally. Similarly, although to a lesser extent, this problem applies to dinophytes which also include forms without chloroplasts.

The name Dinoflagellata is always associated with the classic representatives of this group, namely with *Peridinium* or *Ceratium* where furrows are one

of the basic elements of the cell morphology. Klebs in 1883 discovered that there was no cilia wreath in a circular furrow, as Ehrenberg claimed, instead there is a flagellum. Therefore, the name Cilioflagellatae (according to Claparéde and Lachmann) was then withdrawn and replaced by Bütschli, with the hitherto used term "Dinoflagellatae" (Huber-Pestalozzi 1955, 1968). In taxonomic terms, however, algae that do not have furrows also belong to this group. The name "Dinoflagellata" emphasizes the fact that these organisms spin and have flagella (from the Greek language *δῖνος* – dinos 'spinning'; from the Latin language *flagrum*, *flagellum* – whip, flagellum). In addition, the prefix di-, used in many names, comes from the Greek language and always means something double. Even those dinophytes that lack flagella at typical stages of their development (such as the genus *Stylodinium*) are equipped with flagella during reproduction, when forming double-stranded gametes. The term "nucleus" in dinophytes is associated with the term "dinokaryon". It has several specific features that are not found in other eukaryotic organisms. The nucleus is large with bead chromatin, also visible at rest. The structure of chromatin has many features in common with the structure of the genetic material of prokaryotic cells. Due to the presence of these numerous specific features, the dinokaryon is sometimes called the mesokaryotic nucleus.

Thus, old names associated with furrows, such as Pyrrophyta (Pascher 1914, 1927) or Peridineae (Lindemann 1928) do not refer to the specific structure of the cell nucleus. Based on modern knowledge about the systematic division of the living world, including molecular data on the evolution of chloroplasts, algae are classified in four of the six kingdoms of the living world: Bacteria, Protozoa, Chromista and Plante (Cavalier-Smith 2002). It is clear that algae are organisms occurring in habitats at least temporarily associated with water, however, phylogenetically they are often very distant from each other. Therefore, algae are not a systematic group, but only an ecological one. "Dinophytes" which are the subject of this study, belong to the eukaryotic kingdom of Protozoa (cf. Cavalier-Smith 2003; Cavalier-Smith & Chao 2004). There is no unanimity among researchers regarding the systematization of dinophytes at the division level. Researchers from the botanical world use the name "Dinophyta" more often, while both zoologists and researchers of Protozoa use more often the terms "Dinoflagellata" or "Dinozoa". There are also taxonomic concepts that integrate these organisms into the Myzozoa cluster (Cavalier-Smith in Cavalier-Smith & Chao 2004).

Other plant flagellates considered in this book are included in three divisions: Haptophyta, Cryptophyta and Heterokontophyta. They are mostly unicellular organisms, equipped with flagella and generally having photosynthetic pigments. In the last forty years, systematics of this group has undergone major modifications. Fott (1971) includes them together with diatoms into one

common division of Chrysophyta, but separating cryptophytes as a class with uncertain taxonomic affiliation. In recently propagated textbooks, e.g. van den Hoek et al. (1995), Cryptophyta and Haptophyta are considered as divisions and Chrysophyta are also considered as a class within the Heterokontophyta division, while Graham et al. (2009) place them in the Ochrophyta group. The specificity of cryptophytes has already been noted by Ehrenberg (1838) and today this view is gaining recognition again, hence Cryptophyta are distinguished at the rank of division in the systematics of algae. Diatoms were excluded from the rich group of Chrysophyta at the rank of independent division (Round et al. 1990), and a group of flagellates with specific flagella – haptonema – was distinguished as separate division referred to as Haptophyta (Hibberd 1976).

The level of knowledge of plant flagellates included in the above-mentioned divisions is very low, not only for the Gulf of Gdańsk, but also for the entire Baltic Sea. This is due to a specific methodology required both for collecting and processing the material for taxonomic analysis, involving repeated in-situ tests. The publication of this volume should encourage and help, especially young adepts of science, to undertake research on a very interesting group of algae – flagellates. These organisms are mostly typical for freshwater habitats, but the low level of salinity in the coastal waters of the Baltic Sea promotes their occurrence in this area. These waters are significantly freshened, and there is a clear impact of surface runoff water. Due to the increasing eutrophication and thus the increased water fertility, the number of species representing this group of algae may also increase in coastal waters. Therefore, the presented key includes not only those species that have already been recorded in the southern Baltic waters, but also those that have ecological preferences to occur in the brackish environment and are very common, characterized by a wide ecological spectrum and therefore potentially present in the Gulf of Gdańsk and other Baltic waters.

This handbook presents a list of plant flagellate species recorded in the southern Baltic, especially in the Gulf of Gdańsk (Namysłowski 1924; Wołoszyńska 1928; Bursa 1946; Rumek 1948, 1950; Ringer 1970; Pliński 1975, 1979, 1990; Pliński et al. 1982, 1985; Bralewska & Witek 1995; Pliński & Dobroń 1999; Witek & Pliński 2000, 2005; Rychter 2004; Łotocka 2009; Witek 2010) and in costal, brackish-water bodies, such as the Vistula and Szczecin Lagoons (Szarejko-Łukaszewicz 1957; Zembrzuska 1962; Pliński & Simm 1978; Pliński 1979). The list also includes species occurring in other parts of the Baltic Sea (Hällfors 2004) which have been considered as potentially available for the algal flora of the Gulf of Gdańsk.

This book has a specific editorial layout. It consists of an introduction, comprising the purpose of the publication and five specific separate parts. Each of them deals with a specific division of plant flagellates and at the beginning

contains a brief description of both anatomical and morphological features that are important for the identification of taxa, and then detailed keys for their identification are attached. These keys start with classes and continue with orders, families, genera and finally species. All essential diagnostic characters relevant to a given taxonomic level are included in the keys, while the identification key for species provides also data on size measurements for a given species. The most important part of this handbook are plates with drawings and images of the selected species. This work is provided with original photographs of the selected taxa from the samples collected in the Gulf of Gdańsk and adjacent regions of the Baltic Sea. Thus, we present a modern key useful for the identification of these plant flagellates.

The authors express their gratitude to professor Robert Andersen for his critical remarks and rendering recently published papers on Heterokontophyta accessible, to professor Marc Gottschling for his consultations on the taxonomy and phylogenetics of the chosen parts of the key to dinoflagellates (Dinophyceae), to professor Øjvind Moestrup for having agreed to include in the key several scanned photos of selected species of dinophytes from the Baltic Sea and to professor Lars Edler for completing the list of species. We greatefully acknowledge our colleagues Justyna Kobos, Diana Krawczyk, Maria Łotocka, Irina Olenin, Jolanta Piątek, Małgorzata Poniewozik, Barbara Witek, Bożena Zakryś and Agnieszka Napiórkowska-Krzebietke for sharing colour photographs. We are grateful to Marian Wysocki for technical assistance in preparing specific drawings of the cell structure in the selected taxonomic groups of plant flagellates.

Below we present a simple key to identify the divisions covered by this book.

Key to the divisions:

1. Chloroplasts surrounded by three membranes 2
1a. Chloroplasts surrounded by four membranes 3
2. Cells usually green; chlorophyll-a and chlorophyll-b as photosynthetic pigments . . . . . **Euglenophyta**
2a. Cells usually brown; chlorophyll-a and chlorophyll-c as photosynthetic pigments . . . . . **Dinophyta**
3. Thylakoids in loose pairs . . . . . **Cryptophyta**
3a. Thylacoids in stacks of three 4
4. Cells with 2 flagella and third special – haptonema . . . . . **Haptophyta**
4a. Cells without haptonema . . . . . **Heterokontophyta**

Scheme of the taxonomy for the genera described in this book.

Division: **Euglenophyta**
- Class: Euglenophyceae
  - Order: Euglenales
    - Family: Euglenaceae
      - Genus: Euglena
    - Family: Phacaceae
      - Genus: Phacus, Lepocinclis, Monomorphina
    - Family: Trachelomonadaceae
      - Genus: Trachelomonas, Strombomonas
    - Family: Colaciaceae
      - Genus: Colacium
  - Order: Eutreptiales
    - Family: Eutreptiaceae
      - Genus: Eutreptia, Eutreptiella

Division: **Dinophyta**
- Class: Dinophyceae
- Subclass: Gymnodiniphycidae
  - Order: Gymnodiniales
    - Family: Gymnodiniaceae
      - Genus: Gymnodinium, Nusuttodinium
    - Family: Polykrikaceae
      - Genus: Polykrikos
  - Order: Amphidiniales
    - Family: Amphidiniaceae
      - Genus: Amphidinium, Oxytoxum
  - Order: Ptychodiscales
    - Family: Brachydiniaceae
      - Genus: Karenia, Karlodinium
    - Family: Gyrodiniaceae
      - Genus: Gyrodinium, Ankistrodinium
- Subclass: Peridiniphycidae
  - Order: Prorocentrales
    - Family: Prorocentraceae
      - Genus: Prorocentrum
  - Order: Dinophysales
    - Family: Dinophysaceae
      - Genus: Prodinophysis, Dinophysis

Order: Suessiales
Family: Borghiellaceae
Genus: Borghiella
Family: Suessiaceae
Genus: Biecheleria, Protodinium
Order: Tovelliales
Family: Tovelliaceae
Genus: Jadwigia
Order: Peridiniales
Family: Kryptoperidiniaceae
Genus: Kryptoperidinium, Durinskia
Family: Protoperidiniaceae
Genus: Amphidiniopsis, Protoperidinium, Oblea, Kolkwitziella, Diplopsalis, Preperidinium
Family: Heterocapsaceae
Genus: Heterocapsa
Family: Thoracosphaeraceae
Genus: Speroidium, Scrippsiella, Naiadinium, Apocalathium
Family: Peridiniopsidaceae
Genus: Parvodinium, Palatinus
Family: Peridiniaceae
Genus: Peridinium
Order: Gonyaulacales
Family: Ceratiaceae
Genus: Ceratium, Tripos
Family: Goniodomaceae
Genus: Alexandrium, Triadinium
Family: Ceratocorythaceae
Genus: Protoceratium
Family: Lingulodiniaceae
Genus: Amylax, Lingulodinium
Family: Gonyaulacaceae
Genus: Gonyaulax, Peridiniella

Division: **Cryptophyta**
Class: Cryptophyceae
Order: Cryptomonadales
Family: Cryptomonadaceae
Genus: Cryptomonas
Order: Pyrenomonadales

Family: Pyrenomonadaceae
Genus: Pyrenomonas
Family: Geminigeraceae
Genus: Teleaulax
Family: Chroomonadaceae
Genus: Chroomonas, Komma
Family: Hemiselmidaceae
Genus: Hemiselmis

Division: **Haptophyta**
Class: Pavlovophyceae
Order: Pavlovales
Family: Pavlovaceae
Genus: Pavlova
Class: Coccolithophyceae
Order: Coccolithales
Family: Coccolithaceae
Genus: Syracosphaera, Coccolithus, Discosphaera
Order: Prymnesiales
Family: Prymnesiaceae
Genus: Prymnesium, Chrysochromulina
Order: Phaeocystales
Family: Phaeocystaceae
Genus: Phaeocystis

Division: **Heterokontophyta**
Class: Dictyochophyceae
Order: Dictyochales
Family: Dictyochaceae
Genus: Dictyocha, Octactis
Order: Pedinellales
Family: Pedinellaceae
Genus: Pseudopedinella
Class: Raphidiophyceae
Order: Raphidiomonadales
Family: Vacuolariaceae
Genus: Gonyostomum
Class: Chrysophyceae
Order: Synurales
Family: Mallomonadaceae
Genus: Mallomonas

Family: Synuraceae
Genus: Synura
Order: Chromulinales
Family: Chrysamaebaceae
Genus: Chrysidiastrum
Family: Chrysococcaceae
Genus: Chrysococcus
Order: Ochromonadales
Family: Ochromonadaceae
Genus: Ochromonas, Uroglena
Family: Dinobryaceae
Genus: Kephyrion, Dinobryon, Chrysolykos, Epipyxis