DATA TO KNOWLEDGE OF HUNGARIAN DINOPHYTA SPECIES
III. CONTRIBUTION TO THE DINOPHYTA TAXA OF KÖRÖS
AREA I.

I. Grigorszky, K. T. Kiss, F. Vasas and G. Vasas


Abstract. Dinophyte species were investigated during this study from 28 sites in Körös area. Samples were taken from different oxbow-lakes, canals, and rivers. 30 taxa were identified, including 27 ones that were not previously reported from the Körös area and two from Hungary. New taxa for the Hungarian algal flora are Cystodinedria inermis, and Peridiniopsis kevei (P. kevei is a new freshwater species - Grigorszky et al. in print). The rare and valuable new species from Körös area are Glenodiniopsis steinii, Gymnodinium fuscum, G. hiemale, Katodinium vorticella, Peridiniopsis cunningtonii, P. kevei, Peridinium volzii, Sphaerodinium cinctum, Woloszynskia pseudopalustris. Four different forms of Ceratium hirundinella were recognized, including forma furcoides, forma gracile, forma piburgense and forma robustum.

Keyword: Dinophyta, Körös area, Ceratium, Glenodiniopsis, Gymnodinium, Katadiniunm, Peridiniopsis, Peridinium, Sphaerodinium, Woloszynskia.

I. Grigorszky, Ecological Department of Kossuth Lajos University, H-4010 Debrecen, P.O.Box 71; K. T. Kiss, Hungarian Danube Research Station, H-2131 Göd, Jávorka S.14.; F. Vasas, Laboratory of Environmental Protectorate, H-5701 Gyula, P.O.Box 99; G. Vasas, Botanical Department of Kossuth Lajos University, H-4010 Debrecen P.O.Box 14, Hungary

Introduction

Only a few paper were published about the algal flora of the Körös area, same on diatoms, some on desmids and chlorophytes (Koren 1883, Szalai 1942, Kol 1954, Uherkovich 1963, Vasas 1980a, 1980b, 1986). Three Dinophyta species were reported from this area: Ceratium cornutum (Uherkovich 1968), Ceratium hirundinella (Kol 1954) and Glenodinium gymnodium (Szalai 1941). Concerning on this later species there is a doubt of identification, missing any drawing, micrograph or plate tabulation (unknown species name - perhaps missprint).

Dinophyta species are a distinctive group of unicellular protists recognized by their swimming pattern (spinning while advancing due to transverse and longitudinal flagella), usually golden-brown pigmentation, centrally located nucleus with permanently condensed chromosomes and the lacking of histones. Dinophyta species can be divided into two groups:

(i) those with a cellulose wall composed by plates („armored”), and
(ii) those apparently lacking a rigid wall („naked”).

Determination of armored Dinophyta species must be confirmed by the tabulation of plates, the unarmored species are confirmed by inner structure and cell shape however, certain key features can be recognized in some species which aid in their identification. (Kofoid 1909, Lefèvre 1932, Huber-Pestalozzi 1950, Bourrelly 1968, Starmach 1974, Spector 1984, Popovsky and Pfiester 1990). The objective of the present study is to report on Dinophyta species found in the Körös area and provide a short descriptions and a key, which can be useful to algologists working with phytoplankton samples (Table 1).
Materials and methods

Quantitative phytoplankton samples were taken by 1 l bottles and for qualitative analyses net samples—pore size 10 µm—from the open water of oxbow lakes, canals, rivers and squeezing from the submerse vegetation (sampling sites on Fig. 1). Most part of sampling were made between 1989 and 1994. One half of samples were preserved with Lugol’s iodine and the other half were examined immediately upon return to the laboratory. Line drawings were based on sketches made during microscopic observations and from micrographs.


The description of different oxbows and backwaters were found in book of Pálfi (1995). For identification the books of Starmach (1974) and Popovsky and Pfister ( 1990) were first of all used.

Results

Dinophyte cells are considered to have a typical ventral and dorsal view. The mid-cell cingulum divides the cell into an upper part (epitheca, epicone) and lower part (hypotheca, hypocone). Thus, the cell may be viewed from four directions: ventral, dorsal, apical and antapical. Thcate (armored) Dinophyta species have a cellulose wall divided into plates and their taxonomy is based on the number and arrangement of the plates. Kofoid (1909) proposed a code system for the plate arrangement, so called tabulation. Plates are often in concentric rows above and below the cingulum. The ventral plate in series is the first plate and plates are numbered counterclockwise on epitheca and anticlockwise on hypotheca.

The series of plates closest to the apex is designated apical and has a single prime (’) mark after the number. Precingular plates have two prime following the number, postcingular three prime, and antapical four prime. Plates between the apical and precingular series are anterior intercalary (a), and plates between postcingular and antapical series are posterior intercalary (p).

Plate tabulations are always included in species descriptions (e.g., 4’, 3a, 7”, 5”, 2”’ for Peridinium cinctum). Non-thecate (naked) Dinophyta species lack a well developed cellulose wall and their taxonomy is based on cell shape, pigmentation, presence of an eyespot (stigma), and motility. During this study 30 taxa were identified: 24 armored, and 6 naked, of which 27 are new records for the Körös area, two new species for Hungary (Fig. 2). Most of the taxa recorded here have distinctive features which facilitate their identification.

We present here a key based on the species of Dinophyta species found by the author and does include all previously reported species. (Table 1.)

Ceratium Shrank 1793

Ceratium hirundinella is characterized by one apical, one antapical, and one or two postcingular horns. C. hirundinella as having recognized different forms (Huber-Pestalozzi 1950) varying number of postcingular horns. The Ceratium cells are golden yellow with thick plates displaying reticulate ornamentation. Plate plate-tabulation is 4’, 5”, 5”’, 2”’’. Length 188- 322 µm. Distinctive phytoplankton and the most commonly reported freshwater Dinophyta species. This species is distinguished from C. cornutum by the straight position of the apical horns. (Fig. 2/1, 5).

(i) Cells with 3 horns under optimal conditions:

Ceratium hirundinella forma furcoides (Levander) Schoeder 1920 (Fig. 2/1) Cells are relatively
narrow — up to 60 µm — and long — 180-350 µm — with 3 horns under optimal conditions. The apical horn is in the same angle as the antapical horn. The species was found: 25. collecting site. (The numbers sign the sampling sites on Fig.1.)

(ii) Cells with 4 horns under optimal conditions:

*Ceratium hirundinella* forma *robustum* (Amberg) Bachmann 1911 (Fig. 2/2) has a smaller body volume than the *Ceratium hirundinella* forma *hirundinella* form. The antapical horn is long and slightly divergent, the postcingular horns are half in length of the antapical one. The length of the cells is 168-320 µm. The species was found in 21., 22. collecting sites.

*Ceratium hirundinella* forma *gracilis* Bachmann 1911 (Fig. 2/3) The cell has one or two downward pointing postcingular horns. It is similar to forma *hirundinella*, differing in the direction of horns. The length of the cells is 147-238 µm. The species was found in 24. collecting site.

*Ceratium hirundinella* forma *piburgense* (Zederbauer) Bachmann 1911 (Fig. 2/4) The outer antapical horn and the postcingular horns are divergent. The cells are 163-210 µm long and 40-52 µm wide. The species was found in 8., 14., 15. collecting sites.

*Ceratium hirundinella* forma *caespitosa* Bachmann 1911 (Fig. 2/5) has a relatively short, wide and curved apical horn. The apical horn directed an angle from the longitudinal axis. On the hypotheca *Lachmann 1858* (Fig. 2/5) has a relatively short, wide and large nucleus. The species were found: 25. collecting site.

*Glenodiniopsis* Woloszynska 1916

Cells are oval without apical pore. The chloroplasts are numerous and parietally situated. Cells six to eight postcingular plates on hypotheca. There are no stigma. Numerous red corpuscles can be present within the cytoplasm. The cingulum is deep and spirals to the left.

*Glenodiniopsis steinii* (Lemmermann) Woloszynska 1916 (Fig. 2/7). The cells are somewhat oval and flattened dorso-ventrally. The apical pore is absent. The plate arrangement is asymmetric. The plate formula is 4”, 4a, 8”, (6-8)’’, 2’’. The cells are 36-48 µm long and 32-46 µm wide. The species was found in 28. collecting site.

*Gymnodinium Stein 1878*

*Gymnodinium* is a genus of naked Dinophyta species with the cingulum in a median position. They must be examined and sketched while alive and swimming, because upon death they form featureless spheres (the only way to distinguish *Gymnodinium* from thin walled *Glenodiniopsis*, *Peridiniopsis* and *Wolosznyska*). The species are differentiated by the shape of the epicone and hypocone, details of the sulcus, presence a stigma, and the color of chloroplasts. Species can be photosynthetic with yellow-gold or blue-green chloroplasts, or they can be non-photosynthetic and colorless, or they may have accumulation bodies of various colors (yellow, orange, red).

*Gymnodinium fuscum* (Ehrenbergh) Stein 1878 (Fig. 2/8). The epicone is dome-shaped and the hypocone forming an inverted cone a slightly produced tip. The numerous chloroplasts are radially arranged. The cells are 53-75 µm long and 43-56 µm wide. The species was found in 9. collecting site.

*Gymnodinium hiemale* (Schiller) Popovsky 1984 (Fig. 2/9) is a non-photosynthetic species, its sulcus extends to antapex, the nucleus is in the hypocone, and there can be red inclusion bodies. The specimens from the Körös area are are larger (average length 21 µm) than those described in the literature (16 µm). The cells are 18-25 µm long and 12-26 µm wide. The species was found in 9. collecting site.

*Gymnodinium palustre* Schilling 1891 (Fig. 2/16) is an autotrophic, holophytic species. The epicone can be twice in length of the hypocone. Numerous chloroplasts are parietally arranged. The cells are 36-48 µm long and 20-31 µm wide. The species was found in 9. collecting site.
**Gymnodinium uberrimum** (Allman) Kofoid and Swezy 192 1 (Fig. 2/11). The cells are broadly sphaerical and little flattened dorso-ventrally. The epicone is rounded or bell-shaped. The hypocone is highly variable in size and form. Numerous chloroplasts are radially arranged. The cells are 38-52 µm long and 30-40 µm wide. The species was found in 5., 6., 8., 16., 25. collecting sites.

**Katodinium** Fott 1957

Cells are spherical, oval or mushroom shaped. The cingulum is anteriorly placed and slightly spiral. The cell wall thin and colorless. The species mainly colorless. Fott (1957) placed the species to Massartia Conrad 1926 genus to *Katodinium* genus.

**Katodinium vorticella** (Fig. 2/12) are usually colorless species, if chloroplasts present there are less than 10, which are relatively small and green or grey. Numerous reddish droplets can be present in the cytoplasm. If the shape of these droplets oval, it is a sign of the saprotrophic nutrition. If number of red droplets one or two and the shape is rectangular the cell is in sexual reproduction process. The cells are 18.5-33 µm long and 18-30 µm wide. This is a common species in different peat bogs, ponds and pools. The species was found in 8., 23. collecting sites.

**Peridiniopsis** Lemmermann 1904

Bourrelly (1968) transferred one part of *Glendonium* species with known plate tabulations into the genus **Peridiniopsis**; it remains a highly variable genus (3-5', 0-la, 6-7'', 5''', 2''''').

**Peridiniopsis cunningtonii** Lemmermann 1907 (Fig. 2/13). Cells are elongated. From two to six spines are on the hypotheca. Chloroplasts are numerous and oval. The plate formula is 4', 1a, 6'', 5''', 2'''' or 5', Oa, 6'', 5''', 2'''''. The cells are 32-48 µm long and 27-46 µm wide. The species was found in 2., 21., 26., 28. collecting sites.

**Peridiniopsis elpatiewskyi** (Ostenfeld) Bourrelly 1968 (Fig. 2/14). Cells are pentangular. Several spines or teeth-like projection may be present on the hypocone. There are numerous chloroplasts. The plate formula is 4', Oa, 7'', 5''', 2''''''. The cells are 29-44 µm long and 27-42 µm wide. The species was found in 13., 16. collecting sites.

**Peridiniopsis kevei** Grigorszky, Vasas F. et Klee 1997 (Fig. 2/15). The plate tabulation : 3', 1 a, 6'', 5''', 2'''''; the species is unicellular; theca and plate arrangement of glendon and young cell not visible with light microscope; the average length is 35 µm, 37 µm width; epitheca vary in shape from acute to a little blunt from; cingulum median and deep, narrower than sulcus; sulcus is deep, and is not reach to epitheca; some short spines (cristae) are on the edge of the sulcus, transverse flagellum as long as cingulum; longitudinal flagellum trailing body by less than one cell length; cells with numerous golden-brown chloroplasts generally located peripherally, their shape vary from ovoid to elongate; stigma sometimes present; nucleus large, with conspicuous chromosomes, usually located in hypotheca; pore exist at the apical end; 1'''' antapical plate has a relatively long tapering spines; some short spines (cristae) are on the edges of antapical plates. The species was found in 1., 2., 3., 4., 5., 6., 10., 11., 14., 15., 17., 18., 19., 20. collecting sites.

**Peridiniopsis polonicum** (Wołoszyńska) Bourrelly 1968 (Fig. 2/16) can be recognized by its conical epitheca, rounded hypotheca, and squared shape 1a plate. The plate pattern is 4', 2a, 7'', 5''', 2'''''. The cells are 41-52 µm long and 37-39 µm wide. The species was found in 13., 16. collecting sites.

**Peridinium** Ehrenberg 1830

**Peridinium** is defined by its plate tabulation: 4', 2-3a, 7'', 5''', 2'''''. Species differ from each other in the number of intercalary plates, apical symmetry, and the presence or absence of an apical pore. Most species are found as minor components of the phytoplankton although occasionally one species can be completely dominated in a pond or lake.

**Peridinium aciculiferum** Lemmermann 1900 (Fig. 2/17). Cells are rhomboidal and flattened dorso-ventrally. The plate formula is 4', 3a, 7'', 5''', 2'''''. Chloroplasts are absent. The cells are 40-53 µm long and 36-49 µm wide. The species was found in 15. collecting site.

**Peridinium achromatium** Levander 1932 (Fig. 2/18). The cells are elongated. Usually spines are found on the hypotheca. The plate formula is 4', 3a, 7'', 5''', 2'''''. The apical pore is present. The sulcus reaches the epitheca. The cells are 32-45 µm long and 20-40 µm wide. The species was found in 13., 14., 15., 28. collecting sites.

**Peridinium bipes** Stein 1883 (Fig. 2/19) has an apical pore, its cingulum is offset a cingulum width, and it is ventrally concave. Its plate pattern is 4', 3a, 7'', 5'', 2''. The cells are 45-67 µm long and 41-64 µm wide. Our specimens lack the typical paired antapical flanges. It looks like a *P. willei* with an apical pore. The species was found in 6., 9., 11., 17. collecting sites.

**Peridinium cinctum** Ehrenbergh 1838 (Fig. 2/20). The cells are sphaerical. The cingulum extends further into the epitheca. Chloroplasts are numerous and parietally arranged. Plates are thick. Plate formula is 4', 3a, 7'', 5''', 2'''''. The cells are 43-59 µm long and 42-53 µm wide. This species
widely in oxbows and canals in summer months. The species was found in 10., 26. collecting sites.

*Peridinium inconspicuum* Lemmermann 1899 (Fig. 2/21) is a small, approximately pentagonal cell with an apical pore, yellow-gold chloroplasts, and an approximately equatorial cingulum. Cells may have hypothecal spines. Plate pattern is 4', 2a, 7'', 5''', 2''''. The cells are 18-22 µm long and 15-19 µm wide. The species was found in 1., 2., 3., 6., 10., 11., 17., 18., 19., 20., 21., 27., 28., 29. collecting sites.

*Peridinium gosliaviense* Woloszynska 1916 (Fig. 2/22). The cells are egg or pear-shaped. One large spine present on the hypotheca. The plate formula is 2/22). The cells are 28-34 µm long and 22-32 µm wide. The species was found in 5., 11., 12., 17., 18., 19., 20., 23., 24., 29. collecting sites.

*Peridinium palatinum* Lauterborn 1896 (Fig. 2/23). The cells are ovoid. The absence of pore and the plate formula: 4', 2a, 7'', 5''', 2''''. The cells are 18-22 µm long and 22-32 µm wide. The species was found in 9. collecting site.

*Peridinium volzii* Lemmermann 1906 (Fig. 2/25) has a plate pattern similar to *P. willei* with apical intercalary plates in a symmetrical arrangement, but the cell is less compressed, and the 1' plate smaller than 7''. The cells are round in ventral view, somewhat dorsoventrally compressed, with a defined sulcus reaching the antapex, and thick plates with reticulate ornamentation; plate pattern is 4', 3a, 7'', 5''', 2''''. The cells are 42-50 µm long and 35-44 µm wide. The species was found in 11., 12., 15., 24., 29. collecting sites.

*Peridinium willei* Huitfeld-Kaas 1900 (Fig. 2/26) is a fairly large, golden brown species with distinctive flanges extending from apical plate boundaries, cingulum, and posterior borders, no stigma, concave ventral surface, and the 1st apical plate (1') is large. Its apical and intercalary plates are in a symmetrical arrangement and there is no apical pore. Plate pattern is 4', 3a, 7'', 5''', 2''''. The cells are 48-58 µm long and 49-52 µm wide. It was found fairly commonly throughout the Körös area. The species was found in 13., 23., 24. collecting sites.

*Sphaerodinium Woloszynska 1916
Sphaerodinium cinctum* (Ehrenbergh) Woloszynska 1916 (Fig. 2/27). The cells are oval. The epitheca and hypotheca are equal in size. Plate formula: 4', 4a, 7'', 6''', 2'''. Apical pore is present. The cells are 28-34 µm long and 22-30 µm wide. The species was found in 29. collecting site.

Woloszynska genus Thompson 1950

The cell wall is composed of very fine, numerous platelets, which are usually hardly or not seen during ligh microscopic (LM) investigations. Many species have been described, but it is only possible to unambiguously determine 5-7 species.

Woloszynska *ordinata* (Skuja) Thompson 1950 (Fig. 2/28). The cells contain less than five, big chloroplasts. The size of platelets is the biggest one among the Woloszynska species. The cingulum is broad and deep. The cells are 15-20 µm long and 13-18 µm wide. The species was found in 14., 15. collecting sites.

Woloszynska *pascheri* (Suchlandt) v. Stoch 1973 (Fig. 2/29). The cells is varied in shape and in size. Regular hexagonal platelets cover the cell. The cells are 15-42 µm long and 24-39 µm µ. The species was found in 12. collecting site.

Woloszynska *psuedopalustris* (Woloszynska) Kiselev 1954 (Fig. 2/30). The hypovalva is „excavated”. The morphology and arrangement of platelets are not well documented. Chloroplasts are numerous and are in parietal position. The cell are 34-45 µm long and 34-42 µm wide. The species was found in 11. collecting site.

Discussion

The presence of Dinophyta species, other than that of *Ceratium hirundinella*, is probably under-reported in the literature because of both the inherent difficulty in determination of genera and species, and an old and scattered literature. Armored Dinophyta species require elucidation of the plate pattern and comparison to reponed patterns. Naked Dinophyta species require immediate examination. During this study a few taxa with thin thecae were found but not identified because of insufficient material and lack of definitive characteristics. During our investigation 30 species were found in Körös area and two of them are new species for Hungary: *Peridiniopsis kevei, Cystodinedria inermis*. Up to now 32 freshwater Dinophyta species were known form Hungary and only three species were known from this area. In our
Table 1. Key to the Dinophyta species of Körös area.

1a. Vegetative cells free-swimming................................................................. Cystodinodria inermis
1b. Vegetative cells attached on filamentous algae or submers vegetation
2a. Cells unarmored.......................................................................................... 3
2b. Cells armored............................................................................................... 7
3a. Cingulum is equatorial.................................................................................. Katodinioidium vorticella
3b. Cingulum is not equatorial.......................................................................... 4
4a. Sulcus extends into the epicone more than 1/3 of length of epicone........... Gymnodinium uberrimum
4b. Sulcus does not extend into the epicone.................................................... 5
5a. Cells are spherical......................................................................................... Gymnodinium hiemale
5b. Cells are not spherical.................................................................................. 6
6a. Chloroplasts are parietally arranged............................................................ Gymnodinium fuscum
6b. Chloroplasts are radially arranged................................................................
7a. The cells have numerous, small, similar size plates.................................... 8
7b. Plates not numerous, and dissimilar in size................................................ 10
8a. Less then five, big chloroplasts are present............................................... Wołoszynskia ordinata
8b. Numerous small chloroplasts are present.................................................. 9
9a. The hypovalva is "excavated"................................................................. Wołoszynskia pseudopelastres
9b. The hypovalva is rounded......................................................................... Wołoszynskia pascheri
10a. Cells with one apical and 1-3 antapical horns........................................... 11
10b. Cells without horns...................................................................................... 15
11a. Apical horn straight compared with the longitudinal axis.............................. 12
11b. Apical horn directed at an angle from the longitudinal axis....................... Ceratium cornutum
12a. Cells with 3 horns....................................................................................... Ceratium hirundinella f. furcoides
12b. Cells with 4 horns....................................................................................... 13
13a. Antapical horn and postcingular horn are not divergent............................ Ceratium hirundinella f. gracile
13b. Antapical horns or postcingular horns are divergent.................................. 14
14a. Antapical horn is parallel with the apical horn, but the postangular horns are divergent............... Ceratium hirundinella f. robustum
14b. Antapical horn is not parallel with the apical horn..................................... Ceratium hirundinella f. piburgense
15a. Five postcingular plates (5‘‘)...................................................................... 17
15b. Six or seven postcingular plates (6‘‘ or 7‘‘).................................................... 16
16a. Apical pore present...................................................................................... Sphaerodinium cinctum
16b. Apical pore absent...................................................................................... 18
17a. Cells have zero or one intercalary plate...................................................... 19
17b. Cells have two or three intercalary plates.................................................. 18
18a. Apical pore present...................................................................................... 22
18b. Apical pore absent...................................................................................... 19
19a. Cells have two intercalary plates................................................................. Peridinium palatinum
19b. Cells have three intercalary plates.............................................................. 20
20a. 3a intercalary plate does not reach the 4‘‘ precingular plate........................ 21
20b. 3a intercalary plate reaches the 4‘‘ precingular plate.................................. Peridinium cinctum
21a. 1‘‘ apical plate is pentangular.................................................................... Peridinium volzii
21b. 1‘‘ apical plate is quadrangular................................................................... Peridinium wiliei
22a. Cells have two intercalary plates................................................................. 23
22b. Cells have three intercalary plates.............................................................. 25
23a. Cells have one spine on the hypotheca....................................................... Peridinium goslaviense
23b. Cells without spines or have lots of spines on the hypotheca...................... 24
24a. The cells longer than wider....................................................................... Peridinium umbonatum
24b. The cells approximately as long as wide or little wider............................... Peridinium inconspicuum
25a. Chloroplasts are present............................................................................. 26
25b. Chloroplasts are absent............................................................................. Peridinium achromatium
26a. 3a - intercalary plate - does not reach 4‘‘, precingular plate...................... Peridinium bipes
26b. 3a - intercalary plate - reaches 4‘‘, precingular plate.................................. Peridinium aciculiferum
27a. Cells with 7‘‘, precingular plates............................................................... 28
27b. Cells with 6‘‘, precingular plates............................................................... 29
opinion although the Körös area is full of interesting and wonderful waters (rivers, canals, oxbow-lakes, dead-arms) from algological point of view, but it is not a unique place in Hungary in that point of view, as well. The lack of investigations resulted that this area was „poor” in Dinophyta species. Probably this is true for other part of Hungary. The authors hope that this work will be useful to algologists working with phytoplankton samples, find and want to identify or to know more about these species.

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References

Fig. 2. Dinophyta species from Körös area. Bars beside figures correspond 30 µm. 1.: Ceratium hirundinella f. furcoides. 2.: Ceratium hirundinella f. robustum. 3.: Ceratium hirundinella f. gracile. 4.: Ceratium hirundinella f. piburgense. 5.: Ceratium cornutum. 6.: Cystodinedria inermis. 7.: Glenodiniopsis stenii. 8.: Gymnodinium fuscum. 9.: Gymnodinium hiemale. 10.: Gymnodinium palustre. 11.: Gymnodinium uberrimum. 12.: Katodinium vorticella. 13.: Peridiniopsis cunningtonii. 14.: Peridiniopsis elpatiewskyi. 15.: Peridiniopsis kevei. 16.: Peridiniopsis polonicum. 17.: Peridinium achromatium. 18.: Peridinium aciculiferum. 19.: Peridinium bipes. 20.: Peridinium cinctum. 21.: Peridinium inconspicuum. 22.: Peridinium gosaviense. 23.: Peridinium palatinum. 24.: Peridinium umbonatum. 25.: Peridinium volzii. 26.: Peridinium willei. 27.: Sphaerodinium cinctum. 28.: Woloszynska ordinata. 29.: Woloszynska pascheri. 30.: Woloszynska pseudopalustris.