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PERIDINIOPSIS KEVEI SP. NOV., A NEW FRESHWATER DINOFLAGELLATE SPECIES (PERIDINIACEAE, DINOPHYTA) FROM HUNGARY

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This paper reports results from light and scanning electron microscopic study of a freshwater dinoflagellate considered as a new species for the science, *Peridiniopsis kevei* sp. nov. It was found during the last ten years in different lakes, rivers, canals in Hungary and some European countries. It frequently appeared as a water-bloom forming species. The theca morphology and plate structure analysis of this dinoflagellate established its identity as a new species. *P. kevei* Grigorszky et Vasas is discussed in the paper in comparison with related taxa, moreover data about its occurrence and ecology.

Key words: ecology, freshwater Dinophyta, morphology, *Peridiniopsis kevei*, taxonomy

INTRODUCTION

Few, if any, other protist groups can offer such a wide range of topics of unusual research interest although, until recently, freshwater dinoflagellates attracted little attention except of some specialists. The latter knew them as important members of the phytoplankton, the microscopic photosynthesizers contributing significant quantities of food web both in marine and freshwater habitats. Occasionally they occur in great abundance forming water-blooms, causing the water to turn a reddish-brown colour. More recently, dinoflagellates have aroused the interest of phycologists, protozoologists, evolutionists, and cell biologists due to their extraordinary combination of apparent primitiveness (nuclear features) with elaborate morphological developments (horns, wings, differentiated multicellular forms, coenocytes, etc.) and cytological structures (eyes, nematocysts, etc.).

In the last twenty years few freshwater dinoflagellate species was described as new species, *Amphidinium cryophilum* Wedemayer, Wilcox et Graham (Wedemayer et al. 1982), *Peridinium lingii* Thomasson (Thomasson 1986), *Ceratium rhomvoides* Hickel (Hickel 1988), *Peridiniopsis amazonica* Meyer, Rai et Cronberg (Meyer et al. 1997), *Peridinium euryceps* Rengefors et Meyer (Rengefors and Meyer 1998), *Ceratium monoceras* Temponeras, Kristiansen et Moustaka-Gouni (Temponeras et al. 2000).

During the last fifteen years in Hungary and in some European countries (Italy, Germany, France, Romania, Austria, Slovakia) an unknown freshwater dinoflagellate species was found, which frequently caused brown water colour. Ten-fifteen years ago it was a rare species and was found only sporadically. Nowadays, this medium-sized, single celled armoured dinoflagellate is one of the most important warm-water species in the phytoplankton of the Hungarian and some European waters.

In this paper, the species is described as *Peridiniopsis kevei*, sp. nov., and its taxonomic assignment is discussed. Its occurrence has already been published and shown in drawings, but it has not been recognised as a new species (Schmidt 1989). Several data can be found about the morphology and occurrence of *P. kevei* in a paper of Grigorszky et al. (1998). In a guide book for the identification of Dynophyta taxa from Hungary *P. kevei* was published as a new species with its known Hungarian occurrence (Grigorszky et al. 1999). In another book Grigorszky (1999) published a Latin diagnosis (p. 31), with an English description (pp. 121–122) and a long discussion in Hungarian (pp. 23–34) from the morphological characteristics of *P. kevei* in comparison with related taxa, but it was not published yet in scientific paper as a new species.

MATERIALS AND METHODS

Samples were taken from different lakes, rivers, canals, oxbows and a fish pond in Hungary and some European countries between 1986 and 1995 (Fig. 1). Duplicate water samples were collected with plastic tube, one to be examined immediately upon return to the laboratory, the second preserved with Lugol's iodine or formaline. Line drawings were based on sketches made during LM observations and from micrographs. Light micrographs were made using a Jenamed-2 microscope and Axiovert-135 in-

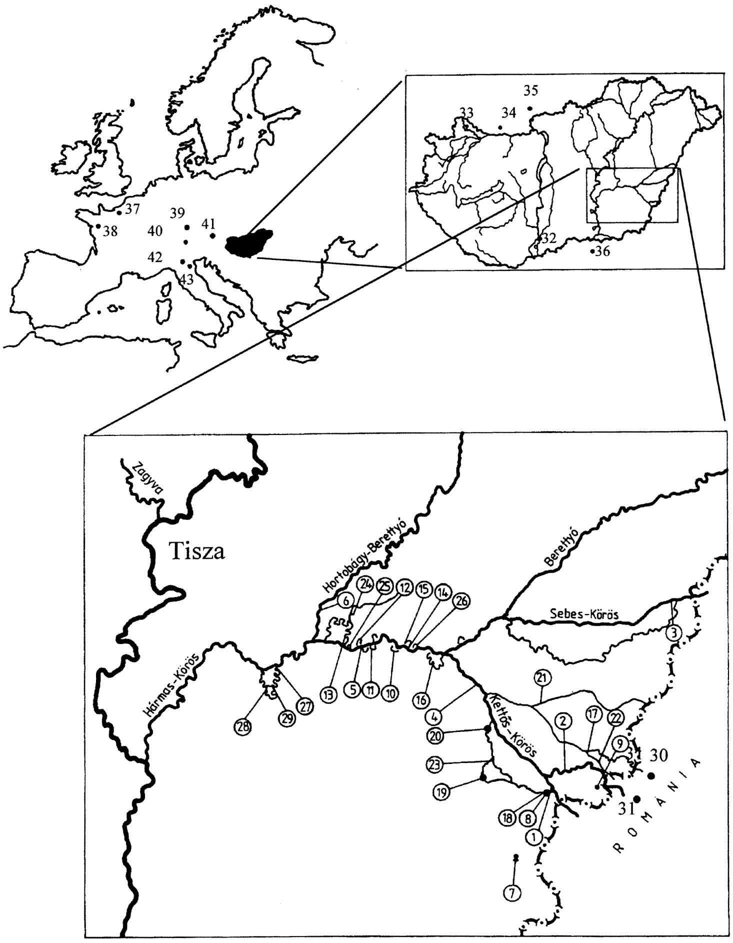


Fig. 1. Map of sampling sites where *Peridiniopsis kevei* were found. 1. Fehér-Körös (river), 2. Fekete-Körös (river), 3. Sebes-Körös (river), 4. Kettős-Körös (river), 5. Hármas-Körös (river), 6. Hortobágy–Berettyó főcsatorna (canal), 7. Kétegyházi belvíztározó (small lake), 8. Gyula belterületi-tó (small lake), 9. Dénesmajori-tó (fish pond), 10. Torzsási-holtág (oxbow), 11. Gyoma belterületi-holtág (oxbow), 12. Templom–Bónom–Socózugi holtág (oxbow), 13. Peresi-holtág (oxbow), 14–15. Siratói-holtág (oxbow), 16. Félhalmi-holtág (oxbow), 17. Gyepes-csatorna (canal), 18. Élővíz-csatorna (Gyula, canal), 19. Élővíz-csatorna (Békéscsaba, canal), 20. Élővíz-csatorna (Békés, canal), 21. Határér (canal), 22. Kopolya (Sarkad, canal), 23. Gerlai-holtág (canal), 24. Malomzugi-holtág (oxbow), 25. Kecskészugi-holtág (oxbow), 26. Kecsegészugi-holtág (oxbow), 27. Szarvasi-holtág (Szivornya, oxbow), 28. Szarvasi-holtág (HAKI, oxbow), 29. Szarvasi-holtág (Anna-liget, oxbow), 30–41. rivers: 30. Fekete-Körös (Romania), 31. Fehér-Körös (Romania), 32. Danube (Baja), 33. Mosoni-Duna, 34. Vág (Slovakia), 35. Ipoly (Slovakia), 36. Tisza, (Zenta, Serbia), 37. Saine (Rouen, France), 38. Loire (Nantes, France), 39. Danube (Ingolstadt, Germany), 40. Inn (Innsbruck, Austria), 41. Danube (Wien, Austria), 42. Lake Garda (Italy), 43. River Po (Ostiglia, Italy)

verted microscope with Kodak black-and-white film. The species description is based on detailed observations of more than one thousand cells. The scanning electron microscopic investigations were made using sedimented samples. Samples were dehydrated in a graded ethanol series, dried at the critical point, sputter coated with gold, and investigated in a Hitachi scanning electron microscope. Concerning the terminology Kofoid's (1909) aim was used. For the taxonomic system, Popovsky and Pfiester (1990) book was followed.

RESULTS

Morphological observations

The thecal plates are sometimes delicate and do not give sufficient support for the cells to maintain their shape on preservation. In the case of young cells the plate structure is not clearly visible (Figs 12–14) as in more slightly armoured species (Figs 3–11). The young cells (gymnoid and glenoid forms) are smaller, slightly spherical in shape, the intercalary bands are not developed (Figs 12–14). Since most of the cells have the cingulum in pre-median position the hypotheca appears little larger than the epitheca (Fig. 3). The sulcus is slightly dislocated and situated on the medium part of the hypotheca and extends to the antapex (Figs 3, 11). Many short spines (cristae) were found at the edge of the sulcus, which is generally a typical feature of the developed cells (Figs 3, 9). On young cells the cristae are situated exclusively around the cingulum (Fig. 12). Some short cristae are on the edges of antapical plates either on young (Fig. 14) or developed forms (Figs 7, 9, 11, 16). The nucleus is located in the central part of the hypotheca. The gold-brown chloroplasts are numerous, from ovoid to elongated in shape and located at parietal position near the theca (Figs 17–20). 1′ plate adjoins with its flattened ends to the anterior sulcal plate (Fig. 3). 2′ and 3′ plates are all regularly polygonal and approximately same in size (Figs 4–6). There is usually one (1a) intercalary plate, which is well visible on developed cells (Figs 4–6). Plate 1a is regularly quadrangular (Fig. 4), and it reaches to the apex on old peridinoid cells, so they have quasi an apical plate (Fig. 6). In the precingular series, the 1′′ and 6′′, the 2′′ and 5′′, the 3′′ and 4′′ pairs are same in size. All of the precingular plates are trapezoid. Consequently the epithecal structure is symmetrical (Figs 3–6).

The hypotheca comprises five postcingular plates (1′′′–5′′′) and two antapical plates (1′′′′–2′′′′). The 1′′′ and 5′′′ postcingular plates are triangular and 1′′′ slightly larger than 5′′′ (Fig. 4). The 2′′′ and 4′′′ plates are trapezoid and similar in size (Fig. 9). The 3′′′ plate is quadrangular and it is the smallest postcingular plate (Fig. 9). The antapical plates usually similar in size (Fig. 9).

Variations in the tabulation are often found on the epitheca: the intercalary plate can be absent. In the course of the development of the cells the 1a plate reaches the apical pore, due to the appearance of wide intercalary bands and it becomes 3′ plate (Fig. 6: 4′, 0a, 6′′ epitheca tabulation). The hypotheca does not show variations in tabulation.

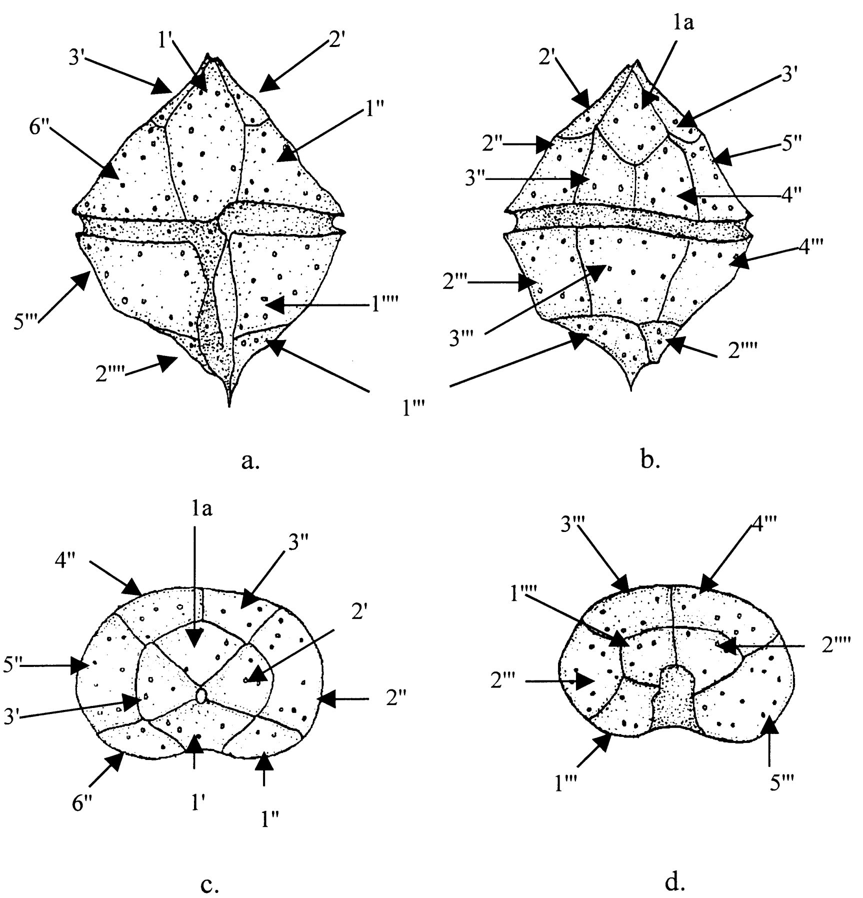
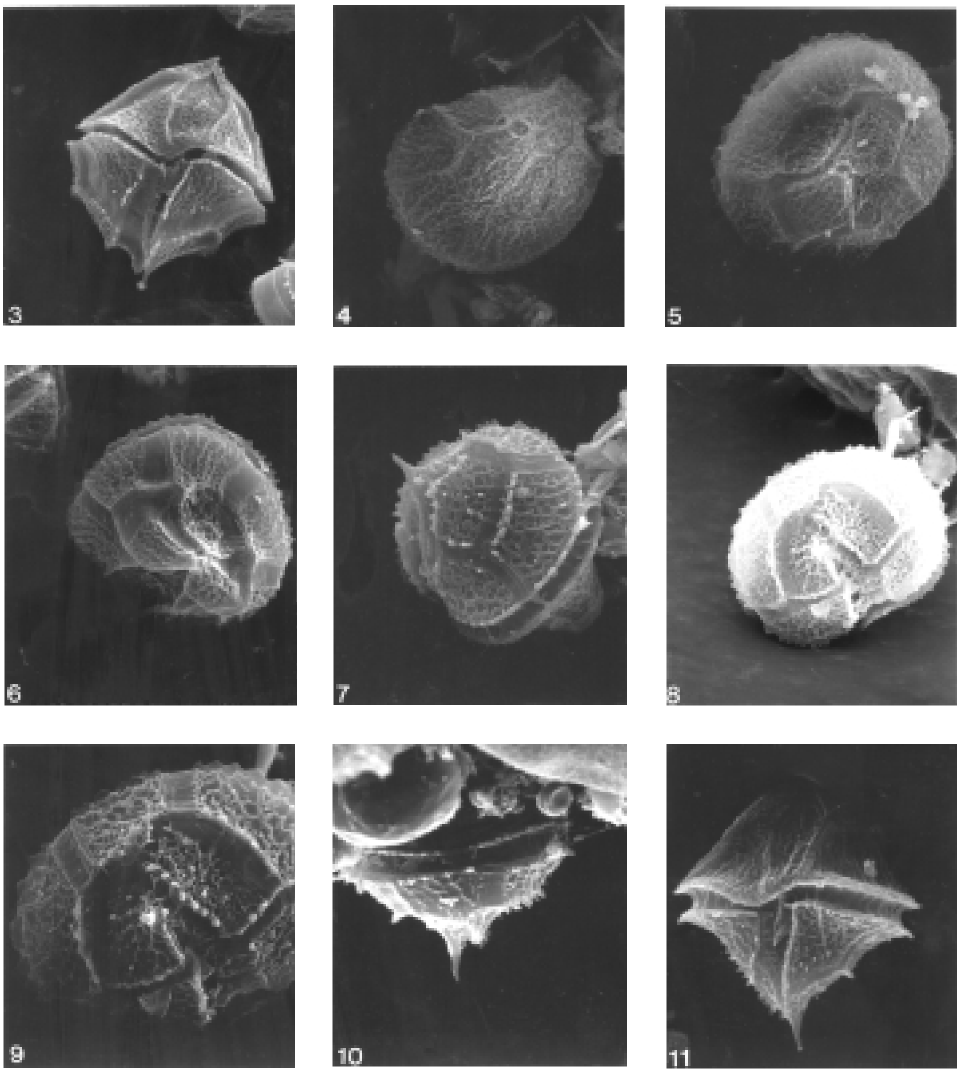


Fig. 2. Peridiniopsis kevei, shape of the theca and plate tabulation. a = ventral view, b = dorsal view, c = apical view, d = antapical view

Diagnosis

Peridiniopsis kevei Grigorszky et Vasas, sp. nova

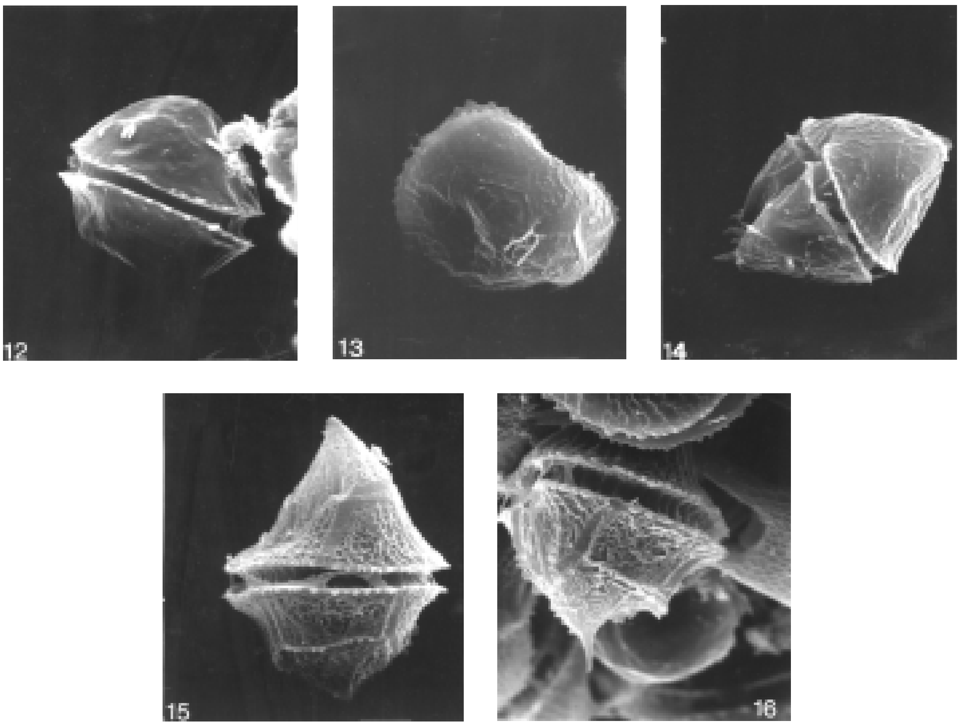
Ordinatorie tabulari 3′, 1a, 6′′, 5c, 5′′′, 2′′′′. Species unicellularis, theca per microscopum luce utentem non visibilis (juvenile peridinoid et glenoid cellulae); cellulae 35 µm



Figs 3–11. SEM micrographs of *Peridiniopsis kevei*. 3 = ventral view with wide sutures, 4 = apical view with narrow sutures, 5–6 = hypotheca with wide sutures, 7 and 10–11 = hypotheca with well-developed spines on the hypotheca, 8–9 = antapical view with cristae on the antapical plates. Scale bar = 5 µm

longitudine, 37 µm latitudina dimensione media; epitheca forma e cono acuto, ad conum obtusum varians; cingulum medium, profundum, angustinor quam sulcus; sulcus profundus, in epitheca apicem non attingens; flagellum transversum aeque longum ac cingulum; flagellum longitudinale per spatium minus quam longitudo cellulae corpus tractum; multi chloroplasti aurei-brunneis, plerumque in periferia dispositi, eorum forma a spherica ad elongatam; stigma exsto, nucleus magnus, chromosomata perspicua habens; in hypocono situs; poro apicali margo. Hypothecae laminae 1'''' spina laevi prominenti, 5–10 µm longa, ventraliter munitae (Grigorszky 1999, p. 31).

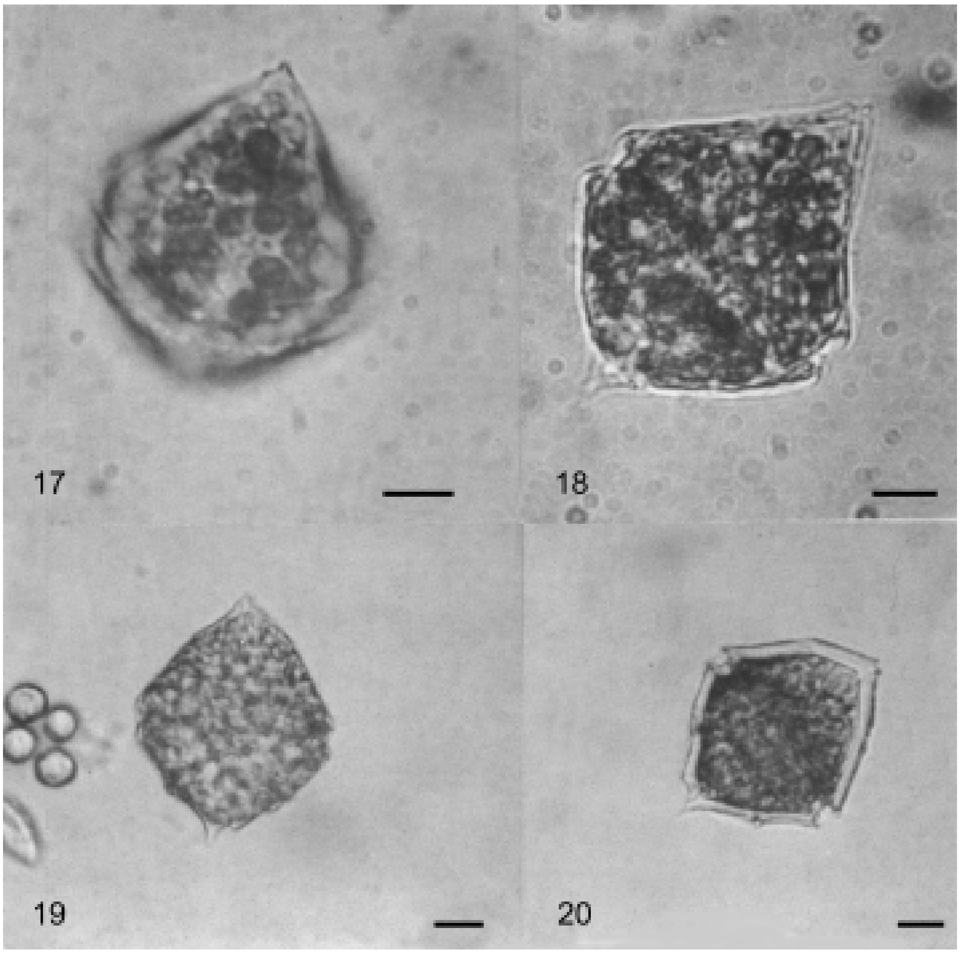
The species is unicellular. The plate tabulation: 3', 1a, 6'', 5c, 5''', 2''''. Thecal plate arrangement of young cells (gymnoid and glenoid phases) are not visible with light microscope. The average cell length is 35 µm, minimum 28 µm and maximum 42 µm, the average cell width 37 µm, minimum 29 µm and maximum 45 µm. Epitheca is varying in shape from acute to a little blunt form. Cingulum is median and deep, narrower than the sulcus.



Figs 12–16. SEM micrographs of *Peridiniopsis kevei*. 12 = dorsal view of young cell without developed plates, 13 = apical view of young cell. The apical pore has been developed and the plates development is in the beginning phase. 14 = lateral view of young cell. The plates development is in the beginning phase. 15–16 = lateral view of developed cell. Scale bar = 5 µm

Sulcus is deep and does not reach to epitheca. Transversal flagellum is as long as the cingulum; longitudinal flagellum less than one cell length. Numerous golden-brown chloroplasts are generally located peripherially. Their shape is varying from ovoid to elongate. Stigma is not visible in each specimen. Nucleus large, with sometimes conspicuous chromosomes, usually located under the cingulum in hypotheca. Pore exists at the apical end. A smooth prominent spine (5–10 µm long) extends from the ventral side of 1'''' antapical plate (Grigorszky 1999, pp. 121–122).

Holotype: Fig. 3 (SEM GI6703), isotype: Fig. 6 (SEM GI6706).

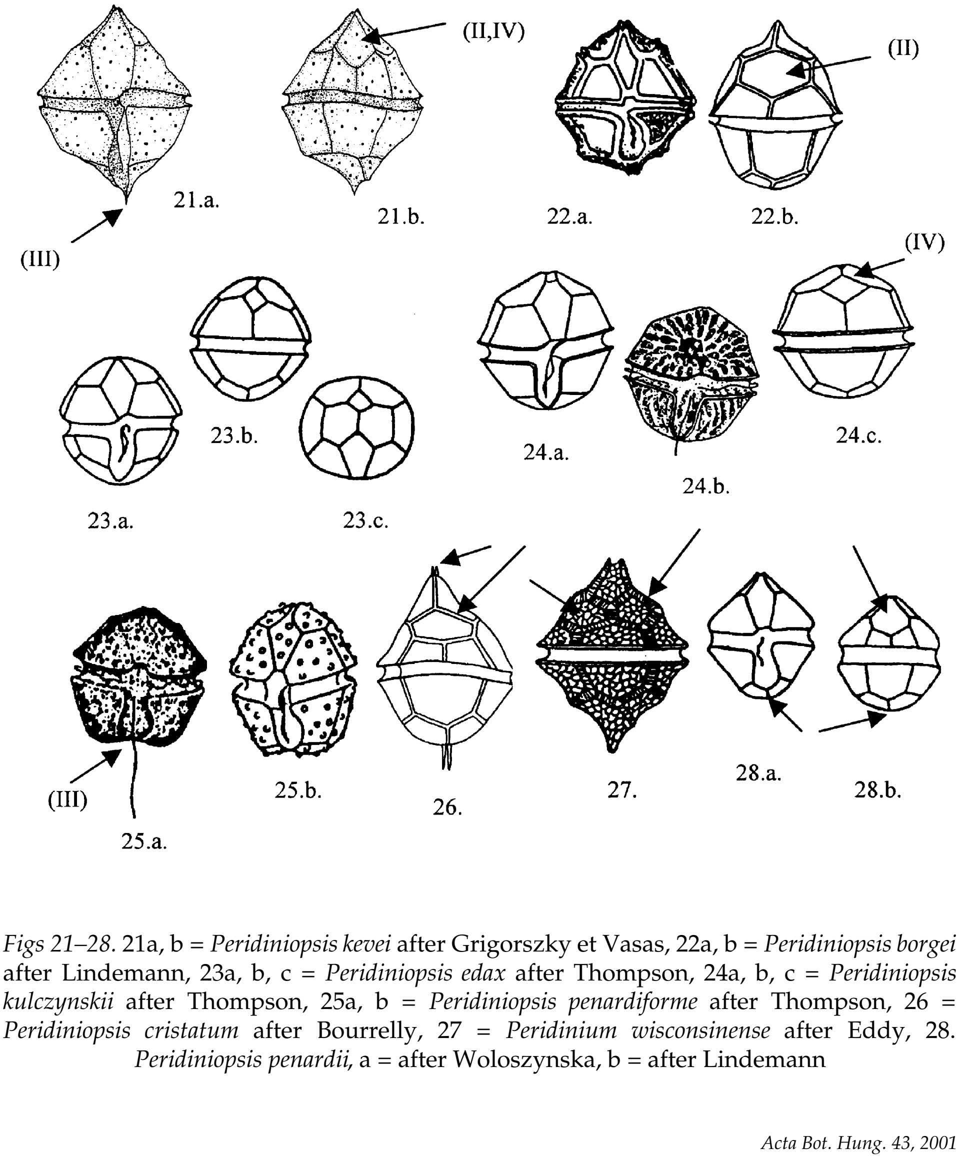


Figs 17–20. LM micrographs of *Peridiniopsis kevei.* 17 = apical-dorsal view, 18 = lateral view, 19 = dorsal view, 20 = ventral view. Scale bar = 5 µm

Type locality: Peresi-Holt-Körös, SE Hungary (Latitude: 46°57′08.37″ N, longitude: 20°43′50.22″E).

Etymology: The species name *kevei* originated from the first name of the Hungarian algologist (Kiss Keve Tihamér), who promotes the algology in Hungary at the end of the 20th century.

Distribution: Known from different running waters and standing waters.



Figs 21–28. 21a, b = *Peridiniopsis kevei* after Grigorszky et Vasas, 22a, b = *Peridiniopsis borgei* after Lindemann, 23a, b, c = *Peridiniopsis edax* after Thompson, 24a, b, c = *Peridiniopsis kulczynskii* after Thompson, 25a, b = *Peridiniopsis penardiforme* after Thompson, 26 = *Peridiniopsis cristatum* after Bourrelly, 27 = *Peridinium wisconsinense* after Eddy, 28. *Peridiniopsis penardii*, a = after Woloszynska, b = after Lindemann

Ecology

According to our data *Peridiniopsis kevei* belongs to more tolerant eurytrophic ecological group with limited adaptabilities. It occurs in both the oligotrophic lakes and in eutrophic waters as well as in all transitional water types. It has a very broad occurrence in relation to nitrogen and phosphorus content, but its occurrence has relatively narrow temperature and alkalinity range. *P. kevei* occurs summer and early fall season of the year. It occurred from 15.8 °C to 26.1 °C. In these seasons it is very widespread, euplanktic and common in small and large lakes as well as in different running waters. In Hungarian waters, *P. kevei* is the most common in mesotrophic-eutrophic lakes and mesotrophic running waters (Grigorszky et al. 1998, Grigorszky 1999, Grigorszky et al. 1999), whereas in Hungary *P. kevei* can reach the considerable proportions of the total biomass in waters. The largest biovolumes were found in summer. Previously it was found in the main arm and in several side arms of the river Danube in south (Schmidt 1989) and west Hungary (Kiss 1987), not identified exactly. *P. kevei* caused water-blooms with high chlorophyll *a* content (130 µg l^{-1}) in a small branch of the River Danube (Disznós-ág at Szigetköz region), when the trophic level was hypertrophic (Kiss 1997).

DISCUSSION

Peridiniopsis kevei is placed in the genus *Peridiniopsis* Lemmermann 1904 by the number of intercalary plate (1a) and in the section Borgei by the plate tabulation 3′, 1a, 6′′, 5c, 5′′′, 2′′′′. *P. kevei* differs from the morphologically similar dinoflagellate species, which are included either the section Borgei or out of it.

The developed cells have recognisable plate tabulation by Kofoidean plate terminology: 3′, 1a, 6′′, 5c, 5′′′, 2′′′′ (Figs 2–11). This species belongs to the section Borgei (Popovsky and Pfiester 1990). In this section *Peridiniopsis kevei* can be distinguished from *P. edax* (Schilling) Bourrelly (Fig. 23) by the presence of chloroplasts (Figs 17–20). *P. kevei* differs from *P. borgei* Lemmermann by the shape of 1a intercalary plate: *P. borgei* has sixangular (Fig. 22b/II), *P. kevei* has symmetrical quadrangular intercalary plate (Figs 2, 5, 6, 7, 21b/II). *P. penardiforme* (Lindemann) Bourrelly differs from *P. kevei* in the pentangular cell shape and rounded and excavated hypotheca (Fig. 25a/III). *P. kulczynskii* (Woloszynska) Bourrelly is ovoid or spherical in shape and the 1a plate is equal sized quadrangular (Fig. 24c/IV) which feature shows marked differences from *P. kevei* (Figs 2, 3, 18, 21).

At the first sight, morphologically *P. kevei* seems to be similar to some species out of the section Borgei, *Peridinium wisconsinense* Eddy (Fig. 27), *Peridiniopsis cristatum* (Balech) Bourrelly (Fig. 26) and *Peridiniopsis penardii* (Lemmermann) Bourrelly (Fig. 28). The main difference between *P. kevei* and *Peridinium wisconsinense* is on generic level. *P. wisconsinense* has two intercalary plates (2a) (Fig. 27), but *P. kevei* has only one, 1a (Figs 4–6). *Peridiniopsis cristatum* has sixangular intercalary plate, a double winged projection at the antapex and a small wing-like process around the apical pore (Fig. 26) (Balech 1961, Bourrelly 1968). The *Peridiniopsis penardii* cells never have pentangular or sixangular intercalary plate and never wear a long tapering spine on the 1'''' antapical plate (Fig. 28). These last mentioned characteristics are the distinctive features of the *P. kevei* and all of them are easily detectable both by light microscope and scanning electron microscope (Figs 3, 10–11, 16, 18–20).

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