Algae
Volume 23(2): 115-118, 2008

[Note]

New Record of the Freshwater Dinoflagellate *Peridinium umbonatum* Stein (Dinophyceae) from Togyo Reservoir, Korea

Jang-Seu Ki and Myung-Soo Han*

Department of Life Science, Hanyang University, Seoul 133-791, Korea

Cells of the dinoflagellate *Peridinium* were frequently observed in water samples of Togyo reservoir, and some species were responsible for dense blooms. Recently, we could identify them as *P. bipes* f. *occultatum* Lindem. and *P. aciculiferum* Lemm., considering morphology (Ki *et al.* 2005a; Ki and Han 2005b): However, some unidentified *Peridinium* cells with different shapes and body sizes were found among the samples collected during early spring. Here we describe their morphological characteristics such as thecal plate and body size to characterize its taxonomic identity by morphological characters. The formula of epithecal plates was recorded as 4 apical, 2 intercalary and 7 precingular plates (i.e. 4', 2a, 7'') and the epicone in an apical view was symmetric. An apical pore was easy to make out under a light microscope. No cingular displacement was observed. The average body size was 33 μm in length with a range of 26-36 μm, and average 26 μm in width with a range of 21-31 μm, respectively; the cell was, therefore, shown slightly elongated. This way we identified *Peridinium umbonatum* Stein, 1883 for the first time from Korean freshwaters.

Key Words: dinoflagellate, morphological characteristics, *Peridinium umbonatum*, thecal plate

INTRODUCTION

To date, more than 250 species of armoured dinoflagellates of the genus *Peridinium* Ehrenberg, 1832 are found in fresh or brackish waters worldwide (data from the algaeBase database; http://www.algaebase.org/). Some *Peridinium* species are responsible for freshwater algal blooms that cause unpleasant odors to drinking water and economical problems for agricultural industries (Kawabata and Hirano 1995). Until now, the taxonomy of freshwater dinoflagellates, including *Peridinium*, has been well documented (Elster and Ohle 1968; Abé 1981). The identification of *Peridinium* species is mainly based on morphological features. Particularly the plate arrangement and apical pore complex are important key characters for the discrimination of armoured dinoflagellates. However, the thecal formula in *Peridinium* species is extremely difficult to construct, and it is necessary to observe the specimens many times by light microscope, since these plates are small in size. Therefore, many uncertainties on proper identities of *Peridinium* species are remaining.

In Korean freshwaters, we observed several dense blooms of *Peridinium* from Togyo Reservoir in 1997, and identified them as *P. bipes* f. *occultatum* Lindem., using microscopical observations (Ki *et al.* 2005a) as well as DNA sequence comparisons (Ki *et al.* 2005b; Ki and Han 2005a). Additionally, we reported *P. aciculiferum* Lemm. from water samples of Togyo reservoir (Ki and Han 2005b), based on morphological observations with scanning electron microscopy. In addition, we found some unidentified *Peridinium* cells with different shapes and body size in the water samples collected during early spring. In this study, we described morphological characteristics of the unidentified *Peridinium* cells in order to collect decisive morphological evidences for the discrimination of species, and could identify them as *P. umbonatum*.

MATERIALS & METHODS

Water sampling

Togyo Reservoir was constructed in 1976 for agricultural irrigation purposes, and is located inside the demilitarized zone (DMZ) in Korea. Since water of Togyo

*Corresponding author (hanms@hanyang.ac.kr)

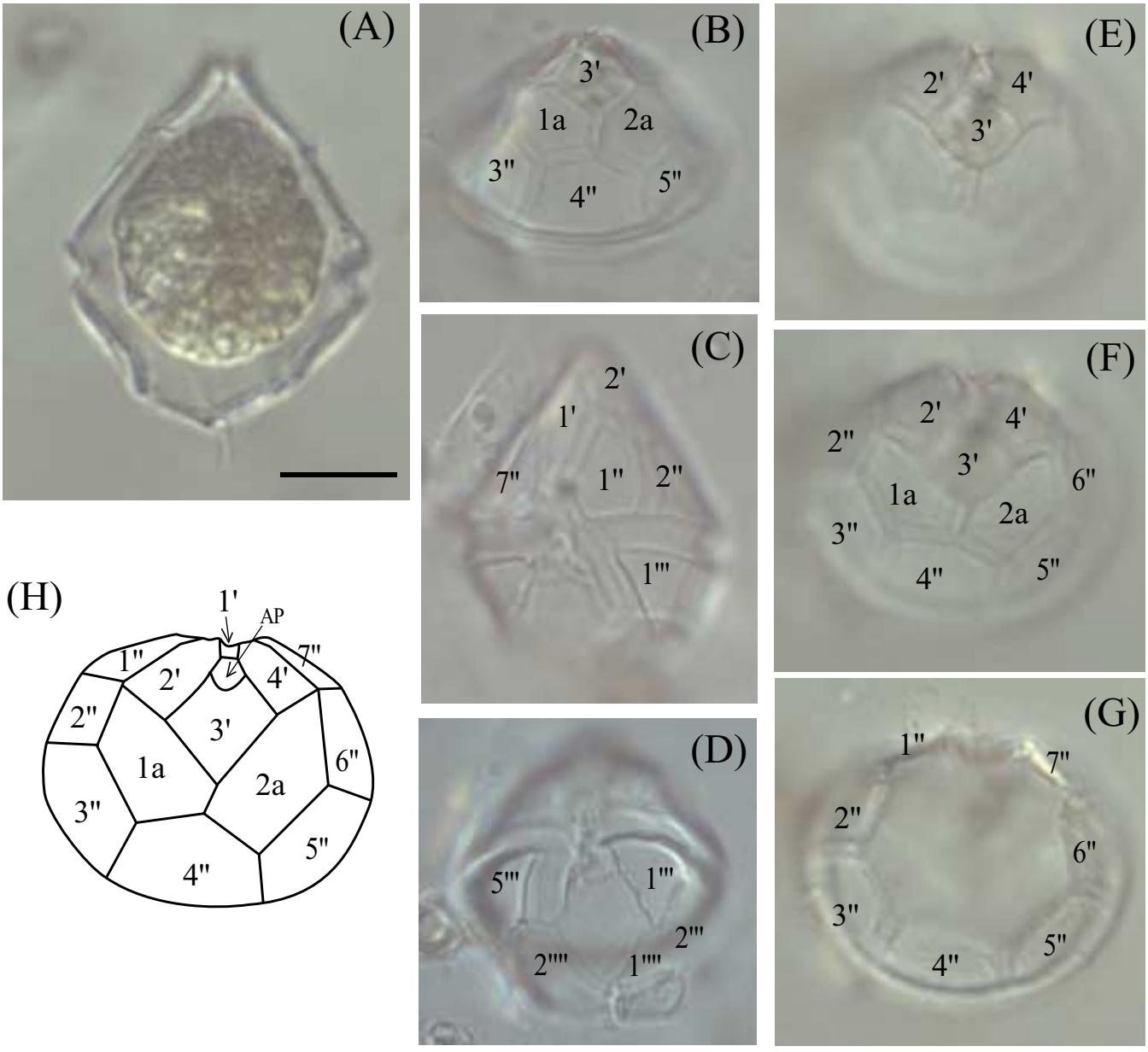

Fig. 1. Light micrographs and drawing of the Korean *P. umbonatum* collected from Togyo Reservoir. Ventral views (A, C); dorsal view (B); apical views (E, F, G). The line drawing (H) was based on the light micrographs of E, F, G. The numberings of thecal plates indicate as 4', 2a, 7'', 5''', 2'''' on the corresponding plates. AP on the drawing indicates the apical pore. Scale bar = 10 μm.

Reservoir was little affected by human activities, its water qualities were characterized by low content of nutrients and a mesotrophic status (Han *et al.* 1995; Ki 1998). Water samples were collected monthly for one year (April 1997 to March 1998), at shallow sites in Togyo Reservoir (38° 16'37.21''N, 127° 17'52.04''E). These water samples were immediately fixed with Lugol's solution and formalin at 1% final concentration respectively.

Morphological observations

Morphological characteristics of *Peridinium* cells were observed with a light microscope (Axioplan, Carl Zeiss, Germany) equipped with a differential interference contrast and CCD camera. *Peridinium* cells were examined for thecal plates and body length. Average body length and width were calculated by measuring approximately 17 cells. Digital images were taken with an SIS Color View 12 camera (Analysis Pro PC EXT software), and analyzed with IMAGE PRO PLUS 3.1 software (Media Cybernetics, Silver Springs, MD).

RESULTS AND DISCUSSION

General description and thecal plate formula

Cell body of Korean *Peridinium umbonatum* was pyriform in shape (Fig. 1A), and were slightly flattened dorsoventrally (Fig. 1). A cingulum was located in the middle of body, separating epicone from hypocone (Figs 1A, C). Lengths of epicone and hypocone were identical in size. No cingular displacement was observed (Figs 1C, D). The epitheca was somewhat spherical with a prominent apex. The plate pattern was overall symmetric, as seen on an apical view (Figs 1E-H). Formula of the epithecal plates were recorded with 4 apical, 2 intercalary, and 7 precingular plates (4', 2a, 7''), as shown in Figs 1D, E, F, and the hypothecal plates were with 5 postcingular and 2 antapical plates (5''', 2''''') as shown in Fig. 1D. Apical plates were numbered on the drawing of Fig. 1H. First apical plate (1') was rhomboidal and connected with the apical pore plate, with one side of the plate being grooved due to a connection with the anterior sulcal plate (Fig. 1D). The third apical plate (3') was rectangular (Figs 1B, E). The first (1a) and second (2a) intercalary plates were connected with each other (Figs 1B, E, F). The fourth precingular plate (4'') was pentagonal and connected with plate 1a, 2a, 3'' and 5'' (Figs 1B, F, G, H). An apical pore was 2-3 μm in size and easily observed under light microscopy (e.g. Fig. 1E). In addition, the cingulum was easily observed under light microscope, and the girdle was not offset (Figs 1A, C). No peculiar spines on the antapical plates were found (Figs 1A, D). The sulcus was straight longitudinally and widened apparently towards the antapex (Figs 1C, D). The sulcal extension lengthened in a measurable length toward the apex.

According to the morphological observations, *P. umbonatum* (4', 2a, 7'') differed from *P. bipes* and *P. aciculiferum*, which can be differentiated mainly on the basis of the plate formation of 4', 3a and 7'', presence of apical pore plate and body shape. At first glance, *P. umbonatum* resembles *P. aciculiferum* due to similar body size, although their plate formula are different from each other. Considering our previous report (Ki and Han 2005b), one of the important characteristics between *P. umbonatum* and *P. aciculiferum* may be the presence or absence of three prominent spines at base of the hypotheca. *P. aciculiferum* possessed the spines, whereas *P. umbonatum* did not possess them. Previously, Popovský and Pfiester (1990) proposed that there are three peculiar spines on the hypothecal plates or intercalary bands in *P. aciculiferum*.

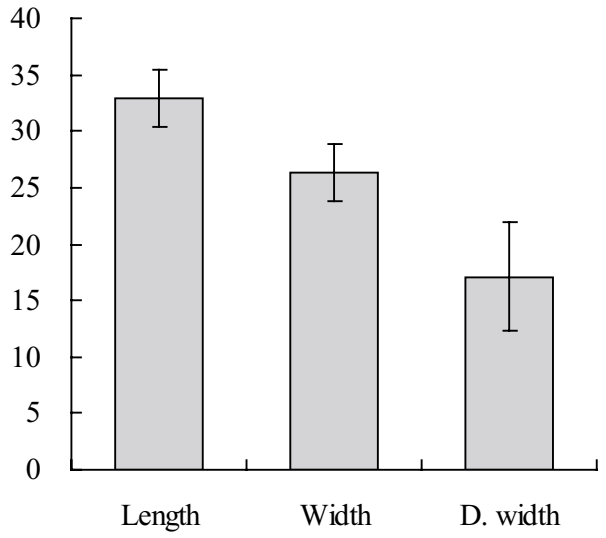

Fig. 2. Body length, width, and dorsoventral width depth of Korean *P. umbonatum*. Each was calculated by measurements of 17 cells. D., dorsoventral.

Body length and width

The body size was 33 μm in length with a range of 26-36 μm, at 26 μm in width with a range of 21-31 μm, and at 17 μm in dorsoventral width with a range of 10-26 μm, respectively (Fig. 2); the cell was, therefore, shown slightly elongated. In earlier studies, Popovský and Pfiester (1990) reported that the body of *P. umbonatum* is 25-35 μm in length and 21-32 μm in width, whose data were generally in accordance with our measurements. With regard to other *Peridinium* species in Togyo reservoir, the body size of *P. umbonatum* differed from that of *P. bipes* (average 50 μm in length and 45 μm in width); however, it was similar to that of *P. aciculiferum* (average 33 μm in length, 25 μm in width). As noted previously, the two species can be discriminated unequivocally by the spines and the number of intercalary plates under light microscopy.

In this study, we described previously undescribed Korean *Peridinium* species with thecal plates and body measurements. Some distinct characteristics observed from the unidentified *Peridinium* cells are as follows: 4', 2a, 7'' of epithecal plate formula, no spine, no girdle-offset, symmetric on an apical view, 33 μm in length, 26 μm in width. Taken together, we could identify them at species level as *P. umbonatum*. The species occurred in Togyo Reservoir during early spring contrary to those of *P. aciculiferum* and *P. bipes* at the same time (Ki *et al.*

2005a; Ki and Han 2005b). This report is the first one for *P. umbonatum* from Korean freshwaters.

ACKNOWLEDGEMENTS

We would like to thank Dr. H.-W. Dahms for English editing and two anonymous reviewers for reading and comments. This research was supported by a grant (no. 2007-491-1, the survey of indigenous biological resources of Korea) from the Ministry of Environment of the Korean Government.

REFERENCES

Abé T.H. 1981. *Studies on the order Peridinidae an unfinished monograph of the armoured dinoflagellata*. The Nippon Printing and Publishing Co., Tokyo, 409 pp.

Elster H.-J. and Ohle W. 1968. *Die Binnengewässer: Einzeldarstellungen aus der Limnologie und ihren Nachbargebieten*. E.E. Schweizerbart's Verlagsbuchhandlung, Stuttgart, 320 pp.

Han M.-S., Lee K. and Yoo K.-I. 1995. Ecological studies on Togyo Reservoir in Chulwon, Korea I. A field test for in situ aquatic net-enclosure mesocosm. *Korean J. Limnol.* **28**: 487-495.

Kawabata Z. and Hirano Y. 1995. Growth pattern and cellular nitrogen and phosphorus contents of the dinoflagellate *Peridinium penardii* (Lemm.) Lemm. causing a freshwater red tide in a reservoir. *Hydrobiologia* **312**: 115-120.

Ki J.-S. 1998. *Ecological studies on Togyo Reservoir in Chulwon, Korea: seasonal succession of phytoplankton community structures with an emphasis on the genus Peridinium (Dinophyceae).* M.S. thesis, Hanyang University, Seoul, 40 pp.

Ki J.-S., Cho S.-Y. and Han M.-S. 2005a. Morphological characteristics of *Peridinium bipes* f. *occcultatum* (Dinophyceae) isolated from three geographically segregated aquatic systems of Korea. *Korean J. Limnol.* **38**: 1-7.

Ki J.-S., Cho S.-Y. and Han M.-S. 2005b. Analysis of small subunit rDNA sequences obtained from Korean *Peridinium bipes* f. *occultatum* (Dinophyceae). Algae **20**: 25-30.

Ki J.-S. and Han M.-S. 2005a. Sequence-based diagnostics and phylogenetic approach of uncultured freshwater dinoflagellate *Peridinium* species based on single-cell sequencing of rDNA. *J. Appl. Phycol.* **17**: 147-153.

Ki J.-S. and Han M.-S. 2005b. First record and morphological features of a dinoflagellate *Peridinium aciculiferum* (Lemm.) Lemm. (Dinophyceae) in Korean freshwater. *Korean J. Environ. Biol.* **23**: 323-327.

Popovský J. and Pfiester L.A. 1990. Dinophyceae (Dinoflagellida). In: Ettl H., Gerloff J., Heynig H. and Mollenhauer D. (eds), *Süsswasserflora von Mitteleuropa*. Fischer Verlag, Jena and Stuttgart. pp. 1-272.

Received 12 March 2008
Accepted 9 May 2008