Korean J. Environ. Biol. 23(4) : 323~327 (2005)

First Record and Morphological Features of the Dinoflagellate *Peridinium aciculiferum* Lemm. (Dinophyceae) in Korean Freshwater

Jang-Seu Ki and Myung-Soo Han*

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

Abstract - Two morphologically different species of *Peridinium* were frequently observed in natural samples collected monthly from Togyo Reservoir. One was previously identified as *P. bipes* Stein f. *occultatum* (Lindem.) Lef. (Ki and Han 2005), the other was remained uncertainly so far. We resolved their identity, based on the morphological observations with scanning electron microscopy. The formula of epithecal plate was recorded with 7 precingular, 3 intercalary and 4 apical plates (4′, 3a, 7″). An apical pore was apparently present. The conspicuous morphology of the *Peridinium* was three spines on the hypothecal plates. The average body length and width were 33.6 μm with a range of 26~45 μm, and 25.7 with a range of 19~31 μm, respectively; the cell was, therefore, shown slightly elongated. Based on their morphological characteristics, the causative organism was identified as *P. aciculiferum* (Lemm.), which was reported for the first time in Korean freshwater.

Key words : Morphological characteristics, dinoflagellate, *Peridinium aciculiferum*

INTRODUCTION

The freshwater dinoflagellates are less common qualitatively and quantitatively than the marine forms. Approximately 220 species of dinoflagelates occur in freshwaters (Bourrelly 1970). Among them, the most common genera are *Ceratium* and *Peridinium*. The worldwide distribution of *Ceratium* was described by Huber-Pestalozi (1951). Since then many new records have become available, especially from water bodies located in less accessible regions (Pollingher 1987). The *Peridinium* likewise has been well documented in different water bodies (Pollingher 1987); however, these studies have mainly been concerned with the bloom-forming species such as *P. bipes, P. gatunense, P. cinctum* and *P. willei*. The other *Peridinium* species have been poorly studied in freshwater environments worldwide, although their taxonomy has been documented clearly (Elster and Ohle 1968; Abé 1981).

In Korean freshwaters, the dinoflagellates are relatively unknown. Aside from the bloom-forming dinoflagellate studies on Ki (1998) and Ki *et al.* (2005), most studies are concerned with the field surveys, based on the taxa observed in freshwater environments (Lee and Cho 1994; Lee 1994; Han *et al.* 1995). Of numerous *Peridinium*, only one species, to date, has morphologically identified in Korean waters (Ki *et al.* 2005). Recently, Ki (1998) pointed out that several *Peridinium* species could be present in phytoplankton assemblages of Togyo Reservoir. Ki *et al.* (2005) reported that one of the dinoflagellates occurred in Togyo Reservoir was *P. bipes* f. *occultatum*, as judged by their thecal formula and fine morphological features. Other species was, however, remained uncertainly so far.

The purposes of the present study was to morphologi-

* Corresponding author: Myung-Soo Han, Tel. 02-2220-0956, Fax. 02-2296-1741, E-mail. hanms@hanyang.ac.kr

cally describe one of *Peridinium* species occurred frequently in Togyo Reservoir, and to identify it to species-level.

MATERIALS AND METHODS

1. Water sampling

Water samples were collected monthly for one year (April 1997 to March 1998), including a freezing season, at the shallow zone beside the Togyo Reservoir bank (Fig. 1). These field samples were immediately fixed with Lugol's solution or formalin at 1% final concentration. Its water quality was reported in our previous studies (Han *et al.* 1995; Ki 1998).

2. Morphological observations

The samples collected from wild populations were used to examine the morphological features of the genus *Peridinium*, using a light microscope (Axioplan, Carl Zeiss, Germany). For scanning electron microscopy, the preserved samples were filtered onto a Nucleopore filter (2-, 5-μm pore size), washed several times with distilled water (D.W.), dehydrated by using a series of alcohol and dried via liquid CO_2 in a critical point drying apparatus (Baltec CPD 010, Liechtenstein). The filters were subsequently glued to the stubs with double-adhesive carbon disks, sputter-coated with gold, and then observed under a scanning electron microscope (XL 20, Philips, Netherlands).

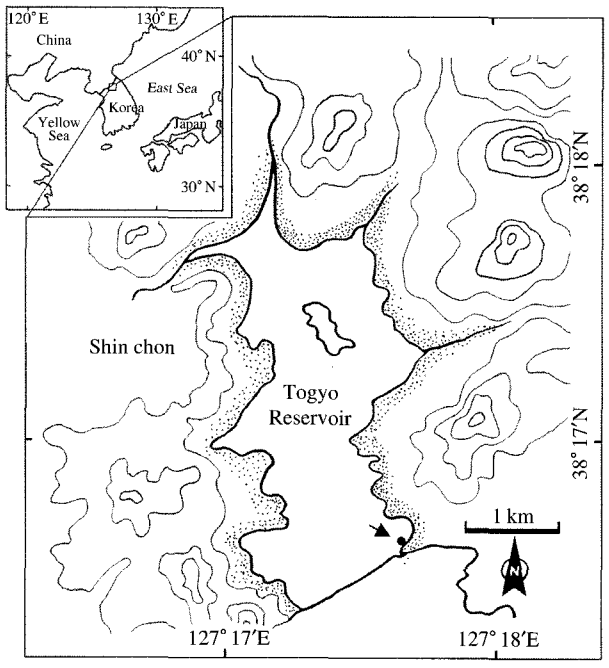

Fig. 1. Location of sampling station (●) at Togyo Reservoir, Korea. It was constructed in 1976 for agricultural irrigation in the demilitarized zone (DMZ) in Korea. Its water qualities were characterized by low content of nutrients and mesotrophic status.

3. Cell size determination

Cell size was calculated by measuring more than 10 cells collected from field samples with the above light microscope.

RESULTS AND DISCUSSION

1. Body shape and thecal plate formula

The Korean *Peridinium* cells in shape were pyriform, and were slightly flattened dorsoventrally (Fig. 2). The epitheca was somewhat spherical with a prominent apex. The thecal plates, which were numbered on the drawings of Fig. 3, were apparent under scanning electron micrographs (Fig. 2). Formula of the epithecal plates were recorded with 7 precingular, 3 intercalary and 4 apical plates (4′, 3a, 7″), as shown in Fig. 2. The plate pattern was apparently asymmetric, as seen on a dorsal view (Fig. 2b). First apical plate was rhomboidal and connected with the apical pore complex; the plate 2a was pentagonal and touched plate 3′, 1a, 3a, 3″ and 4″ (Figs. 2b, 3b). The second (2a) and third (3a) intercalary plates were connected each other (Fig. 2b). An apical pore complex was easily observed under light microscopy (e.g. Fig. 4f). The thick plate suture was easily seen in a scanning electron micrograph (Fig. 2e).

The Korean *Peridinium* was identified mainly on the basis of the plate formation of 4′, 3a and 7″, presence of apical pore plate and body shape. In broad category, the cells were included into Bipes-, Gutwinskii-, Lomnickii- and Allorgei-groups in *Poroperidinium*, as following by the literatures (Elster and Ohle 1968; Popovský and Pfiester 1990). Further, the cells were clearly subdivided into the Lomnickii-group, because of the asymmetric pattern of the plates and pentagonal shape of intercalary plates (Popovský and Pfiester, 1990). Definitely, the Korean *Peridinium* has

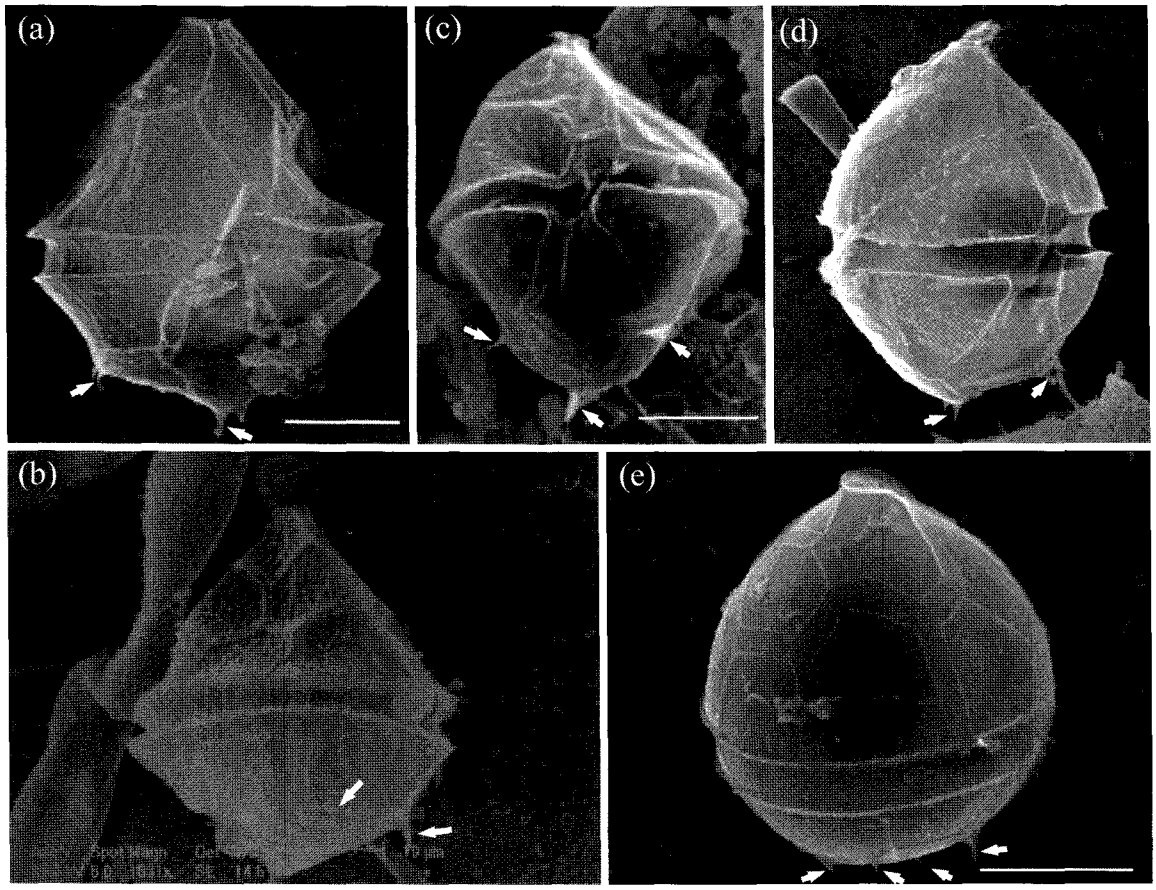

Fig. 2. SEM micrographs of the Korean *P. aciculiferum* collected from Togyo Reservoir. (a, c): ventral views; (b): dorsal view; (d, e): lateral views. Arrows indicate the spines on the cell surface. The tabulation patterns and three apparent spines allow them for morphological identification. Scale bar = 10 μm.

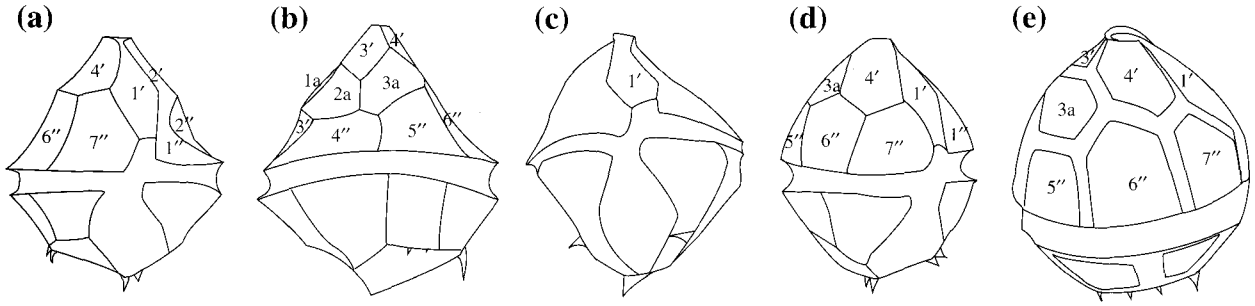

Fig. 3. Line drawings of the Korean *P. aciculiferum*, based on the present work (e.g. Fig. 2): ventral view (a), dorsal view (b), ventral-antapical view (c), lateral views (d, e). The numberings of thecal plate indicate as 4′, 3a, 7″, 5‴, 2⁗ on the corresponding plate. Arrows on the drawing indicate the prominently morphological characteristics (e.g. sulcal extension, girdle-offset, apical pore, the shape of 1′ plate, non-presence of spine) of *P. aciculiferum*.

three spines on the surface of the thecal plates, which could be seen on the scanning electron micrographs (Fig. 2c). Popovský and Pfiester (1990) reported that three prominent spines on base of hypotheca were one of the most important features of *P. aciculiferum* in order to discriminate it from other species within the Lomnickii-group. The Korean cells, therefore, were identified to *P. aciculiferum*, which could be clearly separated from its relatives like *P. lomnickii*

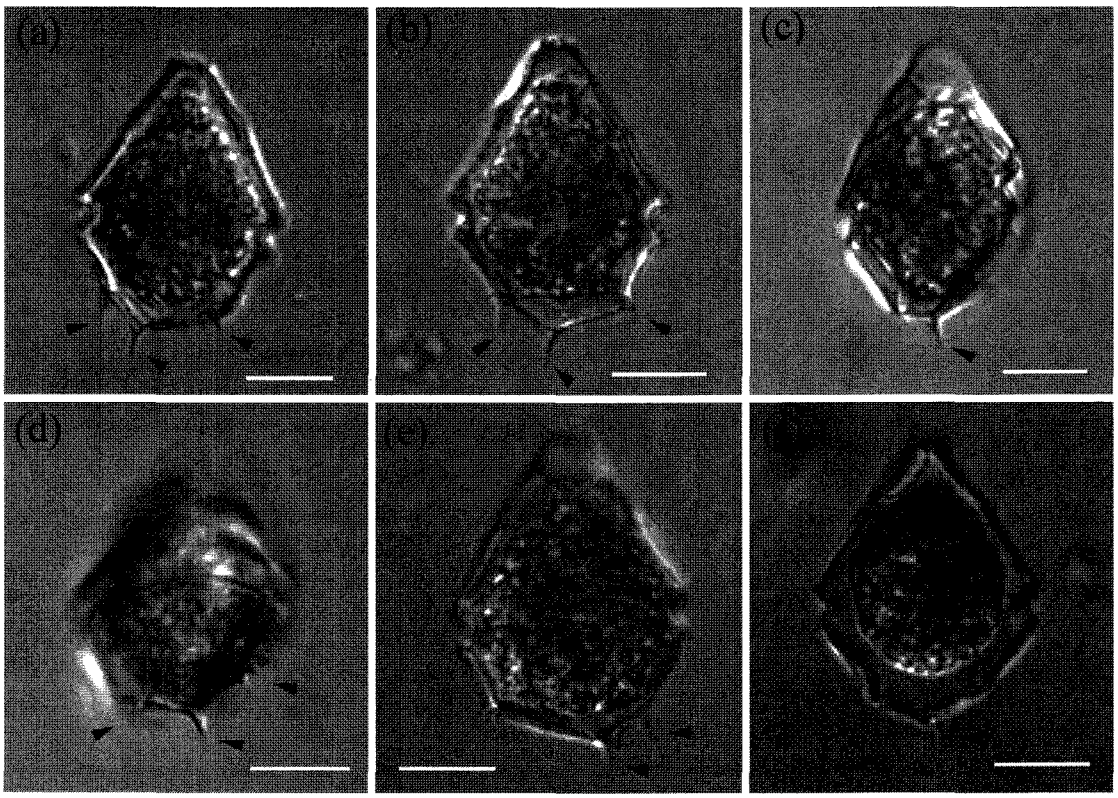

Fig. 4. Light micrographs of the Korean *P. aciculiferum* collected from Togyo Reservoir. (a, b): ventral views; (c): lateral view; (d, e, f): dorsal views. Arrows indicate the spines on the cell surface. Scale bar = 10 μm.

and *P. godlwwskyi*. In addition, the spines could be seen under a light microscope (Fig. 4a-f); therefore, the cells could be discriminated easily from the other *Peridinium* species occurred in Togyo Reservoir. It might be used as a diagnostic characteristic in *Peridinium* monitoring programs of Korea, as shown in Fig. 4.

2. Cingular and sulcual shapes

The cingulum was easily observed under light microscope. It spiraled to the left. The left-side position of cingulum was nearly in center, but its right side was more posterior; the offset, therefore, was measured by approximately one cingulum width (Fig. 2a, d). The sulcus was straight longitudinally, widened along the hypotheca and reached the antapex (Fig. 2a, b, c). The sulcal extension slightly lengthened and connected the first precingular plate (1′). The overall features of sulcus, cingulum and shape were good agreement with the previous descriptions with regard to *P. aciculiferum* (Popovský and Pfiester, 1990).

3. Body size

The average body length were 33.6 μm with a range of 26~45 μm (Fig. 5a), which was calculated by measuring 53 cells from the samples collected monthly from Togyo Reservoir, and the body width was measured at the average 25.7 μm with a range of 19~31 μm (Fig. 5b), respectively. In earlier studies, Lewis and Dodge (2002) reported that the cell observed in England was 35~51 μm long and 29~42 μm wide, in which the ranges were larger than those in the present results.

In this study, the fine structures of Korean *Peridinium* species occurred in Togyo Reservoir were investigated in order to resolve their taxonomic ambiguities. From the present results, one of the causative organisms was identified as *P. aciculiferum*, which was firstly reported in Korean water to the best of our knowledge. The distinct characteristics observed in *P. aciculiferum* are as follows: apparent apical pore plate, plate formula (4′, 3a, 7″), girdle-offset by one cingulum width, three spines. We propose that the spines are used as the morphological fea-

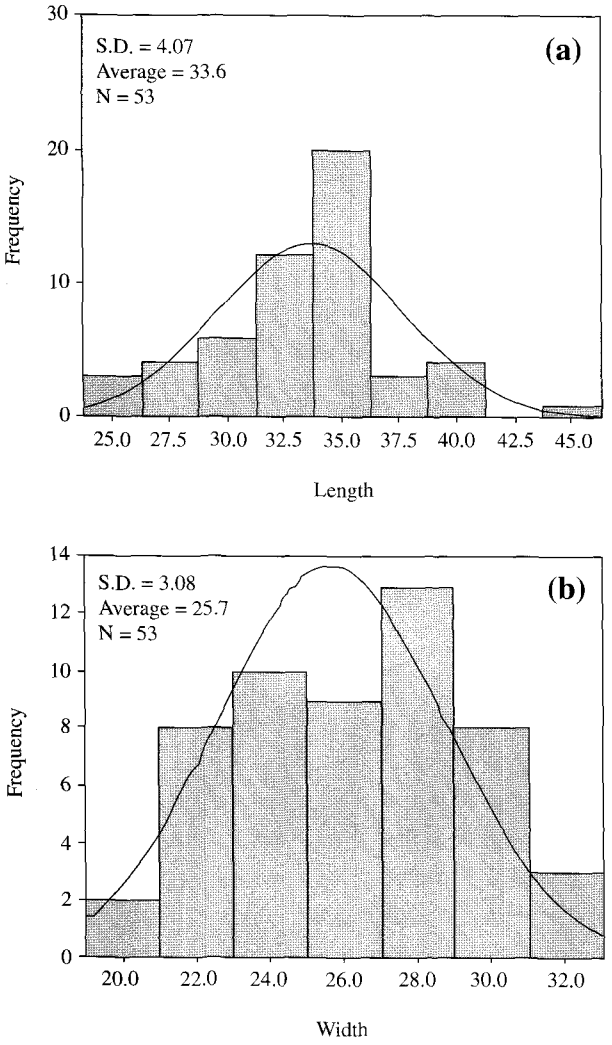

Fig. 5. The frequency distribution of length (a) and width (b) in Korean *P. aciculiferum*. The lines display the normal curves on each histogram (n = 53).

tures of Korean *P. aciculiferum* for monitoring of the cells under a light microscope. The species apparently dominated during winter season, and thus further studies on the abundance and biovolume of the cells are now in progress.

ACKNOWLEDGEMENTS

This research was supported by the Prevention of Nature Disasters (M1-0324-07-0002-03-B31-07-002-00) of the Korean Ministry of Science and Technology.

REFERENCES

Abé TH. 1981. Studies on the order Peridinidae an unfinished monograph of the armoured dinoflagellata. The Nippon Printing and Publishing Co., Tokyo.

Bourrelly P. 1970. Les Algues d'eau douce. III. Algues bleues et rouges. Editions N. Boubée and Cie. Paris.

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

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

Huber-Pestalozzi G. 1951. Die Verbreitung des Susswasserceratien auf der Erde. Verh. Int. Verein. Limnol. 11:152-188.

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

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.Sc. thesis, Hanyang University, Seoul.

Lee E-J and K-S Cho. 1994. Yearly variation of phytoplankton in Lake Soyang. Korean J. Limnol. 27:9-22.

Lee OM. 1994. The annual dynamics of standing crops and distribution of phytoplankton in Juam Lake in 1992. Korean J. Limnol. 27:327-337.

Lewis JM and JD Dodge. 2002. Phylum Pyrrophyta (dinoflagellates). In: John DM, BA Whitton and AJ Brook (Eds.), The Freshwater Algae Flora of the British Isles: an Identification Guide to Freshwater and Terrestrial Algae. Cambridge University Press, Cambridge.

Pollingher U. 1987. Freshwater ecosystems. In: Taylor FJR (Ed.), The Biology of Dinoflagellates. Blackwell, Oxford.

Popovský J and LA Pfiester. 1990. Dinophyceae (Dinoflagellida). In: Ettl H, J Gerloff, H Heynig and D Mollenhauer (Eds.). Süsswasserflora von Mitteleuropa. Fischer Verlag, Jena and Stuttgart.

Manuscript Received: May 20, 2005
Revision Accepted: August 16, 2005
Responsible Editorial Member: Hwan-Goo Yeo (Hanseo Univ.)