

Taxonomical Studies on Dinoflagellates in Masan Bay

1. Genus *Prorocentrum* Ehrenberg

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마산만 일대 와편모조류의 분류학적 연구

I. *Prorocentrum* 속에 대하여

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Abstract: The causative organism of red tide occurred mainly in embayments along southern coast of Korea mostly composes of dinoflagellate species. Among them Genus *Prorocentrum* is predominant in Masan Bay and it has already reported eight *Prorocentrum* species from this area.

The authors have identified five species of Genus *Prorocentrum* during the year of 1982 in the surveyed area and each species was described by means of the observation with light microscope as well as scanning electron microscopy. An additional species, *P. dentatum* is new to Korean waters.

요약: 남해안 일대의 내만에서 다발하고 있는 적조의 원인생물은 다수종의 와편모조류를 포함하고 있으며, 이중에서도 *Prorocentrum* 속은 이 일대에서 발생하는 적조의 중요한 원인종으로 지금까지 마산만 일대에서 8종이 보고된 바 있다.

본인들은 적조원인생물인 와편모조류의 올바른 동정을 통하여 이들의 분류 체계를 확립할 목적으로 1982년 1월에서 12월에 이르는 1년간에 걸쳐 마산만에서 시료를 채집하였다. 그 결과 *Prorocentrum* 속의 다음의 5종을 동정하였다: *Prorocentrum balticum*, *P. dentatum*, *P. minimum*, *P. micans*, *P. triestium*. 이중에서 *Prorocentrum dentatum*은 한국산 미기록종으로 기재한다.

INTRODUCTION

In marine ecosystem the phytoplankton community is mainly composed of two dominant algal taxa, diatom and dinoflagellate, and it plays an important role as a primary producer. Of these the dinoflagellate is known to cause red tide outbreaks and even to produce toxin. Recently, red tide has frequently occurred in embayments of southern coast of Korea and it has brought serious effects to inshore fisheries. Thus,

the red tide research including the taxonomy as well as distribution of toxic dinoflagellates have received ever increasing attention in Korean waters.

Since 1976 the inventories of phytoplankton flora, especially of dinoflagellate species, has been carried out to clarify causative organisms of red tide in Korean waters by many authors (Cho, 1978, 1979; Park, 1979, 1980; Shim et al., 1981; Yoo, 1982; Han and Yoo, 1983a, 1983b; Yoo and Lee, 1985), but our knowledge of the bio-

logy of dinoflagellates in this region is proportional to the visible effects of their presence.

Among the dinoflagellate flora of Masan Bay, where is known as the representative zone of red tide in Korea, the genus *Prorocentrum* is most predominant group throughout the year and it includes some toxic species as *Prorocentrum balticum* and *P. minimum*. In previous record there are eight species of Genus *Prorocentrum* in Masan Bay and the following three species have been already described: *Prorocentrum micans*, *P. minimum* and *P. triestinum* (Yoo, 1982). Recently, additional two species of the genus have been reported by authors from this area.

In spite of their importance in coastal zone there are still many gaps in our knowledge on systematics of dinoflagellate in Korean waters as well as Masan Bay. Therefore, it is necessary for an extensive taxonomical study on red tide organisms in coastal zone of Korea.

The purpose of present study is to clarify the fine structure of five *Prorocentrum* species of Masan Bay using both light microscope (LM) and scanning electron microscope (SEM) and to describe each species with taxonomical notes.

MATERIALS AND METHODS

Samplings were made monthly from 4 selected stations in Masan Bay during the period from January to December, 1982 (Fig. 1). The samples were collected using van Dorn water sampler at surface layer (0.5 meter below surface) and then fixed with 4% neutralized formaldehyde solution on board.

For light microscopic observation the fixed cells were stained with trypan blue and then dehydrated in acetone series and finally mounted in pleurax. For nuclear staining the materials were squashed on a slide glass and stained with acetocarmine.

For scanning electron microscopy the formaldehyde-fixed samples were rinsed in distilled

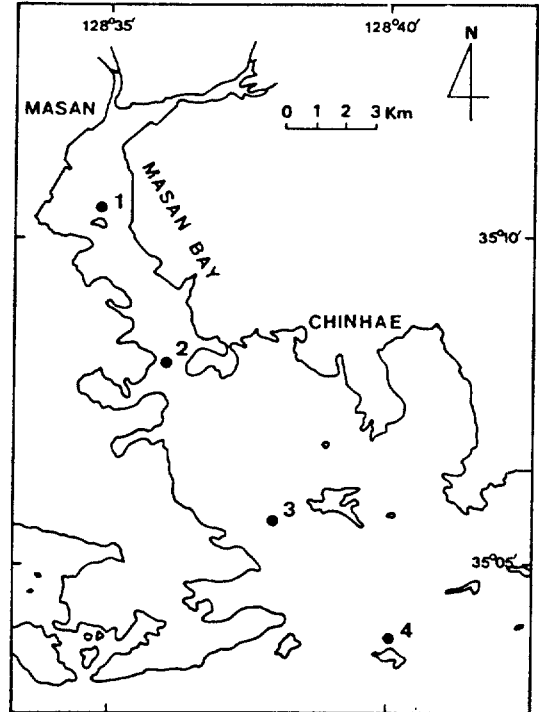


Fig. 1. Sampling stations in Masan Bay.

water and subsequently transferred to 1% glutaraldehyde for one hour at room temperature, then rinsed in double-distilled water, replaced by isoamyl acetate, and critical point dried with liquid CO₂. The material was finally gold-sputtered and examined with JEOL JSM-35C scanning electron microscope.

RESULTS AND DISCUSSION

Systematics

A total of five species of Genus *Prorocentrum* have been identified during the present study and *Prorocentrum dentatum* is new to Korean waters. The species of the genus in Masan Bay are listed as follows:

Prorocentrum balticum (Lohmann) Loeblich,
III 1970

Prorocentrum dentatum Stein, 1883

Prorocentrum minimum (Pavillard) Schiller,
1916.

Prorocentrum micans Ehrenberg, 1833

Prorocentrum triestinum Schiller, 1918

Description of species

Descriptions are given to all species, especially in view of fine structure of scanning electron microscopy and key to all species are provided.

Key to the species of *Prorocentrum*

1. Thecal plates covered with minute spine 2
Thecal plates not spiny 4
2. Posterior end of cell rounded, minute anterior spines 3
Posterior end of cell pointed or not, anterior end of cell pointed or blunt from one side of cell *P. dentatum*
3. Cell spherical or almost so, very small. *P. balticum*
Cell ovate to broadly heart-shaped with tiny anterior spine *P. minimum*
4. Anterior spine prominent, with wing; thecal plates thick and ornamented *P. micans*
Anterior spine small; thecal plates delicate without obvious ornamentation *P. triestinum*

Prorocentrum balticum (Lohmann) Loeblich, III (Pl. 1, 1-4)

Exuviaella baltica Lohmann, 1908, p. 265, pl. 17, fig. 1a-b; Schiller, 1933, p. 17, fig. 10a-b; Braarud et al., 1958, p. 43, pl. 1, figs. a-f.

Prorocentrum pomoideum Bursa, 1959, p. 17, figs. 108-111.

Exuviaella aequatorialis Hasle, 1960, p. 29, figs. 18a, b.

Prorocentrum balticum: Loeblich, III 1970, p. 906; Adachi, 1972, p. 52, pl. 1, figs. d-g, pl. 14, fig. a (sub *P. baltica*); Dodge, 1975, p. 118, fig. 4a-b, pl. 4, fig. d; 1982, p. 35, pl. 1e, figs. 2m,n; Toriumi, 1980, p. 106, figs. 1, 7; Shim et al., 1981, p. 59, pl. 1, fig. 1a-b; Fukuyo, 1981, p. 84, figs. a-f.

Description: The shape of the cell is round to subspherical in valve view, round to lens form in side view. Valve surface is covered with minute spines, which occur also on the intercalary band in rows lying perpendicular to the anterior-posterior axis. Two pores of large and small size are situated at the cell's anterior. Small anterior spine is found adjacent to this large pore. The wide anterior spine is found adjacent to the small pore. The spine diverges at the tip as in *P. minimum*. The two anterior spines lie along at the middle part of each pore. A round nucleus is situated at the posterior end of the cell. Length, 9-15 μm , Width, 7-10 μm .

Remarks: This species is widely distributed in Korea and also world-wide distributed in neritic waters.

This very small species has sometimes occurred in very large quantities in numerous places of the world. Because of its small size it is not usually collected in net samples. *P. balticum* and *P. minimum* are very similar in the structure of anterior spines and minute spiny surface of valves, but they can be distinguished by differences in cell size and shape. The large anterior pore is thought to be the flagellar pore as in *P. minimum* (Loeblich, et al., 1979).

Prorocentrum dentatum Stein (Pl. 1, 5-8)

Prorocentrum dentatum Stein, 1883, pl. 1, figs. 14, 15; Dodge, 1975, p. 116, pl. 4a-b, fig. 4k; 1982, p. 34, fig. 2r; Yuki, 1981, p. 78, figs. a-c.

Prorocentrum obtusidens Schiller, 1928, p. 57, fig. 15.

Prorocentrum veloi Tafall, 1942, p. 437, figs. 4-6.

Prorocentrum monacense Kufferath, 1957, figs. 1-2.

Description: The shape of the cell is elongated

heart-shaped to lanceolate with an anterior extension at one side which may be pointed or blunt. Anterior end sometimes has small depression and posterior end is point or not. The surface of valves and intercalary band are covered with small spines as in *P. balticum* and *P. minimum*. Two small anterior spines lie at the anterior depression of the cell. The trichocyst pores are perforated around the margin of valves. Length, 15-30 μm , Width, 10-15 μm .

Remarks: This species is rare in Korea, but recently it occurs in Masan Bay (Yoo and Lee, 1985) and in the southwestern waters of the Sea of Japan (Shim et al., 1985). This is thought to be an oceanic species, found mostly in many oceans all over the world (Dodge, 1982).

This species is new to Korean waters. The spiny surface of valves of *P. dentatum* are similar to *P. balticum* and *P. minimum*, and these three species were classified into the same section by Dodge (1975). He also suggested that *P. obtusidens*, *P. monacense* and *P. veloi* should be merged with the synonym of *P. dentatum*.

Prorocentrum minimum (Pavillard) Schiller
(Pl. 2, 1-2)

Exuviaella minima Pavillard, 1916, p.11, pl. 1, fig. 1a-b.

Prorocentrum triangulatum Martin, 1929, p. 557, figs. 1-3.

Prorocentrum minimum: Schiller, 1933, p.32, figs. 33a, b; Hulburt, 1965, p. 95, pl. 1, figs. 1-6, pl. 2; Dodge, 1975, p. 117, fig. 4e-g, pl. 3, figs. a-d; 1982, p. 35, fig. 20p. pl. 1f, g; Taylor, 1976, p. 24, pl. 1, fig. 17; Toriumi, 1979, p. 20, figs. a-f; 1980, p. 107, figs. 4, 10; Yoo, 1982, p. 28, pl. 1, figs. 2-5; Han and Yoo, 1983a, p. 39, pl. I, 3.

Exuviaella mariae-lebouriae Parke and Ballantine, 1957, p. 643, figs. 1-18; Dodge, 1965, p. 609, fig. 3, pl. 2, figs. 5-8.

Prorocentrum cordiformis Bursa, 1959, p. 17,

figs. 104-107.

Prorocentrum minimum v. *mariae-lebouriae*: (Parke and Ballantine) Hulburt, 1965, p. 95, fig. 3; Adachi 1972, p. 54, pl. 2 figs. a-g, pl. 14, figs. b-c.

Prorocentrum minimum v. *triangulatum*: (Martin) Hulburt, 1965, p. 95, figs. 1, 4; Adachi, 1972, p. 56.

Prorocentrum mariae-lebouriae: (Parke and Ballantine) Loeblich, III 1970, p. 906, figs. 4-6; Faust, 1974, p. 315, figs. 1-16.

Description: The shape of the cell is ovate, triangular and sometimes heart-shaped in valve view. The posterior end of the cell is usually rounded and the anterior end is truncate with very slight depression. Trichocyst pores are mainly situated around the margin of the valves. The surface of the valve is covered with minute spines. The smaller anterior spine is found adjacent to the large pore and the larger one is found next to the small pore. The latter spine is slight curved and splits in two part at its tip. A nucleus is situated at posterior end of the cell and is sub-spherical in shape. Length, 15-23 μm , Width, 10-15 μm .

Remarks: This species is mostly distributed at southern part of Korea. This is found commonly in the coastal zone of the world and often in very large numbers.

Hulburt (1965) first suggested that *E. mariae-lebouriae* and *P. triangulatum* should be merged with *P. minimum*, but he thought that they should retain varietal status. However, Dodge (1975) proposed that these two names should not be retained, but be the synonym of *P. minimum* in view of the great range of variability.

Prorocentrum micans Ehrenberg
(Pl. 2, 3-6)

Prorocentrum micans Ehrenberg, 1833, p.307; Lebour, 1925, pl 16, pl. 1, fig. 5; Dodge, 1965, p. 608, fig. 1, pl. 1, figs. 1-4; 1975, p. 112, fig. 3a, pl 2, figs. a-c, e-f; 1982, p. 32, fig. 2k, pl. 1c,

d; Abe, 1967, p. 371, fig. la-c; Adachi, 1972, p. 53, pl. 2, figs. h-m, pl. 14, figs. f-g; Taylor, 1976, p. 23, pl. 1, fig. 1; Toriumi, 1979, p. 22, figs. a-h; 1980, p. 106, figs. 3, 9; Shim et al., 1981, p. 60, pl. I, fig. 4a-b; Yoo, 1982, p. 27, pl. 1, fig. 1; Han and Yoo, 1983a, p. 38, pl. I, 1.

Cercaria sp.: Michaelis, 1830.

Prorocentrum schilleri: Bohm in Schiller, 1933, p. 38, figs. 40a-e.

*Prorocentrum levantinoide*s Bursa, 1959, figs 125-127.

Prorocentrum pacificum Wood, 1963, p. 8, fig. 5.

Description: The shape of the cell is ovate to subspherical in valve view. The anterior end of the cell is rounded and the posterior end is pointed. The broadest is around the middle or towards the anterior, usually less than twice as long as broad. The surface of the cell is covered with regularly arranged depression and is perforated by numerous trichocyst pores, mainly in radial row and around the margin of valves. Anterior pores of various size are situated at anterior part of the cell. The long anterior spine sometimes decorated with a wing and the small anterior one without such appendage stand facing each other at the opposite sides of the anterior pores. Trichocyst pores in left valve ring this pore region. A widely developed intercalary band is situated between the two valves. The V-shaped nucleus is placed at the posterior part of the cell. Length, 40-55 μm , Width, 30-50 μm .

Remarks: This species is common in Korea. It is a cosmopolitan neritic species, distributed in practically all parts of the world.

This is an extremely variable species and is probably more abundant than the others of this genus. This most common *Prorocentrum* species has been reported on over 20 occasions all around Korea until now. In shape this is similar to *P. triestinum*, but it has a much more ornamented and more highly perforated theca.

Prorocentrum triestinum Schiller

(Pl. 2, 7-8)

Prorocentrum triestinum Schiller, 1918, p. 252, figs. la-b; 1933, p. 40, fig. 43a-f; Bohm, 1936, p. 15, figs. 3b, 1-2; Dodge, 1965, p. 609, fig. 2; 1975, p. 112, fig. 2a-c, pl. 1, fig. e; 1982, p. 32, fig. 2J; Adachi, 1972, p. 58, pl. 3, figs. j-p, pl. 14, figs. d-e; Toriumi, 1979, p. 21, figs. a-d; 1980, p. 108, figs. 6, 12; Yoo, 1982, p. 28, pl. 1, fig. 6; Han and Yoo, 1983a, p. 40, pl. I, 2.

Prorocentrum pyrenoideum Bursa, 1959, p. 18, figs. 112-120.

Prorocentrum redeldii Bursa, 1959, p. 19, figs. 121-124.

Prorocentrum setouti Hada, 1975, p. 37, figs. 3-4.

Prorocentrum shikokuensis Hada, 1975, p. 36, figs. 1-2.

Description: The shape of the cell is rounded at the anterior end and pointed at the posterior. This species is also variable and similar to *P. micans* in shape but is much smaller. The valves has smooth surface instead of ornamented surface. Particularly, this species have only one flagellar pore at the anterior end. There are a few trichocyst pores situated on the left valve near the pore plates and scattered on the valves. The nucleus is round at the posterior. Length, 15-22 μm , Width, 7-12 μm .

Remarks: This species is widely distributed in Korea and it is a neritic species found in coastal waters all over the world.

Recently, Toriumi (1980) suggested that two new species of *P. setouti* and *P. shikokuensis* described by Hada (1975) should be synonymous with *P. triestinum*.

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LEGEND TO PLATES

Plate 1

1. *P. balticum*, trichocyst visible on valve plate
2. *P. balticum*, flagellar pore
3. *P. balticum*, larger pore viewed from left valve
4. *P. balticum*, wide intercalary band in lateral view
5. *P. dentatum*, valve view
6. *P. dentatum*, anterior depression with two anterior spines
7. *P. dentatum*, anterior projection from one side of cell
8. *P. dentatum*, wide intercalary band in lateral view

Plate 2

1. *P. minimum*, heart-shaped valve plate
2. *P. minimum*, two anterior spines of large and small
3. *p. micans*, valve view
4. *P. micans*, anterior pores of various size
5. *P. micans*, prominent anterior spine with wing
6. *P. micans*, widely developed intercalary band with trichocyst
7. *P. triestinum*, valve plates of smooth surface
8. *P. triestinum*, one anterior pore

** Scale bar represents 1.0 μm .

PLATE 1

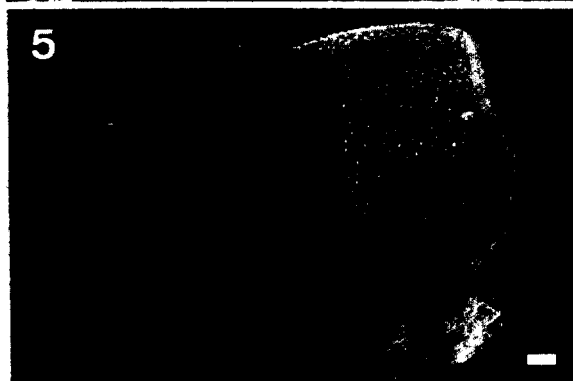


PLATE 2

