The Occurrence of a Dinoflagellate *Gymnodinium catenatum* From Chinhae Bay, Korea

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The resting cyst of *Gymnodinium catenatum* was found in the surface sediments collected from Chinhae Bay in October, 1991. This is the first record of the species in the Korean waters. The relative abundance was low with the maximum of 1.7%. The colonial motile form consisting of four cells was observed in 1992 from the excystment of the cyst collected from the Wonmun Bay in Chinhae Bay. No blooms caused by *G. catenatum* has been observed in Chinhae Bay during the survey.

Key words : dinoflagellate bloom, *Gymnodinium catenatum*, cysts, excystment, Chinhae Bay

Introduction

Gymnodinium catenatum has been attributed to causative species of paralytic shellfish poisoning (Morey-Gaines, 1982; Fukuyo et al., 1993; Balech, 1985; Fraga and Sanchez, 1985). More recently, Oshima et al. (1987) have reported the first evidence for the toxigenicity of *G. catenatum* in Tasmania, Australia and later toxin production of isolates from Japan, Australia and Spain (Oshima et al., 1993).

This species was also indentified as a causative organisms of paralytic shellfish poisoning (PSP) in Senzaki, Japan (Ikeda et al., 1989) and in the Philippins (Fukuyo et al., 1993). Since the original description by Graham (1943), much of new ultrastructural morphological characteristics has been presented for both of the motile and cyst forms by Balech (1964), Morey-Gaines (1982), Estrada et al. (1984), Anderson et al. (1988) and Blackburn et al. (1989). It was proved that this species occurred globally such countries as in Argentina (Balech, 1964), Australia (Hallegraeff and Sumner, 1986), Japan (Yuki and Yoshimatsu, 1987), Kamchatka, Russia (Konovalova, 1995), Mexico (Mee et al., 1986), Phillippine (Fukuyo et al., 1993), Portugal (Moita, 1993), and Spain (Fraga and Sanchez, 1995). However, this species was not identified in the Korean coastal waters. This paper describes, for the first time in Korea, the occurrence of the cyst and the motile forms of *G. catenatum*.

Materials and Methods

The bottom mud samples were collected at 12 stations in October, 1991 by using a lightweight core sampler, TFO-type (Fukuyo and Matsuoka, 1987) (Fig. 1).

The sediments for the species identification were subjected to standard palynological processing techniques (Matsuoka et al., 1989). They were disaggregated with an ultrasonic cleaner with some chemicals of HCL, HF, and sieved to retain the 20~80 μm size fraction. Cysts extracted from the sediment were observed by a light microscope equipped with the interference and phase contrast optics. For the excystment experiment, the live resting cysts were obtained from the 2 cm depth of surface sediment with overlying water. They were sieved through nylon gauze to

obtain the sediment fraction between 20 and 100 μm.

This fraction was suspended in 10 ml of sterilized seawater filtered through Whatman GF/C. The cysts were incubated at 20℃ and 3,500 lux with 12L : 12D photocycle. Appearance of germinated cyst in each test tube was examined daily.

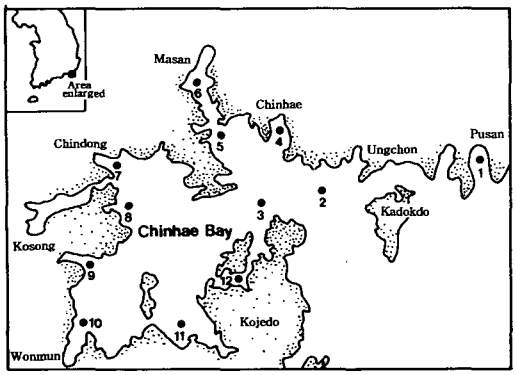

Fig. 1. Map showing the sampling sites of bottom sediment and phytoplankton.

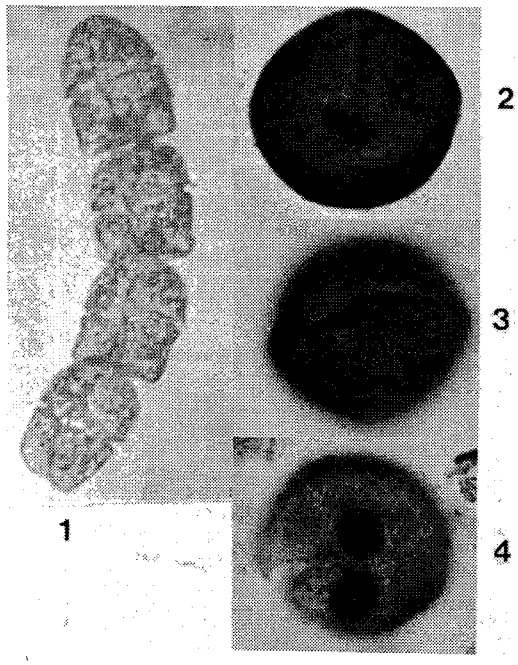

Plate 1. Light micrographs of the motile stage excysted and isolated from St. 10 and the resting cysts of *Gymnodinium catenatum*. A. A chain of four cells. B. Spherical resting cyst. C, D. Cysts with a chasmic archeopyle.

Results

In the present study, 30 cyst taxa were identified (Table 1). Of these, the resting cyst of *G. catenatum* was firstly isolated from the sediment collected from Chinhae Bay in October, 1991.

The motile cell was found through the excystment of isolated cyst collected from St. 10 in 1992. The motile cell is a chain of four-cells. The top cell is elongate-ovoid and the other three cells are rather squarish in ventral view of the theca. Cell size is 48~65 μm in length and 30~43 μ in width (Plate. 1).

Epicone is subconical with truncate apex and hypocone truncated posteriorly with a deep notch at sulcus. The cell has cingular displacement and excavated sulcus. The girdle groove is deep. The taxonomic identification of this species was ascertained by comparing it both to the original (Graham, 1943) and the recent detailed description of the species (Blackburn et al., 1989; Anderson et al., 1988). The cyst is spherical with numerous micro-reticulations over its surface and pigmented brown (Plate 1, B-D). The archeopyle is slit type termed as chasmic (Matsuoka, 1985) and consistent with non-oriented tearing of the cyst wall described by Anderson et al. (1988).

The cysts of *G. catenatum* were found at three stations such as St. 3 (the central part of Chinhae Bay), St. 7 (Chindong Bay) and St. 10 (Wonmun Bay) in Chinhae Bay. In the cental part of Chinhae Bay, the total number of cysts are 2,470 cysts/cm^3 of sediment representing 26 cyst species. Protoperidinioid and Diplopsalid cysts are mainly consisting of round brown *Brigantedinium* spp. Both of *Protoperidinium* sp. and *Dubridinium caperatum* are dominant representing more than 60% of the total cyst assemblages. *G. catenatum* cysts are also present, but rare (1.3%) in to-

Table 1. List of dinoflagellate cysts found from surface sediments of Chinhae Bay

Gymnodinioid cyst
Cochlodinium polykrikoides Margareff
Gymnodinium catenatum Graham
Gyrodinium instriatum Freudenthal et Lee*
Pheopolykrikos hartmannii (Zimmermann) Matsuoka et Fukuyo*
Polykrikos cf. *kofoidii* Chatton*
Polykrikos schwartzii Butschli*
Gonyaulacoid cysts
Spiniferites bulloideus (Deflander et Cookson) Sarjeant
= *Gonyaulax scrippsae* Kofoid*
Spiniferites cf. *delicatus* Reid
= *Gonyaulax* sp.*
Spiniferites elongatus Reid
= *Gonyaulax spinifera* complex*
Spiniferites mirabiris (Rossignol) Sarjeant
= *Gonyaulax spinifera* complex*
Protoceratium reticulatum (Claparede et Lachmann) Butschli
Lingulodinium machaerophorum (Deflandre et Cookson) Wall
= *Lingulodinium polyedra* (Stein) Dodge*
Ellipsoidal cysts probably produced by *Alexandrium catenella** and/or *A. tamarense**
Tuberculodinioid cyst
Tuberculodinium vancampoae (Rossignol) Wall
= *Pyrophacus steinii* (Schiller) Wall et Dale*
Protoperidinioid cyst
Brigantedinium cariacoense (Wall) Reid
= *Protoperidinium avellanum* (Meunier) Balech*
Brigantedinium simplex (Wall) Reid
= *Protoperidinium conicoides* (Paulsen) Balech*
Brigantedinium spp.
Lejeunecysta concreta (Reid) Matsuoka
= *Protoperidinium leonis* (Pavillard) Balech*
Selenopemphix nephroides Benedek
= *Protoperidinium subinerme* (Paulsen) Balech*
Selenopemphix quanta (Bradford) Matsuoka
= *Protoperidinium conicum* (Gran) Balech*
Stelladinium reidii Reid
= *Protoperidinum compressum* (Abe) Balech*
Trinouantedinium capitatum Reid
= *Protoperidinium pentagonum* (Aurivillius) Balech*
Votadinium spinosum Reid
= *Protoperidinum claudicans* (Paulsen) Balech*
Protoperidnium americanum (Gran et Braarud) Balech*
Protoperidnium lattisinum (Kofoid) Balech*
Protoperidnium spp.
Diplopsalid cyst
Dubridinium caperatum Reid
= *Zygabikodinium lenticulatum* (Paulsen) Loeblich et Loeblich*
Diplopsalis lenticula Berg*
Diplopelta cf. *parvum* Abe*
Calciodineloid cyst
Scrippsiella spp. (probably including *Scrippsiella trochoidea* (Stein) Loeblich III)

* biological name for the motile (plankton) form

tal cyst assemblages. In Chindong Bay, the total number of cysts are 2,200 cysts/cm^3 of sediment with 24 cyst species. Three major groups, gymnodinioid, gonyaulacoid and protoperidinioid cysts, occurred, and to the next tuberculodinioid and diplopsalid cysts are followed. The gymnodinioid group consists of the following three species as *Polykrikos kofoidii, Pheopolykrikos hartmannii* and *Gymnodinium catenatum,* which occupies only 0.9% in total dinoflagellate cyst assemblages. The total number of cysts are 1,180 cysts/cm^3 of sediment with 23 cyst species in Wonmun Bay. The gonyaulacoid cysts mainly composed of *Spiniferites bulloideus* and cyst of *Protoceratium reticulatum* are dominated. *G. catenatum* occupies 1.7% in total cyst assemblage.

Discussion

The motile and the cyst forms of *Gymnodinium catenatum* have been found from the several places in the western coastal waters in Japan (Matsuoka and Fukuyo, 1994). The nearest occurrence place to the Chinhae Bay of Korea is the Aso Bay in Tsushima island of Japan (Matsuoka and Fukuyo, 1994). Aso Bay, where the cysts of this species have been identified with low relative frequency at the surface sediment, is located about 100 km southeast off the Chinhae Bay. The maximum frequency is only 1.7% in total dinoflagellate cyst assemblages at St. 10.

Although the density is low, it probably distributes through the bay, because the cysts occurred at three stations which are considerably distant from one another.

This kind of relatively low abundance of *G. catenatum* cyst is similar to the previous records of the species in the western coast of Japan. In the Tasmanian coast of Australia, the relative frequency of *G. catenatum* cysts was more than 10% in total cyst assemblages after the red tide bloom (Hallegraeff et al., 1989).

The excysted motile forms of this species has been observed only once during the excystment test of the cysts collected in Wonmun Bay in 1992. This fact indicates that *G. catenatum* has never made a red tide bloom in Chinhae Bay. Therefore, it is postulated that the main PSP causative organisms in this Bay is not *G. catenatum,* but *Alexandrium tamarense* as clarified in the previous reports (Han et al., 1992; Lee et al., 1992). However, *G. catenatum* produced considerable amount of PSP and made shellfish toxication in Senzaki Bay, Japan in 1989 as well as *Alexandrium catenella* (Ikeda et al., 1989). Further studies have to be made for its deveopment, toxin profile and cellular structure.

Acknowledgements

This work was partly supported by the special research grants from the Ministry of Science and Technology, Korea.

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Received January 26, 1996
Accepted October 19, 1996