

A Study on the Fine Structure of the Marine Diatoms of Korean Coastal Water-Genus *Thalassiosira* 2.

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韓國沿岸域의 浮游性 硅藻類의 微細構造에 관한 研究

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Abstract

A study on the fine structure of the marine diatoms has been carried out for taxonomical purpose during the periods from September 1983 to March 1987 in Korean coastal waters. Fine structure of small *Thalassiosira* (Bacillariophyceae) was studied by means of light microscope and scanning electron microscopy. Secondly, six species of *Thalassiosira* were identified and described. Of these *Thalassiosira aestivalis*, *T. allenii*, *T. binata* and *T. conferta* were new records for Korean coastal waters. *Thalassiosira aestivalis*, *T. allenii*, *T. binata*, *T. conferta*, and *T. pacifica* have a valve with a single labiate process and one central and one marginal ring of strutted processes, but *T. rotula* has many central strutted processes close together instead of one central strutted process.

요약 : 1983년 9월부터 1987년 3월까지 韓國沿岸域에서 출현한 浮游性 硅藻類 중 *Thalassiosira* 屬의 소형종에 대하여 走査電子顯微鏡을 이용하여 微細構造를 연구하였다. 第2報로서 *Thalassiosira aestivalis*, *T. allenii*, *T. binata*, *T. conferta*, *T. pacifica* 및 *T. rotula* 등 6종을 同定·記載하였으며, 이 중 *Thalassiosira allenii*, *T. binata*와 *T. conferta*는 韓國産 未記錄種으로 보고한다.

INTRODUCTION

Makarova (1971) listed seventy-three species and infraspecific living taxa in *Thalassiosira*, and since then, more than thirty species have been described or transferred into the genus (Fryxell, 1977a, b; Fryxell and Hasle, 1972, 1977; Hasle, 1972a, b, 1978; Hasle and Fryxell, 1977a; Makarova, 1975, 1976). Fryxell (1978) suggested that the genus *Thalassiosira* now has included more than one hundred taxa in view of these facts in the world. The genus has a valve with a labiate process, central and marginal strutted processes (Ha-

se, 1972b). The patterns of these processes have been used for the identification and delineation of the genus *Thalassiosira* species during the past two decades (Takano, 1963, 1965, 1978; Hasle, 1968, 1972a, b, 1978; Fryxell, 1977a, b; Hasle and Fryxell, 1977a; Fryxell and Hasle, 1977; Johansen and Fryxell, 1985; Herzig and Fryxell, 1986).

Lee and Cho (1985) listed up a total of eighteen taxa of *Thalassiosira* species in Korean coastal waters from the year of 1931 to 1984. There are no new species from Korean coastal waters till 1985. Lee and Yoo (1986) have studied a fine structures of small *Tha-*

lassiosira by means of LM and SEM and *T. minima*, *T. oestrupii* var. *venrickae* and *T. weissflogii* were new records for Korean coastal waters.

Secondarily, the present study was seriated the fine structure of the *Thalassiosira* species in Korean coastal waters.

MATERIALS AND METHODS

Most of the materials used for this study came from Korean coastal waters during the periods from September 1983 to March 1987 (Fig. 1).

For the sampling one liter of seawater was collected from surface using van Dorn water sampler. Samples were fixed with 5% neutralized formaline on board. These samples were examined in water and permanent mounts. Subsample rinsed off salt was either mounted directly of cleaned or organic materials (Hasle and Fryxell, 1970; Hasle, 1983) and mounted in pleurax for LM and on aluminum stubs for SEM. Materials was coated with gold-palladium and examined with JSM-35CF SEM, Department of Electron Microscope, Catholic Medical University of Korea. Terminology is that suggested by the Working Party on Diatom Terminology (Anonymous, 1975).

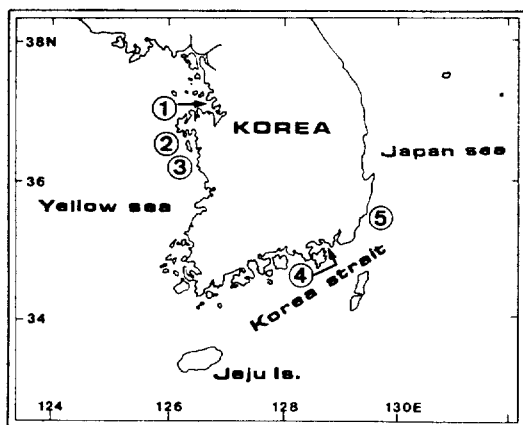


Fig. 1. Sampling areas of phytoplankton diatoms in Korean coastal waters. (1: Asan Bay, 2: Chonsu Bay, 3: Daechon coast, 4: Chinhae Bay, 5: Ulsan Bay).

RESULTS AND DISCUSSION

A total of six species of the genus *Thalassiosira* have been identified during the present study; *Thalassiosira aestivalis*, *T. allenii*, *T. binata*, *T. conferta*, *T. pacifica* and *T. rotula*. Of these *Thalassiosira allenii*, *T. binata* and *T. conferta* were new records for Korean coastal waters. These species have a valve with a single labiate process and one marginal ring of strutted processes. *Thalassiosira rotula* has many central strutted processes close together, the others have one central strutted process.

Description of the species

Thalassiosira aestivalis Gran and Angst (Pl. I, Figs. 1-6).

Type locality: Friday Harbor, Puget Sound, Washington, U.S.A., 18 July 1930.

Thalassiosira aestivalis Gran and Angst 1931, p. 436, Figs. 10a-b; Cupp 1943, p. 47, Fig. 9.

Description: Cells disc-shaped in valve view and quadrangular with rounded corner in girdle view. Valve face almost flat or slightly depressed in the central area. Valve mantle about 2.0 μm in height and cells 19-35 μm in diameter. Areolae well developed, nearly round shape and 13-16 in 10 μm on valve face. Areolae array in straight rows parallel to medial line of a relatively large number of sectors. One central strutted process raised and opening. The central strutted process located eccentrically adjacent to one or more larger areolae. One labiate process just on or in the marginal ring of strutted processes. Valve mantle narrow and slightly smaller areolae than those of the valve face. Areolae number on valve mantle 17-21 in 10 μm .

Taxonomic note and distribution: *Thalassiosira aestivalis* was firstly identified in Friday Bay of Puget Sound in U.S.A. by Gran and Angst (1931). They distinguished from

Thalassiosira nordenskiöldii by smaller marginal processes and a narrower marginal $z.c.$ $\alpha.c.$ Cupp (1943) studied the description and occurrence of *T. aestivalis* in the west coast of north America. Takano (1965) compared *T. aestivalis* with three allied *Thalassiosira* taxa. Hasle (1978) has drawn an exact line between *T. aestivalis* and *T. nordenskiöldii* in a new angle on the problems of marginal ribs, mantle areolae and wall continuations. *Thalassiosira aestivalis* listed from Puget Sound (Gran and Angst, 1931), the west coast of north America (Cupp, 1943), the Gulf of Panama (Smayda, 1966), the Conception Bay of Chile (Rivera, 1968), the northern Atlantic Ocean, the tropical Indian Ocean, and the northern, tropical and southern Pacific Ocean (Markarova, 1971), and Vancouver Island of the northwest America (Hasle, 1978).

Thalassiosira aestivalis was recorded five times in the southern part of Korean coastal waters (Lee and Cho, 1985). The present study was recorded in January and February 1986 in Daechon coast and Ulsan Bay, respectively.

Thalassiosira allenii Takano (Pl. II, Figs. 1-3).

Type locality: Manozuru, Kanagawa Prefecture, Japan.

Thalassiosira allenii Takano 1965, p. 4, fig. 2, Pl. 1, figs. 9-11; Hasle 1978, p. 101, Figs. 100-128; Takano 1979a, Sheet no. 11, Figs. A-H.

Description: Cells chain by gelatinous thread, quadrangular in girdle view. Cell disc-shaped, diameter $15.5 \mu\text{m}$. External valve surface well developed areolae and covered with siliceous granules. Areolae arranged in a number of sectors or diffusive sectors. Areolae number 26 in $10 \mu\text{m}$ of valve center and 40 in $10 \mu\text{m}$ of valve mantle. Central strutted process raised and opening. Central strutted process adjacent to slightly several larger areolae than those of the valve face. One labiate process positioned as for a strutted process and

short cylinder but smaller than marginal strutted processes. Marginal strutted processes about 8 in $10 \mu\text{m}$.

Taxonomic note and distribution: Scientific name of *Thalassiosira allenii* was named in honour of Dr. E.J. Allen by Dr. H. Takano, April 1965. This species is similar to *T. aestivalis*, *T. nordenskiöldii*, and *T. pacifica*. Takano (1965) have mentioned that it was distinguished from them mainly by its smaller cell-size and the finer areolae in the valve. Hasle (1968, 1978) observed minutely areolae arrangements, external and internal view of valve, labiate process, central and marginal strutted processes, distribution and so on. According to the above studies, she has indicated that *Thalassiosira allenii* was estimated the variation in areola array to be greater than that of process number and arrangement and also discussed to require a subdivision of the genus. Hasle (1978) has reported the distribution of *T. allenii*; Adriatic Sea, Hawaii, Gulf of Mexico and Miami coast in U.S.A., Tokyo Bay in Japan, Saronicos Gulf in Greece and off west Africa.

Thalassiosira allenii was new record in Korean coastal water: September 1983 and October 1986 in Chinhae Bay.

Thalassiosira binata Fryxell (Pl. II, Figs. 4-7).

Type locality: Gulf of Mexico, 12 miles east of South Pass, mouth of Mississippi River, 1 June 1974.

Thalassiosira binata Hasle and Fryxell 1977b, p. 244, Figs. 24-38; Takano 1978, p. 45, Figs. 1-9; Takano 1979b, Sheet no. 10, Figs. A-F.

Description: Cells laterally elongated and octagonal in girdle view, cell diameter about 2 times greater than cell height. Valve disc-shaped, diameter $6-11 \mu\text{m}$. Valve center concave with a depressed central cavity. Valve mantle about $1.5 \mu\text{m}$ in height. Areolae distinct and nearly radial rows or not. Foramina external

and cribra internal. One central strutted process opening and raised around 0.5-1.0 μm in center. One labiate process with slender tube and long, 1.2-1.6 μm . Labiate process always located on the left hand of a strutted processes at 12 o'clock position 1-2 areolae apart from the process. One ring of 5-8 marginal strutted processes on the edge of valve mantle with straight external tubes. Distances 2.3-2.8 μm between marginal strutted processes.

Taxonomic note and distribution: The most noticeable feature on the valve of *Thalassiosira binata* is the one pair of processes located very close together, in contrast to the regular spacing of the other processes like the clock face. Specific epithet "binata" means 'with a pair' and refers to the two processes with only one areolae between them (Hasle and Fryxell, 1977b). *T. binata* is very similar to *T. nordenskiöldii*. But the former is distinguished from the latter by the smaller size, narrow, almost pointed tubes and the unique location of the labiate process. Distribution of *Thalassiosira binata* was river, estuarine and marine; the Gulf of Mexico, the Bengal Bay, Weser River near the North Sea, the western Atlantic Ocean, Uruguay (Hasle and Fryxell, 1977b), Sumida River, Tokyo Harbor, Ise Bay and Mikawa Bay in Japan (Takano, 1978). Also Takano (1978) reported that *T. binata* is possibly fond of estuarine conditions.

Thalassiosira binata was new to Korean coastal water in July and September 1985 in Chonsu Bay. Therefore, this species was thought of euryhaline and cosmopolitan with regard to sampling area and time.

Thalassiosira conferta Hasle (Pl. III, Figs. 1-4).

Type locality: Northwest Africa waters, 19°57' 0"-19°55' 2" N, 17°59' 5"-17°58' 5" W, 28 Jan. 1970.

Thalassiosira conferta Hasle & Fryxell 1977b, p. 239, Figs. 1-23; Takano 1981a, Sheet no. 61, Figs. A-H.

Description: Cell octagonal in girdle view in LM. Valve disc-shaped, diameter 6.3-14.0 μm . Cribra internal and foramina external. Areolae irregularly to regularly hexagonal. Areolae radial array from central strutted process, 25-34 in 10 μm . One labiate process long and narrow crack. Labiate process with short external tube between two long external projections of the strutted processes, 0.8-1.3 μm in height. One central strutted process with external tube adjacent to a central areolae, usually large and more irregularly shaped, with cribrum. Central strutted process opposite side of central areolae from marginal labiate process. One marginal of ring strutted processes, 1.0-3.0 μm apart, with long external tubes. Number of marginal strutted processes 5-6 in 10 μm .

Taxonomic note and distribution: the distinctive morphological features of *Thalassiosira conferta* are the two long external projections of the strutted processes and the particular location of the labiate process between two strutted processes. External view of the labiate process is small, but it is large size in internal. Hasle and Fryxell (1977b) pointed out that *T. conferta* is the two closely placed marginal processes adjacent to the labiate process. But *T. conferta* of this study has observed one marginal ring of strutted processes and labiate process between two strutted processes in a different rows. It will be considered that this species is infraspecific species in view of the morphological variations. As the mentioned by Hasle and Fryxell (1977b), the small cells have few marginal strutted processes, while the large cells have more marginal strutted processes. *T. conferta* is distributed in northwest African waters, the north Atlantic Ocean and Trondheimfjord of Norway, the inner Bay of Tokyo to Yokohama Harbor in Japan.

Thalassiosira conferta was new records for Korean coastal waters; July 1985 in Chonsu and Asan Bay, August 1986 and March 1987

in Chinhæ Bay.

Thalassiosira pacifica Gran and Angst (P1. III, Figs. 5-6, P1. IV, Figs. 1-2).

Type locality: Puget Sound of Washington, U.S.A. March-April 1927, 1928.

Synonyms: *Thalassiosira pulchella* Takano 1963, p. 5, Fig. 1, P1. I, Fig. 11.

Thalassiosira pacifica Gran and Angst 1931, p. 437, Fig. 12: Kokubo 1955, p. 126, Fig. 109: Hasle 1976, p. 325, Figs. 14-16: Shim 1977, p. 95, P1. VII, Figs. 3a-b: Hasle 1978, p. 88, Figs. 3, 40, 42-49: Takano 1981b, Sheet no. 63, Figs. A-F.

Description: Cell disc-shaped in valve view, diameter 20.0-33.2 μm observed. Valve face flattened or slightly concave. Areolae usually in faciculated rows with areolae parallel to radius; areolae 12-13 in 10 μm in central part but not developed at margin. The uttermost edge of valve mantle almost flattened. No evident labiate process in external view, but pronounced in internal view. One central strutted process raised and opening and have satellite pores. One regular ring of the marginal strutted processes 5-6 in 10 μm .

Taxonomic note and distribution: Gran and Angst (1931) have distinguished *T. pacifica* from *T. aestivalis* by girdle view, valve structure and the equal thickening of all sutures in the girdle zone. Takano (1965) reported on comparison of the four allied taxa, *T. aestivalis*, *T. nordenskiöldii*, *T. pacifica* and *T. allenii* by diameter, submarginal spinulae, isolated spinule and areolae number in 10 μm . Hasle (1978) pointed out that the main distinction between *T. pacifica* and *T. aestivalis* is more manifest in the areola array. Namely, the areolae of *T. pacifica* are straight or slightly curved tangential rows or in radial rows parallel to the median row of much wider sectors, occasionally with a mixture of curved, tangential rows and sectors. The present study was similar to the above results, but areolae of the valve have not well developed. This result

was analogous to Mahood et al. (1986)'s study.

Thalassiosira pacifica was recorded six times in Korean coastal waters (Lee and Cho, 1985).

Thalassiosira rotula Meunier (P1. IV, Figs. 3-6).

Type locality: Belgium coast, Belgium, 1910.

Thalassiosira rotula Meunier 1910, p. 264, P1. 29, Figs. 67-70: Hustedt 1930, p. 326, Fig. 163: Gran and Angst 1931, p. 438, Fig. 13: Cupp and Gran 1938, p. 76, P1. 4, Fig. 4: Cleve-Euler 1951, p. 156, Fig. 124: Kokubo 1955, p. 125, Fig. 107: Hasle 1976, p. 322 Fig. 13: Shim 1977, p. 95, P1. IX, Figs. 1a-c: Syvertsen 1977, p. 99, Figs. 1-18: Takano 1979c, Sheet no. 12, Figs. A-F: Mahood, Fryxell and McMillan 1986, p. 138, Figs. 49-55 and 105.

Description: Cell united to form chains by means of a very thick gelatinous thread. Frustles in girdle view rectangular in LM. Valve flat, discoid, or only slightly rounded at the extreme margin. Cell diameter 39-49 μm and areolae very fine, only clearly seen in the central area. Cluster of the strutted processes in center, with scattered strutted processes across entire valve face. Single labiate process, valve weakly silicified. Usually observed in chains.

Taxonomic note and distribution: The taxonomical characters of *Thalassiosira rotula* are 1) weakly silicified valve without a regularly formed patterns, 2) one labiate process at valve margin, 3) more than one central strutted processes, and 4) strutted processes scattered over the valve. In spite of this characters, *T. rotula* is liable to confuse *T. gravida* in identification. Syvertsen (1977) studied on the valve morphology changed from that typical of *T. rotula* at 17°C to that typical of *T. gravida* at 3°C. Hasle (1976) pointed out that *T. rotula* had a continuous distribution from about 60°N to 43°S, while *T. gravida* was

found from about 70 to 35° on the northern hemisphere and from about 77 to 33° on the southern hemisphere. Accordingly, distribution of *T. gravis* is bipolar, while *T. rotula* is distributed throughout the warm and temperate seas, with some overlapping. Therefore, it is very reasonable that the occurrence of *T. rotula* was abundant during the periods from 1956 to 1985 in Korean coastal waters (Lee and Cho, 1985). This species was recorded in February and October 1986 in Chonsu Bay and Chinhae Bay, respectively.

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Explanation of Plates

Plate I. *Thalassiosira aestivalis*, SEM. Scales represent 10 μm in Figs. 1,2,5 and 1 μm in Figs. 3,4,6.

Fig. 1-2. External valve view. Note labiate process at about 10:00 o'clock position in Fig. 1 and 5:30 o'clock in Fig. 2.

Fig. 3-4. Labiate process and marginal strutted processes.

Fig. 5. Lateral view of valve and valve mantle.

Fig. 6. Focus showing central strutted process and areolae.

Plate II. *Thalassiosira allenii* and *T. binata*, SEM. Scale = 1 μm .

Fig. 1. External view of *T. allenii* and labiate process near 2:30 o'clock position.

Fig. 2. Labiate process of *T. allenii* showing short cylinder and opening.

Fig. 3. Central strutted process of *T. allenii* and outside detail of valve showing siliceous granules.

Fig. 4-5. External view of *T. binata*. Slender labiate process at 12:00 o'clock always located on the left hand.

Fig. 6-7. Lateral view of *T. binata*. Focus showing narrow valve mantle and surface concave.

Plate III. *Thalassiosira conferta* and *T. pacifica*, SEM. Scales represent 1 μm in Figs. 1-4 and 10 μm in Figs. 5-6.

Fig. 1. External view of *T. conferta* showing two long projections of the strutted processes. labiate process positioned between two strutted processes.

Fig. 2-4. Internal view of *T. conferta*. Focus showing labiate process and marginal strutted processes.

Fig. 5-6. External view of *T. pacifica*. Areolae developed in center but not toward margin. Labiate process invisible and marginal strutted processes evidently.

Plate IV. *Thalassiosira pacifica* and *T. rotula*, SEM. Scales represent 10 μm except Fig. 6 of 1 μm .

Fig. 1-2. Internal view of *T. pacifica*.

Fig. 3. External view of *T. rotula* showing very thick gelatinous thread.

Fig. 4. External view of *T. rotula*.

Fig. 5. Strutted processes scattered over the valve. Labiate process 4:00 o'clock position.

Fig. 6. Cluster of the strutted processes in center and those of inside view.

PLATE I

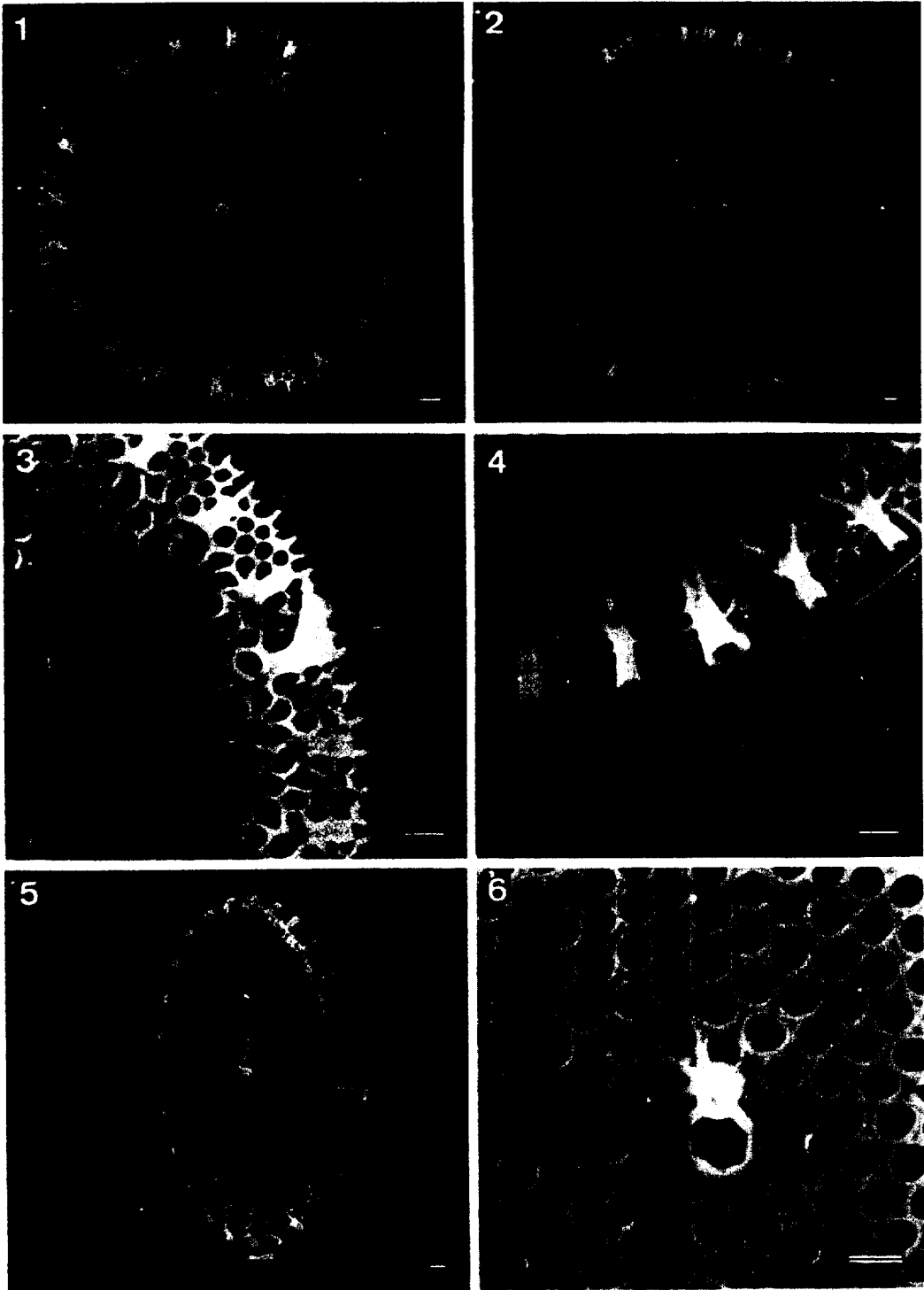


PLATE II

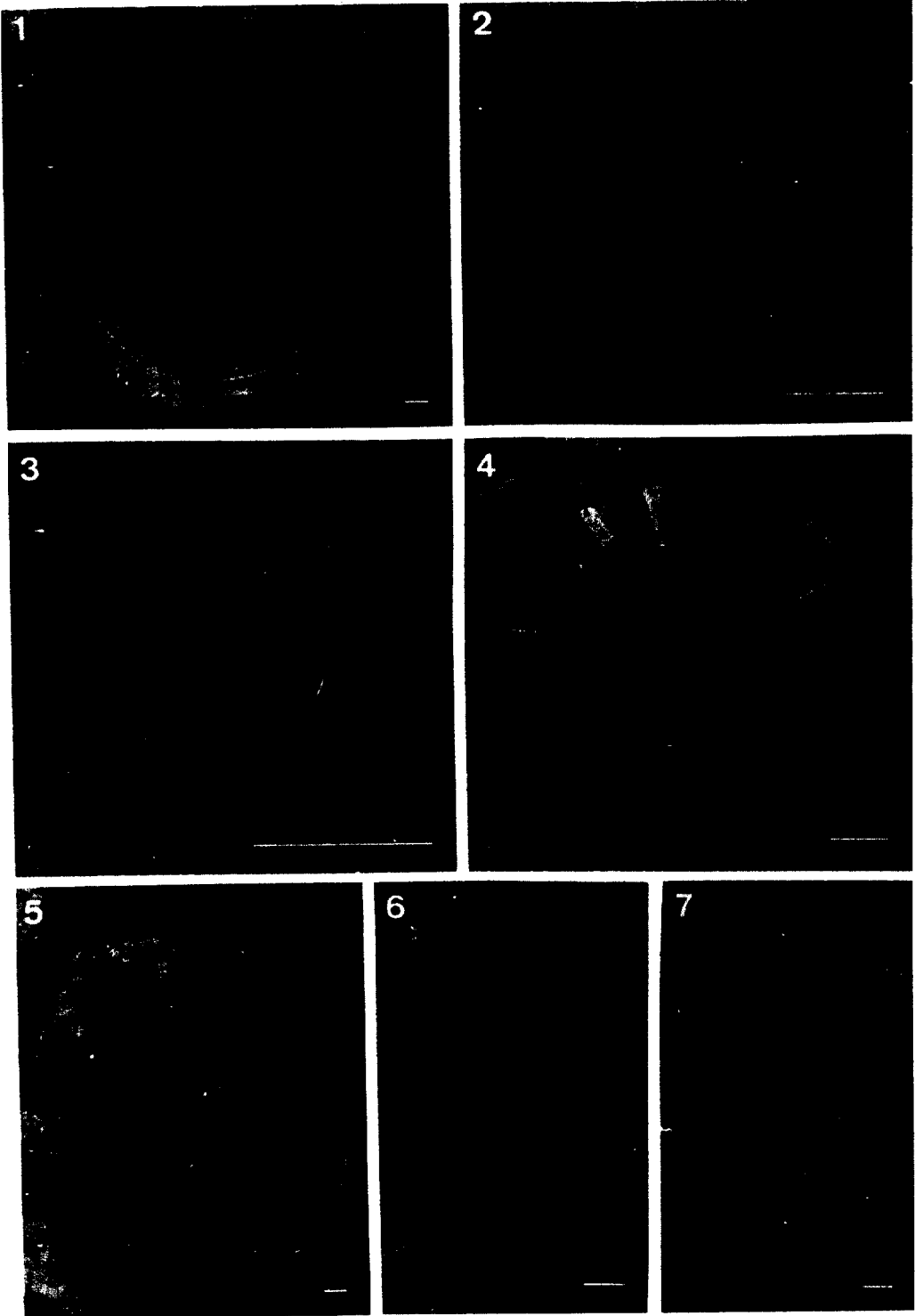


PLATE III

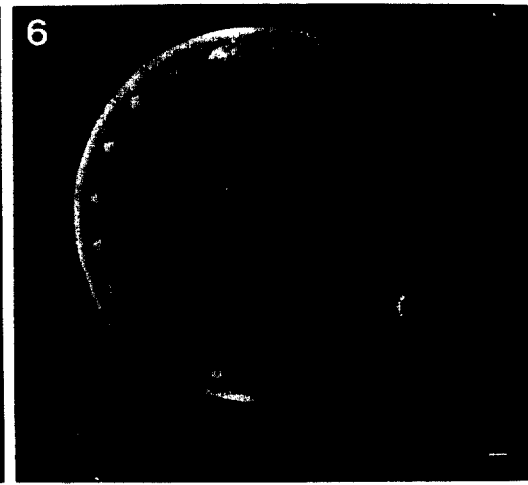
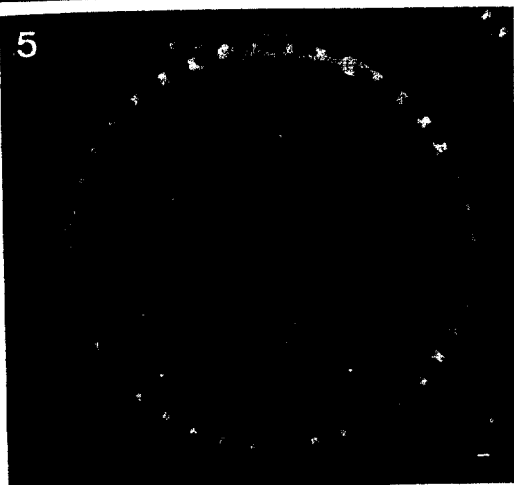
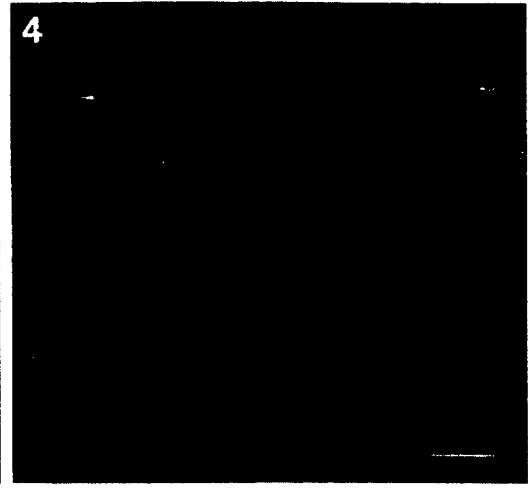
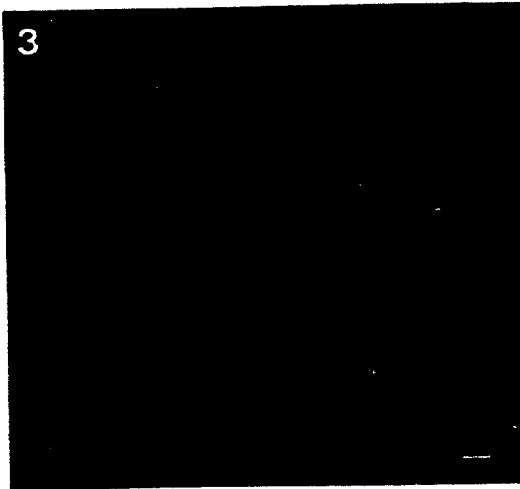
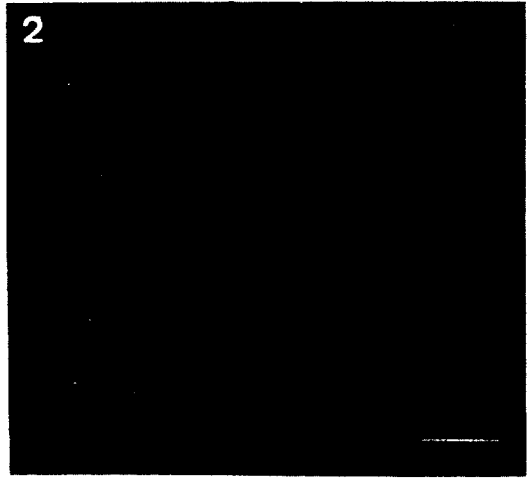
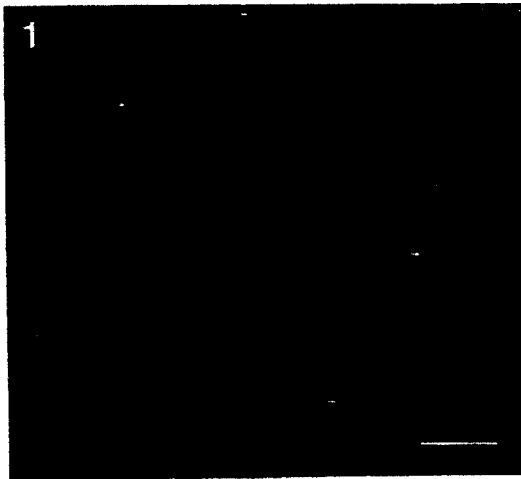


PLATE IV

