

Katsuhisa Yuki: First report of *Alexandrium minutum* Halim (Dinophyceae) from Japan

Key Index Words: *Alexandrium minutum*—*Dinophyceae*—first record—Matoya Bay—thecal morphology.

Katsuhisa Yuki, Matoya Oyster Research Laboratory, Matoya, Isobe-cho, Mie, 517-02 Japan

Among about 30 species hitherto described in the dinoflagellate genus *Alexandrium*, 12 species have so far been recorded from Japan (e.g. Fukuyo *et al.* 1985, Kita and Fukuyo 1988, Yuki and Fukuyo 1992). In addition to these species, I report here for the first time *Alexandrium minutum* Halim found in Japan. This species is extensively distributed in the temperate coastal waters of the world (Hallegraeff *et al.* 1988) and has been known as a paralytic shellfish toxin-producer in South Australia (Hallegraeff *et al.* 1988) and France (Erard-Le Denn 1991, Belin 1993).

The specimens were obtained from part of the samples which have been collected every roughly 3 days at a station (34°21.8'N, 136°51.9'E) in Matoya Bay, Pacific coast of central Japan, between 1956 and 1993. In sampling, 5 liters of seawater were taken from 2 m depth using a handmade pump and fixed with formaldehyde. Planktonic organisms were finally preserved in a volume of 10 ml by siphoning the water. Until December 1993, 4289 samples were thus collected, but about 1000 of these were already lost or unfavorable for a microscopical examination because of desiccation or decomposition of the contents. Of the remainders, about 1700 samples (about 4.7 samples per month on an average) were examined by light microscopy. *Alexandrium minutum* was present in 87 of these samples. For staining the thecal plates, Imamura and Fukuyo's (1987) solution was used.

Alexandrium minutum Halim (Figs. 1-12)

Alexandrium minutum Halim, 1960, p. 102, figs.

Ia-j; Balech, 1989, p. 207, figs. 1-27; Montresor *et al.*, 1990, p. 84, figs. 3a-e, 4a-e; Honsell, 1993, p. 128, figs. 2-8.

Alexandrium ibericum Balech, 1985, p. 37, fig. 15;

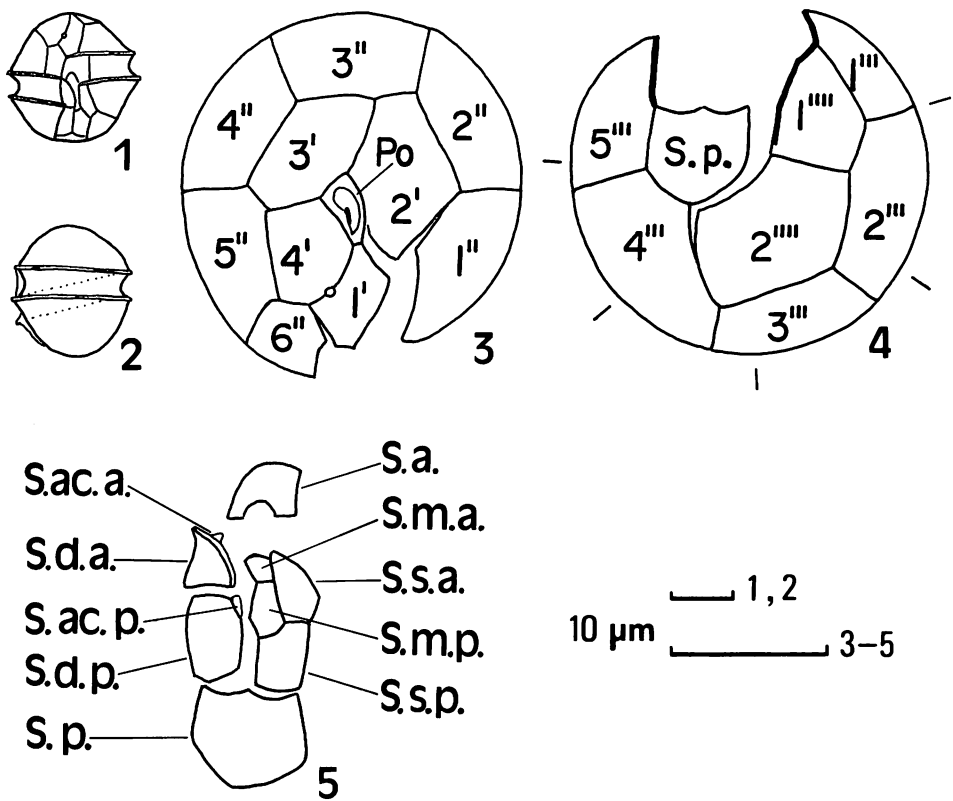
Protogonyaulax tamarensis, Su *et al.*, 1989, p. 86, figs. 1-12;

Alexandrium tamarense, Su and Chiang, 1991, p. 231, figs. 26-34.

Description: Cell solitary, globular, almost circular in cross-section, with equal epitheca and hypotheca in length, 20-26 (rarely 30) μm long, 20-25 (rarely 30) μm wide (Figs. 1, 2, 6). Epitheca hemispherical with convex shoulders. Hypotheca broadly rounded. Cingulum median, moderately wide and deep, descending one cingular width, without overhanging. Sulcus slightly widening posteriorly, faintly indenting antapex. Cingular and sulcal ridges scarcely salient. Excepting scattered numerous pores, no ornamentation present on thecal surface in most of specimens, but coarse and irregular reticulations rarely present on surface of hypothecal and some sulcal plates (Fig. 12).

Plate formula Po, 4', 6'', 6c, 5''', 2'''' and 10s (Figs. 3, 4, 5). Apical pore plate (Po) drop-shaped, tapering ventrally, with comma-shaped apical pore (Fig. 7). Callus developed. Po without attachment pore. First apical 1' asymmetrical-rhomboidal, with truncate posterior end, in contact with Po (Figs. 3, 9). Ventral pore small, posteriorly situated on suture between apicals 1' and 4' (Figs. 3, 9). Precingular 6'' rather narrow, nearly twice as long as wide (Fig. 9).

Sulcus composed of ten plates (Figs. 5, 10, 11). Anterior sulcal plate (S.a.) as long as wide, with shallow posterior indentation. Right and left posterior sulcal plates (S.d.p. and S.s.p.) slightly longer than wide. Anterior inner corner of these plates roundly scraped. Right anterior sulcal plate (S.d.a.) triangular, about as long as wide. Anterior accessory sulcal plate (S.ac.a.) granular,



Figs. 1-5. *Alexandrium minutum* Halim collected in Matoya Bay, Japan. Fig. 1. Ventral view. Fig. 2. Left side view. Fig. 3. Epithelial plates seen apically. Fig. 4. Hypothecal plates seen antapically. Short bars denote positions of sutures of cingulars 1-6. Fig. 5. Sulcal plates, showing anterior sulcal plate (S.a.), posterior sulcal plate (S.p.), left anterior sulcal plate (S.s.a.), right anterior sulcal plate (S.d.a.), left posterior sulcal plate (S.s.p.), right posterior sulcal plate (S.d.p.), median anterior sulcal plate (S.m.a.), median posterior sulcal plate (S.m.p.), anterior accessory sulcal plate (S.ac.a.), and posterior accessory sulcal plate (S.ac.p.).

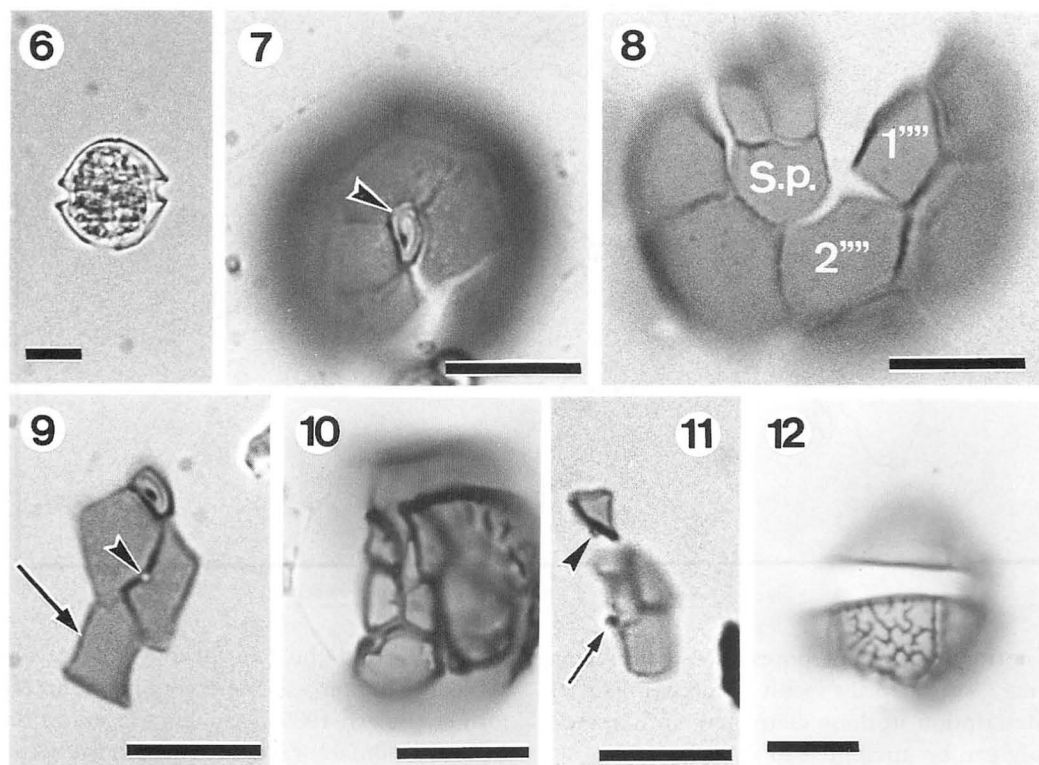
difficult to discern without dissociation of sulcal plates, adhering to thickened left anterior side of S.d.a. (Figs. 5, 11). Posterior accessory sulcal plate (S.ac.p.) very small, fitted into small indentation between left anterior corner of S.d.p. and right posterior corner of S.m.p. (Figs. 5, 11). Two median plates (S.m.a. and S.m.p.) very small, unequal in length; S.m.p. longer than S.m.a. Posterior sulcal plate (S.p.) heart-shaped or nearly rectangular, wider than long, its lateral sides almost parallel (Figs. 5, 8). No attachment pore present on S.p.

Postcingular 4''' largest of hypothecal plate. Postcingular 5''' second largest, four-sided, occupying right ventral side. First antapical 1''' bordered by six plates, with thickened right margin, connected with S.s.a. by

its very short anterior side. Antapical 2''' wide, distorted pentagonal, but degree of distortion slight because of rather long suture between this plate and 1'''.

Nucleus C-shaped, located in cytoplasm behind cingulum. Chloroplasts small, numerous.

Geographic distribution: *Alexandrium minutum* was originally reported from Alexandria, Egypt (Halim 1960), and also has been recorded from Spain and Portugal (Balech 1985), coastal Tyrrhenian waters (Montresor *et al.* 1990) and Adriatic Sea (Honsell 1993) in Italy, France (Erard-Le Denn 1991), South Australia (Hallegraeff *et al.* 1988), the east coast of North America (Balech, E. cited by Hallegraeff *et al.* 1988), and southern Taiwan (Su *et al.* 1989, Su and Chiang, 1991). Newly



Figs. 6–12. Light micrographs of *Alexandrium minutum* Halim collected in Matoya Bay, Japan. Scale bars = 10 μm . Fig. 6. Optical cross-section in dorso-ventral view. Fig. 7. Apical view of the epitheca, showing apical pore plate (arrowhead). Fig. 8. Antapical view of the hypotheca. Note the posterior sulcal plate (S.p.) which is slightly wider than long. Fig. 9. Part of ventral epithecal plate, showing the Po and 1' contact, a ventral pore (arrowhead) on the suture between 1' and 4', and the narrow precingular 6'' (arrow). Fig. 10. Ventral view of sulcal plate pattern. Fig. 11. Anterior (arrowhead) and posterior (arrow) accessory sulcal plates. Fig. 12. Coarse and irregular reticulations on the postcingular plate. Note the smooth epitheca.

observed from Japan (Matoya Bay, Ago Bay and Gokasho Bay located on the Pacific coast of central Honshu). These findings well document a world-wide geographic distribution of this species (Fig. 13).

Seasonal and long-term distributions: In the samples taken after 1956 in Matoya Bay, *A. minutum* was first observed in April 1967 and has continued to be found almost every year since then (Fig. 14). Although the maximal annual concentration in 1968 was considerably higher than those in other years, no noticeable long-term trend of increase or decrease in population density was observed. In Matoya Bay *A. minutum* appeared during the long period from early winter to late summer (mainly April and August); however, it was very rare or absent in fall (October–Novem-

ber) (Fig. 15). *Alexandrium minutum* was numerically a minor species in the bay (mostly less than 100 cells $\cdot l^{-1}$) unless it reached the concentration of about 1700 cells $\cdot l^{-1}$ in late April 1968 and became a major constituent among dinoflagellates. In Ago Bay and Gokasho Bay (within 20 km of Matoya Bay), *A. minutum* was found in March 1993, but in very low concentrations less than 20 cells $\cdot l^{-1}$.

Remarks: According to Balech's (1989) revised description, *A. minutum* is characterized by its small size (usually 17–29 μm , exceptionally 36 μm), the rhomboidal first apical 1' which is directly or indirectly connected to the Po, a ventral pore which is situated in the posterior half of the right upper side of 1', the small and short S.p., the narrow precingular 6'', and the constant lack of anterior and

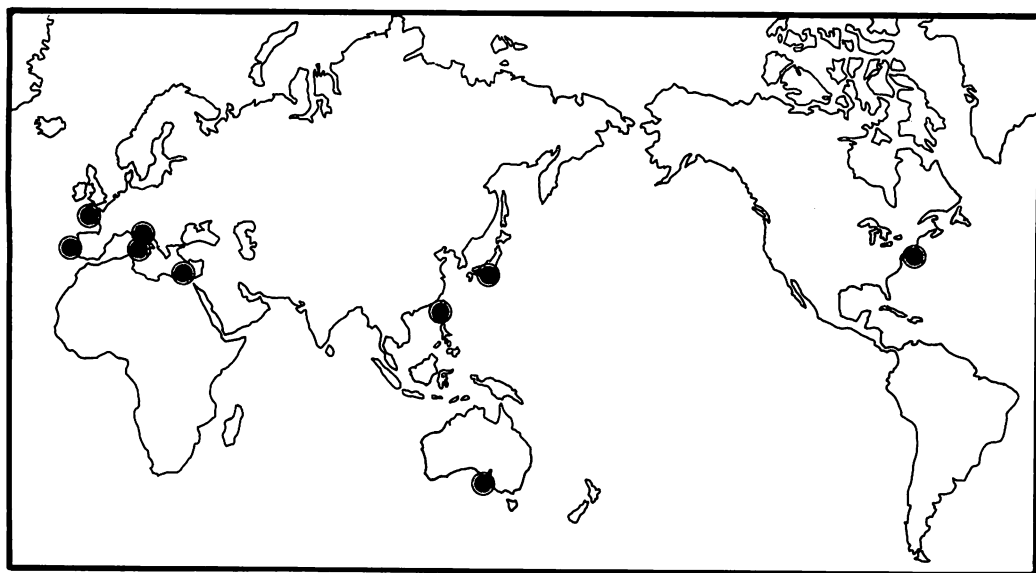


Fig. 13. Geographic distribution of *Alexandrium minutum*.

posterior attachment pores. My specimens agree satisfactorily with Balech's (1989) redescription in these characters and accordingly can be attributed to *A. minutum*.

Alexandrium minutum shows a high variability in the appearance of hypothecal surface. In the cells from coastal Tyrrhenian waters of Italy the hypotheca is smooth or highly ornamented with reticulations (Montresor *et al.* 1990) as in the Japanese specimens. Both types of cells were also observed in clonal cultures established by Montresor *et al.* (1990). Whereas, there is no obvious thecal sculpture in the specimens from other localities.

Besides, in the specimens from the type locality the cell having direct contact between

Po and 1' and the one lacking it were observed; the latter was more common than the former (Balech 1989). Such variation in the Po and 1' contact was also shown in the specimens from South Australia (Hallegraeff *et al.* 1988), coastal Tyrrhenian waters (Montresor *et al.* 1990) and Adriatic Sea (Honsell 1993). In my specimens, however, the 1' always made direct contact with the Po, although nearly fifty cells obtained mainly in spring and summer of several years were dissected.

Su *et al.* (1989) and Su and Chiang (1991) reported a small-sized toxic dinoflagellate from southern Taiwan as *A. tamarensis* (Lebour) Balech. However, the organism shown by them possesses smaller size (14–34 μm

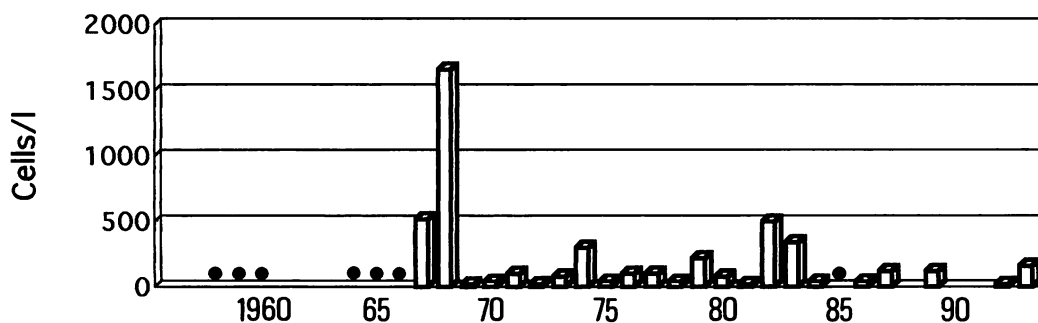


Fig. 14. Long-term changes in the maximal annual abundance of *Alexandrium minutum* in Matoya Bay. Closed circles denote the absence of data.

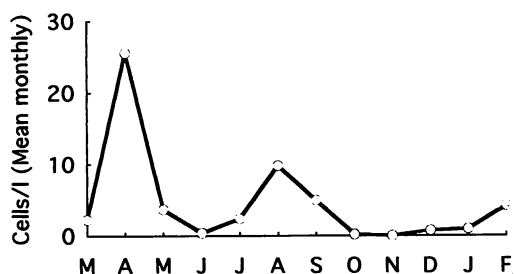


Fig. 15. Mean seasonal pattern of the abundance of *Alexandrium minutum* in Matoya Bay for the period 1967 to 1993 (excl. 1985).

long), the narrower precingular 6'' (Fig. 8 in Su *et al.* 1989, Fig. 31 in Su and Chiang 1991), a ventral pore which is more posteriorly situated (Fig. 8 in Su *et al.* 1989, Fig. 31 in Su and Chiang 1991), and the smaller and shorter S.p. (Fig. 9 in Su *et al.* 1989, Fig. 32 in Su and Chiang 1991) than *A. tamarense*. These characters are in satisfactory agreement with those of *A. minutum*. In addition, the resting cyst (about 22 µm) of their organism (Fig. 12 in Su *et al.* 1989, Fig. 34 in Su and Chiang 1991) is much smaller than that of *A. tamarense* (38–56 µm in Fukuyo *et al.* 1985) and is similar to that of *A. minutum* (24–29 µm) described by Bolch *et al.* (1991). I therefore consider that Su *et al.* (1989) and Su and Chiang's (1991) specimens are synonymous with *A. minutum*. In Japan no true *A. minutum* has been appeared in previous reports dealing with the morphology of *A. tamarense* and other allied species.

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結城勝久：本邦新産渦鞭毛藻 *Alexandrium minutum* Halim

三重県の矢湾とその周辺海域より得られた渦鞭毛藻 *Alexandrium minutum* Halim を記載した。細胞は長さ 20–26 μm 、幅 20–25 μm の球形で、第 1 頂板の右上辺部後方に腹孔を有し、前・後部接続孔を欠く。第 1 頂板は頂孔板に接する。鎧板配列は Po, 4', 6'', 6c, 10s, 5''', 2'''' と表示される。さらに、第 6 前帯板の幅が狭いことと、後縦溝板が短く、その両側部がほぼ平行な点も本種の識別上、重要である。下殻の表面には稀に粗い網目模様が見られる。連鎖群体は形成されない。本種は温帯沿岸域に広く分布し、麻痺性貝毒の原因生物として知られるが、本邦からの出現報告はこれが初めてである。的矢湾では、本種は 1960 年代後半以降、ほとんど毎年、低密度ながら散在的に出現している。(517-02 三重県志摩郡磯部町の矢 的矢湾養殖研究所)

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