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## Unarmoured dinoflagellates collected during the cruise of the r/v *Oceania* to the European Arctic, in June–August 1992 and 1993

**ABSTRACT:** Phytoplankton samples were collected at 141 stations in the Norwegian, Greenland, Barents and Baltic seas, in July–August 1992 and July–August 1993. In fifteen of these stations 22 unarmoured dinoflagellate species from the order Gymnodiniales belonging to the genera *Amphidinium*, *Cochlodinium*, *Gymnodinium*, *Gyrodinium*, *Torodinium* and *Polykrikos* have been found. Data on 16 species are given here, including synonyms, size or size variation, localities and environmental factors (temperature and salinity at the surface). 14 species are illustrated.

**Key words:** Arctic, Norwegian, Greenland, Barents seas, phytoplankton, Dinoflagellata, Gymnodiniales, taxonomy.

### Introduction

Unarmoured (naked) dinoflagellates are likely the least known group of marine phytoplankton, since studies on their morphology present a considerable challenge. Works with lists of phytoplankton species are more numerous than those containing data on their morphology or documented by drawings or micrographs. This statement concerns Arctic phytoplankton to a greater extent compared with that from southerly areas. About 60 unarmoured dinoflagellate species were recorded from the Arctic, 46 species representing the family Gymnodiniaceae (Okolodkov and Dodge, *in press*). Some data on naked dinoflagellates from the European Arctic collected on the *Oceania* cruises have been previously published (Okolodkov 1993, Wiktor and Okolodkov 1995). This paper is a continuation of publication of the materials collected during the Arctic cruises on board of the r/v *Oceania*.

## Material and methods

Phytoplankton was sampled at 74 stations in the period 26 July – 30 August 1992, and at 67 stations in the period 24 June – 30 July 1993, during the cruises of the *r/v Oceania* organized by the Institute of Oceanology, Polish Academy of Sciences, to the European Arctic. Oceanographic data on the stations where dinoflagellate species under discussion were collected are present in Table 1. The methods used and the map of stations' distribution are given by Okolodkov (1993). In the present article, primarily the data obtained when studying living cells of unarmoured dinoflagellates are presented.

Table 1

Data on stations distributed in the European Arctic and the North Sea, in June–August 1992 and 1993, mentioned in the text (literature and salinity are given for the surface or depth of 2 m).

Station code	Date	Sea	Latitude °N	Longitude °E	T °C	S‰
A18	06.08.92	Barents	75°33'	18°04'	8.00	–
B1	07.08.92	Barents	77°14'	22°18'	-0.06	32.75
B3	08.08.92	Barents	76°47'	17°22'	3.44	31.85
B5	08.08.92	Barents	75°48'	17°09'	3.84	31.64
B21	10.08.92	Greenland	77°16'	13°46'	3.78	32.90
C2	13.08.92	Greenland	76°30'	16°00'	2.75	33.31
C14	17.08.92	Greenland	74°30'	17°00'	7.48	33.81
C23	21.08.92	Norwegian	71°30'	15°00'	9.86	34.63
C25	22.08.92	Norwegian	70°30'	15°00'	10.77	34.94
D1	22.08.92	Norwegian	69°30'	14°08'	11.20	–
D2	23.08.92	Norwegian	68°06'	11°54'	12.50	–
D6	24.08.92	Norwegian	63°06'	05°18'	12.00	–
A8	28.06.93	Norwegian	64°41'	06°55'	10.40	–
A9	28.06.93	Norwegian	65°13'	07°29'	10.40	–
D9	26.07.93	North	59°34'	03°03'	13.80	–

– no data.

## Results

Twenty-two unarmoured dinoflagellate species belonging to the order Gymnodiniales have been found in plankton samples collected during the *r/v Oceania* cruise in Kattegat, the North, Norwegian, Greenland and Barents seas in 1992 and 1993. Six species are new and described in another source (Okolodkov, *in press*). The new species are: *Gymnodinium acutiusculum*, *G. galeiformis*, *G.*

*nucaceum*, *G. obliquum*, *G. ovoideum* and *Gyrodinium oecaniae*. The remaining 16 species are treated here, and 14 of them are illustrated by line drawings.

Family **Gymnodiniaceae**

Genus *Amphidinium* Claparède et Lachmann

*Amphidinium* cf. *fusiforme* Martin

(Plate 1, Fig. 1)

Martin 1929, p. 556, figs. 4–11.

Size: 17–31 µm long, 8–14 µm wide.

**Distribution.** — Observed at St. B3 in 1992, rare. *A. fusiforme* was described from brackish waters of New Jersey, USA. In addition, it was recorded from the Chukchi Sea, at Point Barrow.

*Amphidinium* cf. *carterae* Hulburt

(Plate 1, Fig. 2)

Hulburt 1957, p. 199, pl. 1, fig. 1.

Size: 29 µm long, 23 µm wide.

**Distribution.** — A single cell observed at St. D2 in 1992. *A. carterae* was reported from many parts of the world.

**Note.** — *A. carterae* can be confused with *A. operculatum* Claparède et Lachmann 1858–1859, because the arrangement of the chloroplasts is the only difference between the two species. Unfortunately, in our specimen the chloroplasts were not satisfactorily studied.

*Amphidinium sphenoides* Wulff

(Plate 1, Fig. 3a–c)

Wulff 1916, p. 105, pl. 1, fig. 9a, b.

Size: 39–45 µm long, 12–15 µm wide.

**Distribution.** — Found as Sts. B1, B5 and B21 in 1992, rare. The species was recorded from the Arctic, North Atlantic, North and Equatorial Pacific.

**Note.** — The species was identified in the fixed sample.

Genus: *Cochlodinium* Schütt

*Cochlodinium helix* (Pouchet) Lemmermann

(Plate 1, Fig. 4a, b)

Lemmermann 1899, p. 360.

Syn. : *Gymnodinium helix* Pouchet 1887, p. 94, fig. 1.

*G. helix* Schütt 1885, pl. 22, fig. 77 (1–4).

Size: 44 µm long, 37 µm wide, 28 µm deep.

**Distribution.** — Two cells occurred at St. C14 in 1992. The species was recorded from the North Pacific, Adriatic Sea and from the waters near the eastern coast of Australia.

Genus: *Gymnodinium* Stein  
*Gymnodinium elongatum* Hope  
(Plate 1, Fig. 5)

Hope 1954, p. 152, fig. 1a, b.  
Size: 25  $\mu\text{m}$  long, 9  $\mu\text{m}$  wide.

Distribution. — Recorded from St. D9 in 1993, rare. Known from the Norwegian Sea and Kattegat.

*Gymnodinium gracile* Bergh  
(Plate 1, Fig. 6)

Bergh 1881, p. 251, pl. 16, figs. 68, 69.  
Size: 80  $\mu\text{m}$  long, 35  $\mu\text{m}$  wide.

Distribution. — A single cell found at St. D6 in 1992. Known from Kattegat.

*Gymnodinium* cf. *heterostriatum* Kofoid et Swezy  
(Plate 1, Fig. 7)

Kofoid et Swezy 1921, p. 221, fig. Y, 7, pl. 2, fig. 24, pl. 5, fig. 56.  
Syn. : *G. spirale* var. *obtusum* Dogiel, 1906, p. 38, pl. 2, figs. 50–56.  
? *G. rhomboides* Schütt in Lebour, 1917, p. 190–192, fig. 6a, b.  
? *G. rhomboides* Schütt in Lebour, 1925, p. 47–48, pl. 6, fig. 1a–c.  
Size: 40–48  $\mu\text{m}$  long, 33–42  $\mu\text{m}$  wide.

Distribution. — Recorded from St. D1 in 1992, rare. Known from the English Channel, Mediterranean and North Pacific, near California.

Note. — *G. heterostriatum* is probably conspecific with *G. rhomboides* Schütt, 1895 (Dodge 1985). Our specimens have a nucleus in the epicone, and a large food vacuole in the hypocone. Their longitudinal striation is distinguishable only on the epicone.

*Gymnodinium* cf. *regulare* van Meel  
(Plate 1, Fig. 8)

van Meel 1969, p. 9, pl. 2, fig. H.  
Size: 27  $\mu\text{m}$  long, 20  $\mu\text{m}$  wide.

Distribution. — A single cell found at St. A9 in 1993. The species was described from the brackish waters of the Belgian coast.

Note. — Our specimen is very similar to the description of *G. regulare* given by Van Meel (1969), although the latter presents a cell in dorsal view, so the sulcus was not observed. It is one of the numerous species unsatisfactorily described.

Genus: *Gyrodinium* Kofoid *et* Swezy  
*Gyrodinium* cf. *aureolum* Hulburt  
(Plate 2, Fig. 1)

Hulburt 1957, p. 209–210, pl. 2, figs. 8, 9.

Size: 26–30  $\mu\text{m}$  long, 24–28  $\mu\text{m}$  wide, 21–24  $\mu\text{m}$  deep.

**Distribution.** — Identified reliably from St. C25. Recorded from the North Atlantic.

**Remarks.** — *G. aureolum* is probably conspecific with *Gymnodinium mikimotoi* Miyake *et* Kominami ex Oda, 1935 (syn.: *Gymnodinium nagasakiense* Takayama *et* Adachi, 1984). The taxonomy, ecology and distribution of *Gyrodinium* cf. *aureolum*, along with about ten other species, is discussed by Partensky and Sourmia (1986). Our specimens are characterized by sulcus not reaching the apex (like in Hulburt's (1957) description of *Gyrodinium aureolum*) and the presence of yellow-brown pyrenoid at the posterior end of the cell (pyrenoid was not mentioned by Hulburt). Cell dorsoventrally flattened. Chloroplasts numerous, yellow-brown, slightly elongated.

*Gyrodinium crassum* (Pouchet) Kofoid *et* Swezy  
(Plate 2, Fig. 2a, b)

Kofoid *et* Swezy, 1921, p. 294, fig. CC21.

Syn.: *Gymnodinium crassum* Pouchet 1885, p. 66, pl. 4, fig. 28.

*Spirodinium crassum* Lemmermann 1899, p. 359.

Size: 80–90  $\mu\text{m}$  long, 50–60  $\mu\text{m}$  wide.

**Distribution.** — Two cells occurred at Sts. A8 and A9 in 1993. Known from the Arctic, the waters near Spitsbergen, the North Atlantic and Mediterranean.

*G. glaucum* (Lebour) Kofoid *et* Swezy  
(Plate 2, Fig. 3a–c)

Kofoid *et* Swezy 1921, p. 308–309, fig. DD16, pl. 9, fig. 94.

Syn.: *Spirodinium glaucum* Lebour 1917, p. 196–197, fig. 13 a–f.

*Massartia glauca* (Lebour) Schiller 1933, p. 436, fig. 46a–c.

*Katodinium glaucum* (Lebour) Loeblich III 1965, p. 15.

Size: 27–33  $\mu\text{m}$  long, 14–18  $\mu\text{m}$  wide.

**Distribution.** — Occurred at Sts. B1 and B3 in 1992. Recorded from the English Channel, Kattegat, near the coast of Portugal, Adriatic, the North Sea, Sea of Japan, U.S. coast near California and in the Woods Hole area.

**Note.** — All cells were measured in the fixed samples, so the dimensions are distorted, in particular, the width. The length is in accordance with the data presented by Hulburt (1957) from the Woods Hole area (28–32  $\mu\text{m}$ ).

*Gyrodinium grave* (Meunier) Kofoid *et* Swezy  
(Plate 2, Fig. 4a, b)

Kofoid *et* Swezy 1921, p. 309.

Syn.: *Spirodinium grave* Meunier 1910, p. 64, pl. 14, figs. 27, 28.

Size: 24 µm long, 17 µm wide.

**Distribution.** — A single cell observed at St. C25 in 1992. The species was described from the Arctic, off Novaya Zemlya.

*Gyrodinium lachryma* (Meunier) Kofoid *et* Swezy  
(Plate 2, Fig. 5)

Kofoid *et* Swezy 1921, p. 314, fig. EE6.

Syn.: *Spirodinium lachryma* Meunier 1910, pl. 14, figs. 21, 22.

Size: 63 µm long, 26 µm wide.

**Distribution.** — A single cell found at St. A18 in 1992. The species was recorded from the Arctic, North and South Atlantic, Adriatic and Black seas, the Sea of Okhotsk and the Antarctic.

*Gyrodinium cf. pepo* (Schütt) Kofoid *et* Swezy  
(Plate 2, Fig. 6)

Kofoid *et* Swezy 1921, p. 326, fig. DD2.

Syn.: *Gymnodinium spirale* var. *pepo* Schütt 1895, p. 112, fig. 69.

Size: 44 µm long, 45 µm wide, 40 µm deep.

**Distribution.** — A single cell found at St. C2 in 1992. Known from the North Atlantic and Mediterranean.

**Note.** — Our specimen resembles *C. cf. pepo* in Hansen and Larsen (1992) (figs. 4.42a–f, 4.43a) rather than is close to the descriptions and figures given by Kofoid and Swezy (1921) or Dodge (1985), therefore its identification to the specific level is doubtful.

Genus *Torodinium* Kofoid *et* Swezy  
*Torodinium cf. robustum* Kofoid *et* Swezy

Kofoid *et* Swezy 1921, p. 391, figs. II, 1–3, pl. 4, fig. 49.

Size: 84 µm long, 26 µm wide.

**Distribution.** — A single cell occurred at St. A18 in 1992. *T. robustum* is known from the Canadian Arctic, North Arctic, Adriatic and Black seas, South Atlantic and South Pacific, near the coast of South America.

**Note.** — The species was identified in the fixed sample. The longitudinal striation was still seen

**Family Polykrikaceae**  
**Genus *Polykrikos* Bütschli**  
***Polykrikos* cf. *schwartzii* Bütschli**

Bütschli 1873, p. 673, pl. 26, fig. 22.

Size: 106 µm long, 50 µm wide.

**Distribution.** — A colony, not considering individual nematocysts, was found at St. C23 in 1992. *P. schwartzii* was recorded from the North Atlantic, from the western coast of Africa to Scotland and Iceland, the Mediterranean and Black seas, the North Sea, Skagerrak and Kattegat, the western Baltic Sea, Arabic Sea, the Indian Ocean near Madagascar, the seas of Japan and Okhotsk, near California, near the eastern coast of Australia, and the coast of Peru. It seems to be a tropical-boreal species.

**Remarks.** — Colony composed of 4 zooids has 2 nuclei 15 to 18 µm in diameter. Individual zooids are not clearly demarcated, which is characteristic of *P. schwartzii*, but the surface bears the longitudinal ridging peculiar for *P. kofoidii* Chatton, 1914 (Dodge 1985), although the ridging is not so pronounced. Kofoid and Swezy (1921) state that the surface of the hypocone is deeply ribbed in *P. kofoidii*, and smooth in *P. schwartzii*. The barrel-shaped colony is closer to *P. beauchampii* (Chatton) Loeblich III, 1980 illustrated by Dodge (1985), however *P. beauchampii* is characterized by the same number of nuclei as zooids. Nematocysts 16–18 µm long and 5–6 µm wide. Records of peculiar cysts with ridges from the neighbouring stations indirectly testify that the colony examined belongs to *P. schwartzii* rather than to *P. kofoidii*.

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## Streszczenie

W 15 próbach fitoplanktonu (tab. 1) zebranych w czasie trwania dwóch arktycznych rejsów *r/v Oceania* stwierdzono 22 gatunki nieopancerzonych bruzdnic (Dinoflagellata). Sześć spośród tych gatunków okazało się nowymi dla nauki; są one opisane w odrębnej pracy (Okolodkov, *w druku*). Pozostałych 16 gatunków zostało omówionych w niniejszej publikacji, spośród nich 14 przedstawiono na rysunkach.

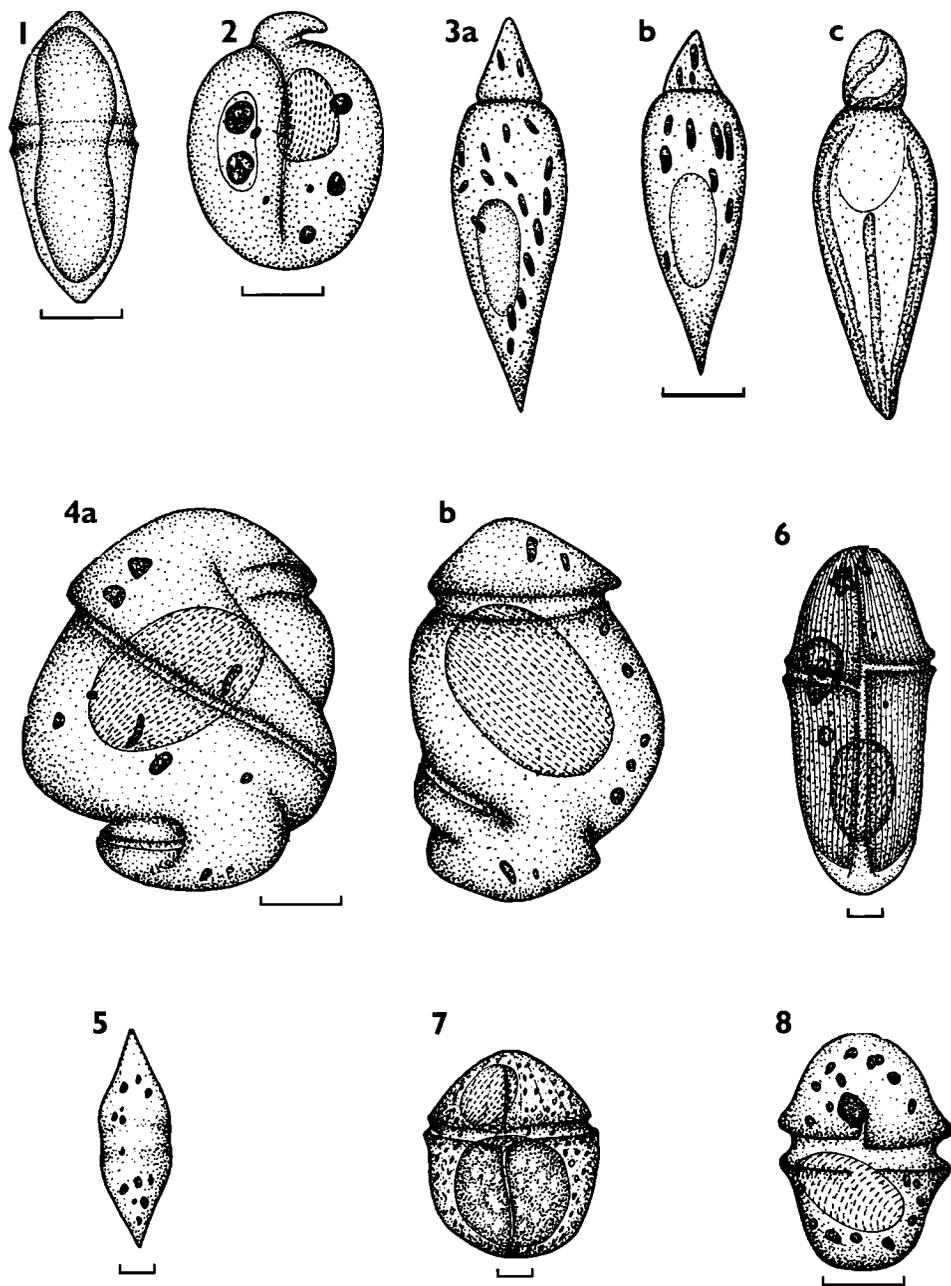


Fig. 1-8. Morphology of dinoflagellates of the genera *Amphidinium*, *Cochlodinium* and *Gymnodinium* (scale bar 10  $\mu\text{m}$ ):

1 - *Amphidinium* cf. *fusiforme*, 2 - *Amphidinium* cf. *carterae*, 3a-c - *Amphidinium* *sphenoides* (in fixed sample), 4a, b - *Cochlodinium* *helix* (a - ventral view, b - left side view), 5 - *Gymnodinium* *elongatum*, 6 - *Gymnodinium* *gracile*, 7 - *Gymnodinium* cf. *heterostratum*, 8 - *Gymnodinium* cf. *regulare*.

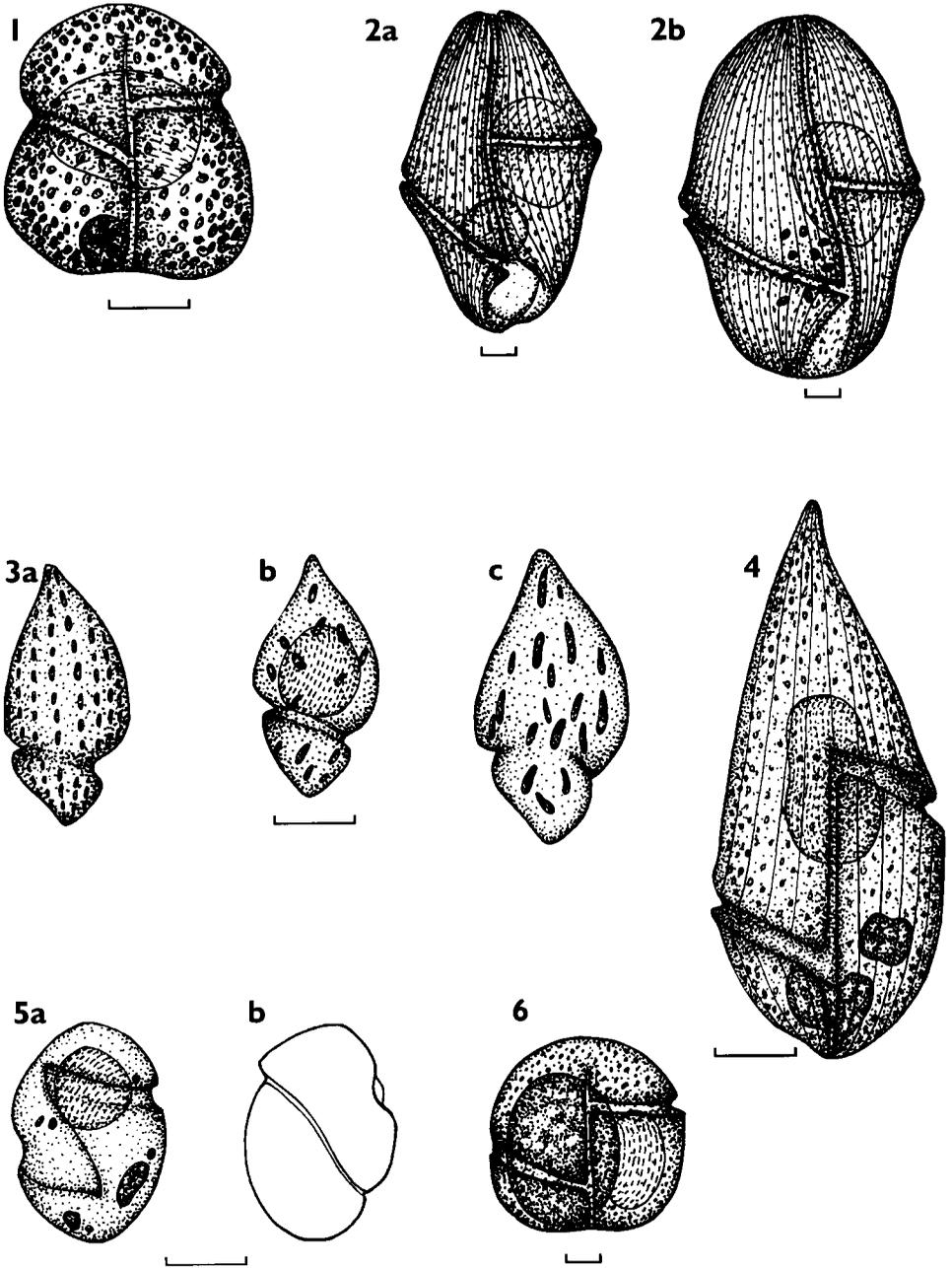


Fig. 1-6. Morphology of dinoflagellates of the genus *Gyrodinium* (scale bar 10  $\mu$ m):  
 9 - *Gyrodinium* cf. *aureolum*, 10a, b - *Gyrodinium* *crassum*, 11a-c - *Gyrodinium* *glaucum* (in  
 fixed sample), 12a, b - *Gyrodinium* *grave* (a - ventral view, b - right side view), 13 - *Gyrodinium*  
 cf. *pepo*.