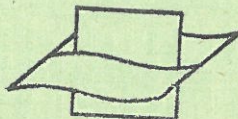


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**Resting spores in *Goniaulax polyedra* Stein.**

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Særtrykk av  
Nytt Magasin for Naturvidenskapene  
B. 88



**Visser's Instituut voor de Zee**  
*Flanders Marine Institute*

**Oslo 1951**



# Resting spores in *Goniaulax polyedra* Stein.

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(With 3 Figures)

In dinoflagellates, resting spores have been difficult to identify, as the flagellates, when cysts are formed, lose their sculptured thecae, which are of such importance for classification.

The connection between the motile dinoflagellates and their immotile cysts may be ascertained through culture experiments. In natural populations it may also be proved by means of stages exhibiting both the characters of the motile organism and those of the cyst as well. Such a case is being described below.

In plankton samples from the Oslo fjord at Drøbak, September 1950, cyst formation was observed in *Goniaulax polyedra* Stein. The majority of cysts gave no other indication of their origin than their synchronic occurrence with the organism, while a few were enveloped by the characteristic epitheca of *Goniaulax polyedra*. The identity of the cysts was, therefore, clearly demonstrated. (Fig. 1, d).

The cyst is sphaeroid and is a darker brown than the motile stage of *Goniaulax polyedra*. Its diameter is mostly 40–46  $\mu$ , a few specimens only of 36  $\mu$  (the smallest diameter in an egg-shaped cyst) and some of 54  $\mu$  were observed. According to Kofoed (1911) the diameter of motile cells in natural populations varies between 43  $\mu$  and 54  $\mu$ . In cultures, we have observed variation in size as 1 : 2, the largest cells corresponding to the largest in natural populations. The wall of the cyst is set with spines of a rather variable shape. Their length varies from a few  $\mu$  to half the diameter of the cyst. Short spines are mostly cylindrical, some times with a swollen vesicle at the top. The long spines are pointed. Several types of spines may occur on the same cyst

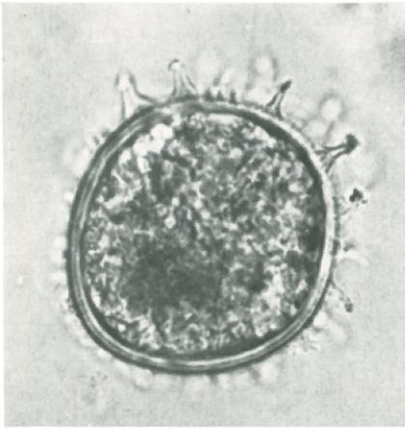
(fig. 1. e), the spines probably developing after the breaking up of the original theca. The fact that free cysts, and cysts with epitheca retained may have exclusively quite short spines or vesicles, support this assumption. (Figs. 1, a, c and f).

Cysts with crooked spines were also observed, but these may have been produced secondarily by some mechanical effect (Fig. 1 b).

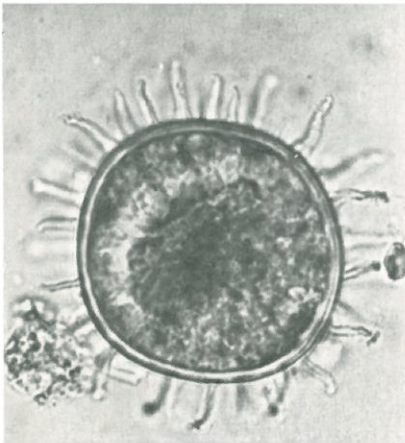
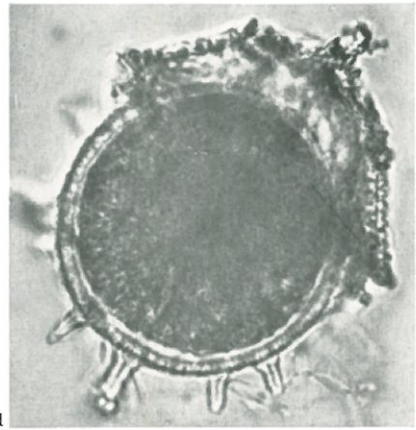
The cysts were observed at a time when the plankton of the Drøbak sound for at least a fortnight had been dominated by large population of *Goniaulax polyedra* and *Ceratium furca*, the sea within the whole sound being coloured reddish-brown («red water»). This was first observed on September 6th, 1950, during the weekly survey of the plankton at this locality. 10 ml of the surface water, preserved with formalin showed the following population:

<i>Chaetoceros curvisetus</i>	12	<i>Glenodinium</i> sp.	6
<i>Leptocylindrus danicus</i>	15	<i>Goniaulax polyedra</i>	1592
<i>Rhizosolenia</i> sp.	2	<i>Peridinium</i> sp.	62
<i>Synedra</i> sp.	6	<i>Prorocentrum micans</i>	303
<i>Ceratium furca</i>	1710	<i>Phalacroma</i> sp.	1
» <i>fuscus</i>	38	<i>Ciliata</i>	16
» <i>tripos</i>	2	<i>Rotatoria</i>	23
<i>Dinophysis</i> sp.	13	<i>Nauplii</i>	5

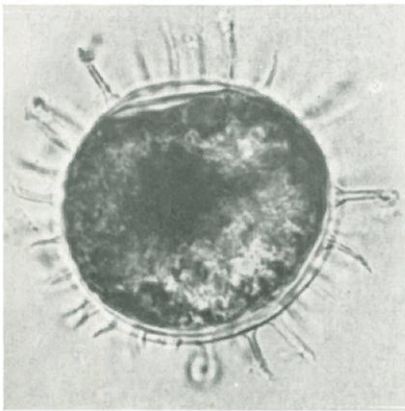
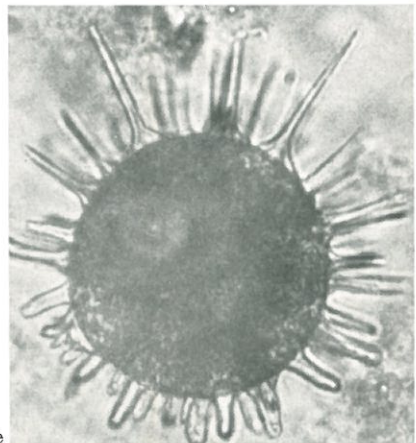
*Ceratium furca* with 171 000 cells per liter and *Goniaulax polyedra* with 159 200 per liter formed the main components of the population, while *Prorocentrum micans* also was numerous. A week later, when the first cysts were observed, the plankton had a similar composition, the populations of *Ceratium furca* and *Goniaulax polyedra* having declined to about 50 000 and 60 000 per liter respectively. The following week (September 20th), the plankton was somewhat richer in species, *Ceratium furca*, *Prorocentrum micans* and *Goniaulax polyedra* still being the predominant species. The cysts were again encountered in considerable numbers on October 4th, while a week later, (Oct. 11th), only one single cyst was observed. In the weekly samples during the remainder of October no cysts were found, while on November 1th neither cysts nor motile stages were observed. Figu-



a d



b e



c f

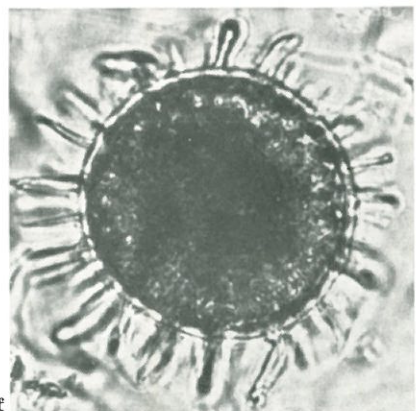


Fig. 1. Cysts of *Goniaulax polyedra*. a. with few short spines b. with crooked spines, c. with thin spines, d. with epitheca retained, e. with different types of spines, f. with relatively thick spines. ( $\times 870$ ).



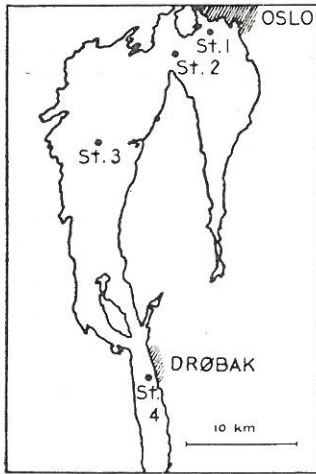


Fig. 2.

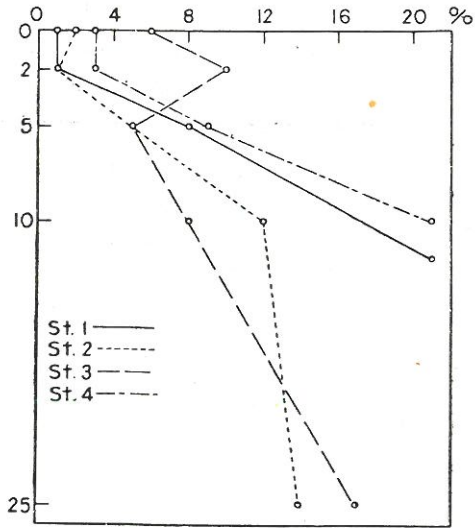


Fig. 3.

Fig. 2. Inner Oslo fjord with the four localities of observation.  
 Fig. 3. Diagram showing the percentage distribution of cysts at the four different stations. (Depts in metres.)

res for the relative abundance of motile cells and cysts at the surface are given in table 1.

In order to compare the occurrence of *Goniaulax polyedra* and its cysts in Drøbak sound and in the innermost part of the fjord, a series of samples were collected on September 26th. At the following stations: Oslo harbour (St. 1), between Nesodden and Huk (st. 2), the West fjord off Steilene (St. 3) and the Drøbak sound (st. 4). 1 liter water samples were collected from the depths

Table 1.

Percentage of cysts in surface net samples at St. 4.

	9/9	13/9	20/9	Sum	26/9	4/10	Sum
Motile cells	1592	1522	151	270	421	702	94
Cysts	0	15	18	17	35	45	8
Sum	1592	1537			456	747	
% of cysts	0	1			8	6	10

Table 2.  
*Motile cells and cystes in sedimentation samples.*  
 26. september 1950.

Depth in m	Salinity, ‰	Tempe- rature, °C	10 ml		50 ml		Sum	Cysts, ‰
			Motile stages	Cysts	Motile stages	Cysts		
<i>Station 1.</i>								
0	19,46	13,40	1215 <sup>1</sup>	8 <sup>1</sup>			1223	1
2		13,75	470	7			477	1
5		13,80	40	8				
					193	17	210	8
12		9,41	2	0				
					11	3	14	21
<i>Station 2.</i>								
0	18,64	13,20	506	9			515	2
2		13,66	438	6			444	1
5		12,83	57	3				
					255	15	270	5
10		11,89	21	2				
					97	13	110	12
25		9,17	8	1				
					32	5	27	14
40		7,23	Sample too turbid					
<i>Station 3.</i>								
0	18,11	13,10	306	18			324	6
2		13,51	267	29			296	10
5		13,66	229	12			241	5
			34	4				
10		12,33						
					158	13	171	8
25		12,01	10	2				
					39	8	47	17
40		7,06	3	1				
					7	1	8	
75		7,36	1	0	2	1	3	
<i>Station 4.</i>								
0	17,70	12,90	465	13			478	3
2		13,59	389	10			399	3
5		14,65	79	7				
					344	33	377	9
10		15,21	14	3	(turbid	sample)	17	21
25		15,07	5	1				
					29	1	30	
40		15,21	3	0				
					12	0	12	
75		12,01	1	0				
					8	1	9	

0, 2, 5, 10, 25, 40 and 75 m. The samples were examined for their content of *Goniaulax polyedra* and cysts. The distribution of motile cells and of cysts are shown in table 2, where also the percentage of cysts at each depth is given. A diagram of the relative distribution of motile cells and cysts with depth at the four stations is shown in fig. 3.

The percentage of cysts increases with increasing depth. Below the thermocline they are extremely scarce and percentage figures are therefore not given for these depths.

The figure demonstrates how the percentage of cysts increases with depth at all stations.

Although no actual observations on the *Goniaulax* population in the inner fjord previous to this cruise are available, recent surveys of the phytoplankton of the inner Oslo fjord have recorded mass occurrence of *Goniaulax polyedra* (Hasle 1949). There is good reason for assuming that also in the inner part of the fjord cyst formation, in accordance with what has been described above for the Drøbak sound, has taken place after a period of mass occurrence of the species.

In samples of marine plankton cysts are often encountered which are not easily identified or even classified to group. Some of them have been assumed to be stages of dinoflagellates, but we know very little of the connection between dinoflagellates and their cysts. (Schiller 1933).

The cysts described above resemble the organisms referred to *Trochischia* Kütz. (syn. *Xanthidium* Ehrbg.), which seems to be rather heterogeneous. Lohmann (1904) assumed that most of the *Trochischia*'s were copepod eggs and demonstrated this for one species by hatching nauplii. This species Lohmann referred to *Xanthidium hystrix* Cleve, which Cleve (1900) himself considered to be »probably a stage in the development of some dinoflagellate«. Cleve's diagnosis is, however, not so detailed that the possibility

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<sup>1</sup> Figures from net sample. Number of cysts possibly too high. A comparison between the percentages for the surface layers in table 2, st. 4 and the net haul figures in table 1 for the same locality shows a discrepancy. The cause is probably that the spiny cysts may more easily be caught in the net than the motile stages of the species.

of confusion may be excluded. The collective genus *Trochischia* probably includes organisms of very different origin, in spite of the similarity in shape.

By culturing *Protoceratum reticulatum*, Braarud (1945) has shown that this dinoflagellate forms cysts with spines, not unlike those of *Goniaulax polyedra*. In cultures of *Goniaulax polyedra* we have, however, not yet observed normal cysts of the type occurring in the Oslo fjord. Kofoid (1911) does not mention cyst formation in his study of *Goniaulax polyedra*.

### Summary.

Cyst formation in *Goniaulax polyedra* Stein is described from the Drøbak sound, Oslo fjord, September 1950. It occurred after a period of mass occurrence of the species together with *Ceratium furca* and *Prorocentrum micans*. The depth distribution of motile stages and cysts at four stations in the inner Oslo fjord is described, the percentage of cysts showing an increase from the surface downwards. At 40 and 75 m cysts as well as motile stages were very scarce. The resemblance of the cysts with species of the dubious genus *Trochischia* Kütz. is discussed.

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