

**The size structure
of the *Mesodinium*
rubrum population
in the Gdańsk Basin**

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Abstract

The ciliate *Mesodinium rubrum* Lohmann 1908 (= *Myrionecta rubra* Jankowski 1976) is an important phototrophic organism in the Gdańsk Basin. In June 2002 the vertical distribution and size structure of the *M. rubrum* population were studied. Its presence was generally observed in the whole water column (one exception was the anoxic near-bottom zone in the Gdańsk Deep) at all stations studied. Maximum abundance (18 300 cells dm^{-3}) was recorded at 26 m depth at the station located in the inner Gulf of Gdańsk. Analysis of the size structure of the counted organisms demonstrated the co-existence of small and large cells of *M. rubrum* in the upper layer of the water column and a gradual increase with depth of the prevalence of large specimens. This shows that at least two forms of *M. rubrum* exist in the region studied. Deep migrations are probably undertaken only by relatively large organisms.

For many years the common marine ciliate *Mesodinium rubrum* Lohmann 1908 (= *Myrionecta rubra* Jankowski 1976) has astonished researchers with its unique symbiosis with cryptophytes (Lindholm 1985, Crawford 1989, Gustafson et al. 2000). This species complex is an important phototrophic organism in the marine environment (Crawford 1989). In the Gdańsk Basin it makes up on average 6–9% of the annual biomass of phototrophs (Witek 1998). *M. rubrum* is also known for its migrations in search of nutrients to deeper parts of the water column below the euphotic zone. Migrating organisms usually descend no deeper than 30 m (Olli

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1999). However, research carried out in the Gotland Deep by Passow (1991) revealed that a fraction of the *M. rubrum* population in the water column was located below 30 m and did not demonstrate diurnal migration. Samples were taken to a depth of 60 m and the presence of this organism was recorded everywhere. In addition, as mentioned by Lindholm (1985), *M. rubrum*'s presence in the Baltic Sea at 100 m was noted by Leegaard in 1912. Similar observations were also reported in the Gdańsk Basin (Witek 1998).

Previously conducted observations in the Gdańsk Basin (Witek 1998) demonstrated a seasonal change in the size of *M. rubrum*. The ciliates could be grouped into two main size classes: 12.5–16 μm and 25–32 μm . In the second half of the year, smaller organisms outnumbered the larger ones. Consequently, Witek (1998) proposed the hypothesis that in the second part of the year, the larger organisms are grazed more intensively than small *M. rubrum* specimens.

The present paper analyses the vertical distribution and size structure of *M. rubrum* observed at various depths.

Sampling was carried out during a cruise on r/v 'Baltica' in June 2002 at five stations located (Fig. 1.) in different parts of the Gdańsk Basin (Baltic Sea). Water was taken between 10 and 12 a.m. from discrete levels covering the whole water column. Samples were collected with Niskin bottles and preserved with acidic Lugol solution (Edler 1979) at a final concentration of 0.5%. The abundance and biomass of *M. rubrum* were analysed under an inverted microscope (Utermöhl 1931). Usually more than 100 cells were counted. In samples with a low *M. rubrum* abundance, the pool was smaller, but no less than 30 specimens were counted. The shapes of the organisms were approximated to a sphere and volumes were converted to carbon units by means of the factor 110 fgC μm^{-3} (Edler 1979). Simultaneously, nutrient concentrations were measured with colorimetric methods (Grasshoff et al. 1983). Oxygen concentrations were established by the Winkler method.

M. rubrum was found to be present at all the stations visited. Vertical profiles of *M. rubrum* abundance are presented in Fig. 2. At G2 and P110 maximum abundances were recorded in the surface layers (0–10 m) – 5100 cells dm^{-3} and 6050 cells dm^{-3} respectively, whereas at station P63 (the farthest out in the open sea), the maximum abundance (7960 cells dm^{-3}) was encountered at 20 m depth. At these three relatively deep stations the abundance of *M. rubrum* decreased below 40 m. However, with the exception of the anoxic near-bottom zone in the Gdańsk Deep (station G2), the presence of *M. rubrum* was observed in the whole water column. Low oxygen conditions (above the bottom at station G2 the oxygen concentration was 0.00 $\text{cm}^3 \text{O}_2 \text{dm}^{-3}$) delimit the occurrence of *M. rubrum* (Lindholm 1985). At station E52a (located near the mouth of the river

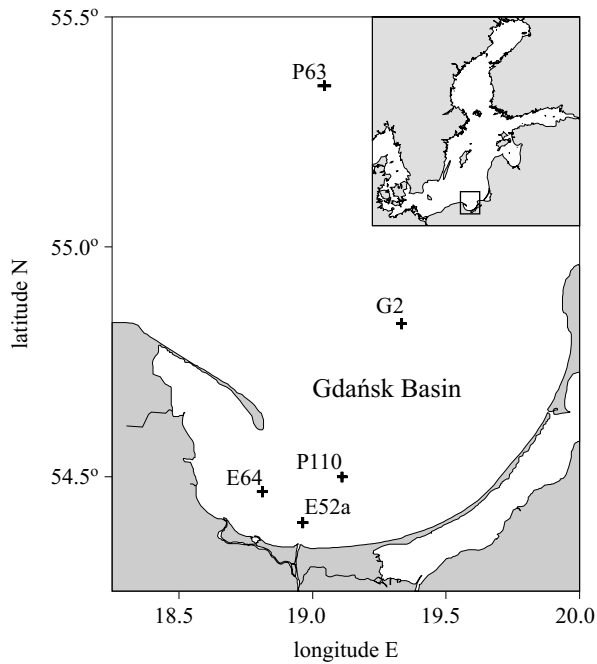


Fig. 1. Gdańsk Basin (Baltic Sea). Location of sampling stations

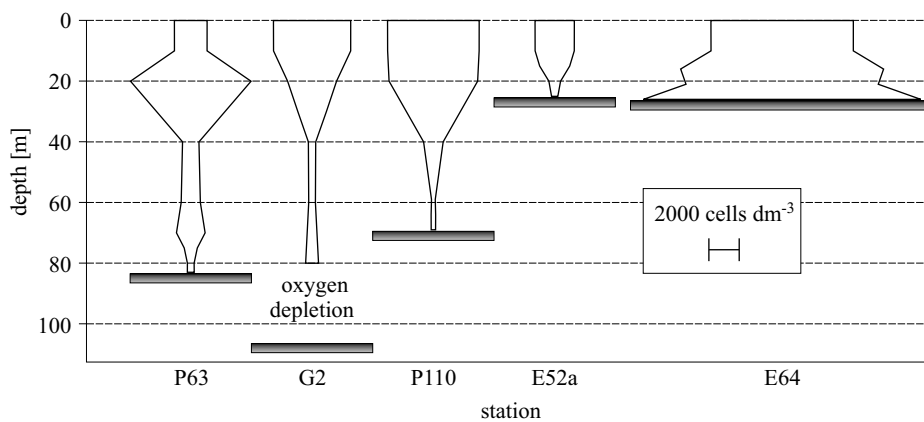


Fig. 2. Vertical distributions of *Mesodinium rubrum* abundance at 5 stations in the Gdańsk Basin. The width of the diagrams at particular depths correspond to the abundance of *M. rubrum*. The scale bar is presented in the figure

Vistula) the maximum abundance of these ciliates was observed in the 0–10 m layer ($2600 \text{ cells dm}^{-3}$). At this station abundance decreased with depth. In contrast, the abundance of *M. rubrum* at station E64 (inner Gdańsk Basin) increased with depth and reached a maximum

(18 300 cells dm^{-3}) just above the bottom at 26 m. Simultaneously, the highest abundance of these organisms was noted at this station. In general, the observed abundances were not high enough to cause water discoloration (McAlicie 1968). The vertical distribution of *M. rubrum* is governed mainly by light conditions and the availability of nutrients (Passow 1991, Olli & Seppälä 2001). At stations G2, P110 and E52a *M. rubrum* abundance decreased with depth. It is suggested that these distributions were governed by light availability. A different situation was observed at P63, where the abundance peaked at 20 m. At station E64 *M. rubrum* also preferred greater depths. Identifying the factor responsible for such a situation is difficult because of the relatively small amount of data and the patchy distribution of nutrients. Vertical profiles of temperature, salinity and NH_3 , NO_2 , NO_3 , PO_4 concentrations all varied, and did not explain the vertical distributions of *M. rubrum*.

Specimens observed in the near-bottom zone at stations P63 (83 m) and P110 (69 m) were in a good state after preservation and were almost certainly alive before fixation. *M. rubrum* can survive several weeks without conducting photosynthesis at a temperature of 4°C (in this research the temperature was $3\text{--}5^\circ\text{C}$) (Wistbacka 1982, Lindholm 1985). Near the bottom at deep stations (P63, P110), the respective *M. rubrum* abundances were 400 and 300 cells dm^{-3} . These values were roughly similar to the values recorded just below the euphotic zone at the shallow station E52a (450 dm^{-3}). These data did not allow me to show that this organism can migrate so deep and return to the euphotic zone. Two points speak in favour of this: *M. rubrum's* swimming ability (Lindholm 1985), and the distinct concentration of these organisms just above the oxygen-depleted area at 80 m at station G2. Due to the fact that only one profile was done at every station, the basis for describing migration patterns was insufficient. Also, because of this, the mechanism of formation of a distinct second abundance peak occurring at approx. 60 m at station P63 could not be explained.

The analysis of frequencies of specimens in particular size classes demonstrated the co-existence of small and large organisms in surface waters and the gradually increasing domination of large *M. rubrum* in deeper parts of the water column (Fig. 3). These tendencies are statistically significant (χ^2 test, Table 1). At stations G2 and E52a, two dominant size classes were distinguished: 15 μm and 25 μm . A more complicated situation was encountered at station P110, where between 0 and 10 m the size distribution was not clearly bimodal; above the bottom, however, the dominance of large (29 μm) organisms was obvious. A similar tendency was noted at

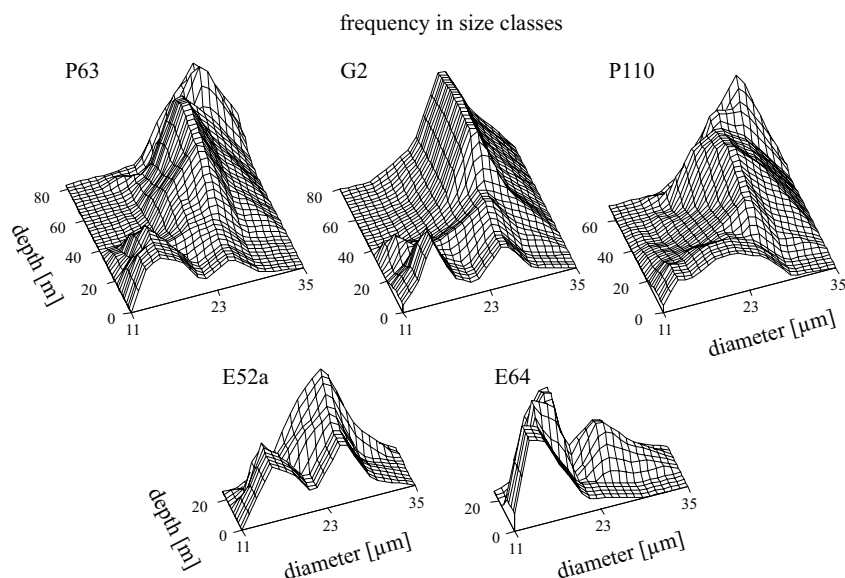


Fig. 3. Vertical profiles of *Mesodinium rubrum*'s frequency in size classes at 5 stations located in the Gdańsk Basin. Horizontal axis – size, vertical – depth, heights correspond with *M. rubrum*'s frequency [%] in size classes at particular depths

Table 1. The analysis of differences between the frequency distribution of *Mesodinium rubrum* in particular size classes in surface waters (0–10 m) and the near-bottom zone (at station G2 – the lowest level where *M. rubrum* was present – 80 m). The size classes had to be combined

Station	Degrees of freedom	χ^2	p
P63	1	44.1*	< 0.0001
G2	1	52.5*	< 0.0001
P110	1	47.0*	< 0.0001
E52a	1	11.9*	0.0006
E64	2	106.4	< 0.0001

* value χ^2 with Yates' correction.

stations P63 and E64. These observations indicate that at least two forms of *M. rubrum* exist in the region studied. Deep migrations are undertaken only by relatively large organisms (probably with better swimming abilities). However, this could be a result of grazing pressure, strongest in the euphotic layer, which causes the elimination mainly of larger specimens (Witek 1998).

Differences between particular forms of *M. rubrum* could be elucidated by the *in vitro* cultivation of *M. rubrum*, the isolation of particular forms and genetic analysis with the PCR (polymerase chain reaction) method.

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