

Isolation and characterization of Parmales and its dynamics in the Oyashio region, western North Pacific

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The order Parmales (Heterokonta) is a group of marine phytoplankton species with small solitary cells that are generally 2 to 5 micro-meter in diameter and surrounded by 5 to 8 silica plates. Since diatoms, which are the most successful groups of marine phytoplankton, are also composed of silica cell walls, Parmales has a possible close association with diatoms. Parmales may play a key role in the diatom evolution, to acquire silica synthesis and unique life cycle of diatoms. However, the relationship between Parmales and diatoms is unknown because there is no phylogenetic study due to lack of Parmales culture.

We successfully isolated and characterized a Parmales species, *Triparma laevis*, in the Oyashio region, the western North Pacific for the first time with the aid of a fluorescent silicon tracer. Molecular phylogenetic analyses of SSU rDNA and *rbcL* gene showed that our strain was within the bolidophycean clade of autotrophic naked flagellates and a sister group of diatoms. This indicates a close evolutionary relationship between Parmales, Bolidophyceae and diatoms. We can hypothesize that parmalean and bolidophycean algae or their common ancestor have a life cycle switching between silicified non-flagellated and naked flagellate stages. This hypothetical life cycle is similar to centric diatoms. Centric diatom species also have a silicified vegetative stage and produce naked flagellated male gametes (sperms).

It is important to elucidate similarity and difference between Parmales and diatoms for understanding the evolutionary relationship between these two algae. However, there is little ecological information about Parmales, such as seasonal variations and life cycles, while it is known that Parmales mainly distributes in polar and sub-polar waters. We investigated the seasonal variations of abundance and species composition of the Parmales assemblages in the Oyashio regions.

Samplings were conducted in the Oyashio region on March, May, July and October 2009. The samples for quantifying abundance of the Parmales assemblage were collected from seven depths at 0-100 m. On March and May, the water column was vertically mixed and water temperature was less than 10 degree centigrade at almost stations. Abundance of the Parmales assemblage was high at the stations where water temperature was less than 10 degree centigrade. On the other hands, the vertical stratification was evident between 10-40 m on July and October. Parmales was absent above pycnocline, being abundant in the subsurface layer of 30-50 m where water temperature was lower than 10 degree centigrade. Abundance of the Parmales assemblage on July and October was lower than that on March and May, as the decline of the abundance over pycnocline. Among the Parmales assemblage, *T. laevis* was almost dominant and the seasonal variation of the species composition was small. This characterized the Parmales assemblage compared to the diatom assemblage with clear seasonal succession. Our results showed that the Parmales assemblage, mainly composed of *T. laevis*, would grow in the surface layer in winter-spring and maintain its population under pycnocline in summer-winter. The population under pycnocline would play a role as the initial cells, so-called seed population, for the vegetative growth.

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