Carbon fixation by endosymbiotic algae within protistan microzooplankton

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Endosymbiosis with algae (photosymbiosis) is one of the styles of acquired phototrophy seen in marine protistan microozooplankton such as radiolarians and foraminifers. Although their biomass in the ocean is not so large, the number of cells of their symbiotic algae within one host organism (< ca. 500 μm) is well over a few thousands or even said to reach several tens of thousands. It means that the amount of photosynthesis mediated by their symbiotic systems might be “hot spots” of primary production especially in oligotrophic oceans. Of those photosymbiotic organisms, planktic foraminifers that precipitate calcite tests contribute to both inorganic carbon production by calcification, and organic carbon production via photosynthesis of their symbionts, which should be an important key player in the carbon cycle. However, compared to the famous photosymbiotic system found in coral reefs, the basic knowledge of photosymbiosis and the photosynthesis itself in pelagic microzooplankton are quite limited and have been overlooked.
Here, we performed ^{14}C-tracer experiment to estimate photosynthetic carbon-fixation rates (CFR) of the symbionts within planktic foraminifers, together with photophysiological measurement using an active fluorometry (fast repetition rate fluorometry, FRRF). The main purpose of this study is (1) to estimate the CFR of the symbionts under different light conditions, (2) to evaluate the photophysiology of the symbionts, and as a preliminary investigation, (3) to extrapolate the CFR information to field data to estimate the contribution of the symbiosis-related photosynthesis in oligotrophic oceans. The samples for the laboratory experiments were collected from Sagami Bay by surface plankton net towing. The target species was *Globigerinoides sacculifer* which has dinoflagellate symbionts. In the laboratory experiment, FRRF measurement was firstly performed on each individual under certain actinic light level (either of the three irradiance levels, 220, 150, 70 μmol photons m^{-2} s^{-1}). Right after the measurement, each specimen was transferred to a jar with $NaH^{14}CO_3$ and incubated for 1h, then radioactivity of the fixed organic carbon was measured with a liquid scintillation counter. The CFR was estimated accordingly. The field observation for the purpose (3) was conducted by R/V Shinsei-Maru in the subtropical Northwestern Pacific (KS-16-9). Vertically stratified samples were collected by VMPS towing. The standing stock, the species composition, and the size structure of the samples were analyzed.
The photophysiological parameters of the symbionts photosynthesis all demonstrated the healthy state of their photosynthetic system, indicating fine relationships between the host and the symbionts. The chlorophyll-based CFRs (median values) were 16.5, 18.2, and 9.1 mmol C (mol Chl)$^{-1}$ s^{-1} for 220, 150, 70 μmol photons m^{-2} s^{-1}, respectively. Using a size-chlorophyll relationship of the nominal species, the above results enable us to make an assumption of the CFR from the shell size of foraminiferal specimens as long as the information of the light environment of their habitat is available. In the presentation, we also show the rough estimation of the vertical structure of the symbiosis-related primary production in the studied site, their contribution, and insight of their importance in the oligotrophic ocean ecosystem.

Keywords: carbon fixation, photosymbiosis, microzooplankton, planktic foraminifers

