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Detecting algal photosymbiosis from ontogenetic isotope analyses of living planktonic foraminiferal test from Sagami Bay

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Some modern planktonic foraminifers harbor photosynthetic algae in their cells throughout their life. This symbiosis contributes to foraminiferal nutrition through the exchange of metabolic and/or photosynthetic products between foraminifers and algae. Therefore, in the evolutional history of planktonic foraminifers, development of photosymbiotic ecology is expected to enable foraminiferal species to radiate into oligotrophic ocean habitats unexplored by then. Thus, for further understanding of the dynamics of paleobiodiversity in planktonic foraminifers, it is significantly important to identify photosymbiotic ecology of extinct species.

In order to disclose the photosymbiotic signal, some previous authors have analyzed ontogenetic variations of stable isotopic compositions in foraminiferal tests. Among those studies, cultural experiments indicated that symbiont-bearing species show characteristic increasing trend in $d^{13}C$ through the individual ontogeny[1)]. This is because symbiont's photosynthesis makes seawater surrounding foraminifers enriched in ^{13}C by preferential uptake of ^{12}C. This effect becomes more prominent along host's size increase through ontogeny. Therefore, isotopic variations with respect to ontogenetic stages of foraminifers would be a possible candidate as a proxy for identifying the photosymbiotic ecology even for fossilized specimens. Although the proxy seems to be plausible in laboratory-cultured specimens, we should test it with modern wild specimens obtained from natural environment.

Here, we show ontogenetic isotopic variations from a single foraminiferal test recovered by a plankton tow. Four species, *Globigerinoides sacculifer*, *Globigerinoides conglobatus*, *Neogloboquadrina dutertrei*, and *Globorotalia inflata* recovered at Sagami Bay were utilized for the analyses. Cytoplasm of each specimen was decomposed with sodium hypochlorite and residual tests were dissected chamber-by-chamber with micro-scalpels under a binocular microscope. Isotopic measurements were performed on each single chamber using the customized continuous-flow IRMS (IsoPrime) at Geological Survey of Japan (AIST), which enables measurements of micro-volume samples as small as 1.5 micro grams of carbonate[2)].

Continuous increases in $d^{13}C$ with growth are observed in two species; by 1.1 permil in *Gs. sacculifer* and by 1.4 permil in *Gs. conglobatus*. In comparison, *Gr. inflata* exhibits much smaller isotopic variation for both $d^{13}C$ and $d^{18}O$. On the contrary, *Nq. dutertrei* shows significant positive correlation between $d^{13}C$ and $d^{18}O$. The median of $d^{18}O$ of *Gr. inflata* is obviously ^{18}O-enriched than those of the other three species.

Successive increase with growth and rather positively deviated value from isotopic equilibrium in $d^{13}C$ of *Gs. sacculifer* and *Gs. conglobatus* represent classic signals of algal photosymbiosis observed in cultural experiments. Since these two species are known to be symbiont-bearing species, this result shows that we successfully detected the photosymbiotic signal from ontogenetic isotope analyses in live-caught wild specimens.

1) Spero and Lea, 1993, Marine Micropaleontology, DOI:10.1016/0377-8398(93)90045-Y.
2) Ishimura et al., 2004, Rapid Comm. Mass Spectrom., DOI:10.1002/rcm.3571.

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