学 位 論 文 内 容 の 要 旨/Dissertation Abstract

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Factors controlling high productivity of coral reefs, viewed via nitrogen isotope ratios of amino acids in Cnidarians under autotrophic and mixotrophic laboratory breeding
（珊瑚礁の高生産性を支えるメカニスズム：独立栄養および混合栄養条件で飼育した刺胞動物（サンゴ・イソギンチャク）に含まれるアミノ酸の安定同位体比からの評価）

Many Cnidarian species host dinoflagellates, known as zooxanthellae, within their polyps, forming the Cnidarian-algal symbiosis. This symbiotic relationship enables Cnidarians to obtain nutrition both autotrophically, through photosynthesis by the zooxanthellae, and heterotrophically, through the capture of external particles or the assimilation of dissolved organic materials. Consequently, Cnidarians exhibit a mixotrophic mode of nutrition, functioning between autotrophy and heterotrophy in marine ecosystems. It is simply thought that this trophic flexibility contributes to the high productivity of coral reefs even in oligotrophic oceans, based on an assumption that symbiotic species benefit energetically from living together. However, little quantitative data is available on the trophic transfer of nutrients and energy within the Cnidarian-algal symbiosis, particularly for (1) the efficiency of trophic transfer of photosynthates from algal symbionts to Cnidarian hosts; (2) the balance between autotrophy and heterotrophy to the nutrient assimilation for Cnidarians (and algae); and (3) the form of the food web pyramid (e.g., biomass size for each of trophic steps) in coral reef ecosystems.

In this study, we carried out compound-specific isotope analysis of nitrogen within amino acids to quantify the assimilation flux in the autotrophic (i.e., symbiont-derived photosynthate is a solo resource for Cnidarians) and mixotrophic (i.e., both symbiont-derived photosynthate and commercial coral foods are resources for Cnidarians) nutrition of Cnidarians in laboratory aquariums, and to illustrate the form of the food web pyramid in coral reef ecosystems. The results show large inter- and intra-specific diversities in the nitrogen isotope ratio of Cnidarians in both autotrophic and mixotrophic conditions. In autotrophic condition, the isotope ratios of amino acids in Cnidarians should be explained by (1) the assimilation of algal-derived photosynthate and (2) isotopic fractionation during the metabolism (i.e., deamination) of amino acids. Based on the isotope ratios observed, we quantified that the efficiency of trophic transfer is 56% for the utilization of algal products in Cnidarian hosts in the autotrophic condition, in which the degree of efficiency is approximately twice compared to non-symbiotic herbivorous species. Moreover, we quantified that the relative contribution of heterotrophy is 34.6% ± 27.2 in the mixotrophic condition, in which the contribution of heterotrophy-derived nutrition accounts for approximately 31% of the autotrophy- derived nutrition in the Cnidarian-algal symbiosis.

Based on these results, we conclude that (1) this high efficiency (i.e., 56%) of the trophic transfer of nutrients from symbiotic algae to host Cnidarians and (2) additional assimilation of nutrients (i.e., 43%) from heterotrophy of Cnidarians are critical factors to explain the high productivity of coral reefs even in oligotrophic oceans.