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Estimation of internal and external nitrogen for corals with a long-term ^{15}N-labelling experiment and subsequent model calculations

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Coral reef ecosystems maintain high primary productivity though the seawater is extremely oligotrophic. One of the hypotheses to explain this paradox is the recycling of nutrients in animal-algal symbiotic organisms such as corals. It is relatively easy to measure nutrient uptake rates by corals from seawater, but the proportion of internally circulating nutrients between the coral host and the endosymbiotic algae (zooxanthellae) is more challenging. Here, we performed a long-term and continuous ^{15}N-labelling experiment to quantify the proportionate contribution of seawater (external N source) and the animal host (internal N source) to the total N influx in the endosymbiotic algae. Branches from the scleractinian corals *Porites cylindrica* and *Montipora digitata* from Okinawa, Japan, were cultured for 2 months in indoor, flow-through, filtered seawater tanks with the continuous supply of ^{15}N-labelled nitrate. At the initial and after 2, 4, and 9 weeks of the study, coral branches were collected and the algal and animal fractions were separated for isotopic analyses. In both corals, the N isotope ratio of symbiotic algae exponentially increased and the values were much higher than those of the host tissue, suggesting that the algae had a faster turnover N time than the animal host. Algal and host N biomass normalized to the coral surface area slowly decreased in both coral species over the study period. To calculate the contribution of internal and external N, a simple mixing model of algal N metabolism was designed. Using differential equations of ^{15}N balance and N biomass balance, F1 and F2 (external and internal N fluxes to symbiotic algae, respectively) were expressed as the functions of time. The model calculations showed that F2 was much higher than F1 in *P. cylindrica* and the percentage of internal N to the total influx N (PIN) was >70%. On the other hand, the contribution of F1 and F2 was comparable in *M. digitata* and the PIN was 40–70%. These results quantitatively showed that the internal N pool in the coral tissue plays an important role in the symbiotic algal metabolism. The application of the present ^{15}N-tracer technique would enable us to further calculate the fluxes of internal and external N in not only corals but also other algal-animal symbiotic organisms under various environmental conditions.