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Feeding on pico-and nanoplankton by scleractinian corals from Okinawa

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学 位 論 文 要 旨

Abstract of Doctoral Thesis

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論文題目：沖縄の造礁サンゴによるピコ・ナノプランクトンの捕食

Title of Thesis：Feeding on pico- and nanoplankton by scleractinian corals from Okinawa

Abstract：

Coral reefs are complex ecosystems referred as the forest of the sea, maintaining a high biological diversity. They show high gross primary production rate that depends on a rapid nutrient recycling among reef organisms. The main successful of corals' life is the nutrient exchange between the coral host and its symbiosis algae, a dinoflagellate named Symbiodiniaceae and the environment. The Symbiodiniaceae provide food for the corals by translocating photoassimilates (mainly glucose, glycerol, lipids and amino acids) supporting coral metabolism and skeleton formation. However, as N is not substantially provided by the Symbiodiniaceae, corals need to feed on plankton to balance their diet by releasing mucus net to trap suspended particles in the seawater. Under recent global warming scenario, the coral-symbiont relationship is strongly affected causing coral bleaching: corals lose their Symbiodiniaceae and concomitantly, a decrease in organic matter translocation, which results in coral starvation. Therefore, an exogenous food source as plankton may play a crucial role in coral survival under environment stress and bleached conditions. The objective of this study was to understand the grazing strategies of two common scleractinian corals in Okinawan reefs under healthy and bleached conditions. The effect of thermal stress was also investigated for the two coral conditions. The study focused on their picoplankton and nanoplankton grazing efficiencies considering that these two plankton size fractions are the most abundant in the reef waters and therefore the most important sources of organic matter for scleractinian corals.

Firstly, I studied the feeding rate of the scleractinian corals *Montipora digitata* (branching) and *Porites lutea* (massive) under healthy and bleached conditions, taking into account that Okinawan reefs have been subjected to prolonged thermal stress and recurring bleaching events. Coral nubbins were incubated for 6 h at normal (27 °C) and stressful (33 °C) seawater temperatures. They were supplied with a natural assemblage of picoplankton and nanoplankton concentrated via a tangential flow system. Densities of bacteria (BA), picocyanobacteria (PCY), picoflagellates (PF), nanoflagellates (NF), and concentration of dissolved organic carbon (DOC) were monitored at the start and end of the incubations. Grazing rates were calculated in terms of cell consumption and converted to carbon units considering the

carbon biomass of the different plankton groups. In addition, protein, glucose and glycerol concentrations and Symbiodiniaceae density in coral tissue were monitored. Results of grazing rates of healthy corals showed that, at 27 °C or 33 °C, *M. digitata* consumed 87 and 72% more pico-nanoplankton cells and 94% or 70% more organic carbon than *P. lutea*. In terms of plankton preference and carbon incorporation, *M. digitata* consumed mainly NF as major carbon source and *P. lutea* consumed equally on all food items.

I also studied grazing rates of bleached corals and this represents the first study revealing grazing rates of bleached corals under heat stress. Moreover, the combination of bleached condition and high seawater temperature was exercised in incubations to understand coral responses under prolonged heat stress that recently occur in Okinawan reefs. Results showed that bleached and healthy *M. digitata* consumed almost the same amount of carbon, but under thermal stress carbon incorporation widely decreased in bleached corals. Despite the comparatively lower carbon incorporation under thermal stress, *M. digitata* incorporated ~50% more carbon than *P. lutea*. Under thermal stress, both coral species consumed almost the same amount of cells but *P. lutea* consumed mainly PCY and PF, which provided relatively less organic matter source but with high C/N ratio. To understand possible changes in grazing strategies, I followed the dissolved organic matter (DOC) fluxes dynamics during incubations. A negative DOC flux in bleached *M. digitata* at 33 °C showed that *M. digitata* needed to uptake DOC from the surrounding seawater to compensate metabolic cost therefore decreased plankton capture was due to the lack of mucus secretion. Conversely, *P. lutea* continued to release DOC even under the heat stress. Therefore, I concluded that mucus release could serve for another purpose besides plankton trapping in *P. lutea*. During my incubations, I measured concentrations of glycerol and glucose, calculated their fluxes (in terms of organic carbon) and compare with the incorporation of organic carbon from heterotrophy. Carbon acquisition from heterotrophy respect to dark metabolic consumption (consumption of glycerol and/or glucose) varied from 3% to 65% in *M. digitata* and from 7% to 68% in *P. lutea*.

As main conclusion in this research, *M. digitata* was highly dependent on heterotrophy and very efficient at food capture. Nevertheless, its plankton capture performance was substantially diminished by the combination of bleaching and heating. On the other hand, *P. lutea* was comparatively less dependent upon heterotrophy, it utilized organic matter translocated from its endolithic community to produce mucus and was able to maintain certain level of heterotrophy (~7% of dark consumption under thermal stress) with selection of higher C/N ratio food items. Therefore, this coral species is relatively more resistant to bleaching events even at elevated seawater temperatures. This study shows that *P. lutea* is relatively more tolerant to bleaching, having greater chances of survival and recovery. Therefore, this species is more likely to be able to colonize decimated coral reef ecosystems.