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Effects of ocean acidification on calcification of symbiont-bearing reef foraminifers

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Ocean acidification (the decrease in the carbonate ion concentration and the pH) in response to rising atmospheric $pCO_2$is generally expected to reduce calcification by reef calcifying organisms, with potentially severe implications for coral reef ecosystems. Algal symbiont-bearing, reef-dwelling foraminifers are one of the most important primary and carbonate producers in coral reefs. They mainly produce high-Mg calcite shells, whose solubility can exceed that of aragonite produced by corals, making it the "first responder" in coral reefs to the decreasing $CaCO_3$ saturation state of seawater. Previous laboratory experiments have shown that the decrease in the pH causes Marginopora (a large discoid foraminifer with a porcelaneous shell and dinoflagellate symbionts) to reduce their calcification rates. However, it has recently been suggested that the response of marine calcifying organisms to ocean acidification varies between species. Here we report the results of culture experiments to investigate the effects of ongoing ocean acidification on the calcification of three taxa of symbiont-bearing reef foraminifers by using a high precise pCO_2control system (the AICAL system). Living clonal individuals of three foraminiferal taxa (Baculogypsina, Calcarina, and Amphisorus) were subjected to seawater with five different pCO_2 levels from 300 to 1000 ppm, which were adjusted and kept constant by bubbling with CO_2gas with the AICAL system. Cultured individuals were maintained for 12 weeks in an indoor flow-through system under constant seawater temperatures, light intensity, and photoperiod. After experiments, the shell diameter and shell weight of each cultured specimen were measured. Results showed that net calcification of Baculogypsina, which secretes a hyaline shell and is host to diatom symbionts, increased under the intermediate levels of pCO_2(600 and 800 ppm) and decreased at a higher pCO_2level (1000 ppm). Net calcification of Calcarina, which also secretes a hyaline shell and is host to diatom symbionts, generally decreased under elevated pCO_2, but increased under the intermediate levels of pCO_2(600 or 800 ppm). Net calcification of Amphisorus, which secretes a porcelaneous shell and is host to dinoflagellate symbionts, tended to decrease under elevated pCO_2. Size-normalized shell weights under different pCO_2levels indicate that shell weights of Baculogypsina increased, but those of Calcarina and Amphisorus decreased with elevated pCO_2. These different responses among three taxa are possibly attributed to the decrease in the carbonate ion concentration, the enhancement of calcification by the photosynthesis of algal symbionts, and differences in calcification mechanisms (in particular, different carbonate species used for calcification) among taxa. Our finding suggests that ongoing ocean acidification will be favorable for some hyaline taxa of symbiont-bearing reef foraminifers under the intermediate levels of pCO_2(600 and 800 ppm), but unfavorable for those with both hyaline and porcelaneous shells at higher pCO_2levels (over 1000 ppm).