Effects of ocean acidification under different light availability on the warm temperate coral *Acropora solitaryensis*

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Introduction – Increase in seawater temperature due to climate change is leading to the poleward shift of hermatypic corals geographic distribution. However, ocean acidification (OA), the decrease in oceanic pH result due to the-absorption of CO_2, could limit the expansion to higher latitudes. Additionally, in comparison to lower latitudes, higher latitudes tend to have limited light availability, and it could limit the habitable depth range[1]. Thus, ocean acidification increases the energetic cost of calcification[2], and as corals relies on the energetic input of photosynthesis from their symbiont[3], lower light level could further enhance the negative effects of OA. Therefore, we investigated the interaction of future pH conditions with differing light conditions, as these factors could determine the potential of high latitudes as a coral refugia.

Methodology – Colonies of the warm-temperate coral species *Acropora solitaryensis* were sampled at Shikine island (Tokyo Prefecture, Japan, 34° 19' 34" N 139° 12' 36" E), fragmented into microcolonies and acclimatized prior to the experiment for two weeks. Four experimental treatments were chosen by fully-crossing two pH,　equivalent to present and end-of-century OA scenario, and light conditions, equivalent to 5 m (high light) and 15 m depth (low light): (1) High light × Present pH (mean ± se, n = 8, 7.86 ± 1.80 mol photon s m^{-2} d^{-1}, 8.22 ± 0.08 pH, 353 ± 56 µatm pCO_2), (2) High light × OA pH (n = 5, 8.56 ± 2.46,7.86 ± 0.16, 923 ± 180), (3) Low light × Present pH (n = 5, 3.19 ± 1.75 , 8.17 ± 0.11, 409 ± 75), (4) Low light × OA pH (n = 5, 3.09 ± 1.04 ,7.83 ± 0.15, 994 ± 94). Both the coral host and symbiont physiology and metabolism were assessed to gauge their response to differing stressors.

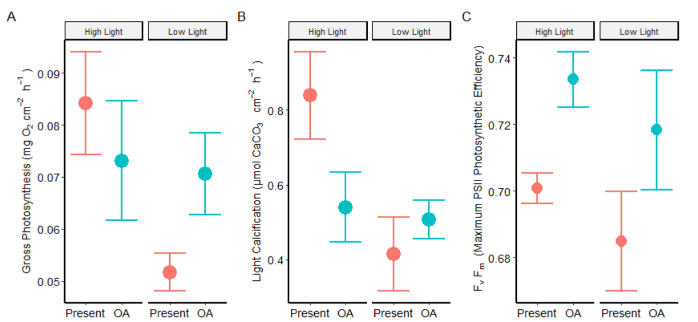

Figure 1: Maximum PSII photosynthetic efficiency (A), gross photosynthesis rates (B) and calcification rates (C).

Results – Under present-day of pCO_2, corals reared under low light conditions showed decreased metabolism (photosynthesis and respiration; Figure 1A) and growth (skeletal growth and calcification; Figure 1B). The only significant difference observed in OA conditions regardless of light condition, was observed for the symbiont maximum photosystem II efficiency ($F_v F_m$), which increased under OA (Figure 1C, ANOVA OA p = 0.012). Corals reared under OA and low light availability showed an increase, albeit non-significant, in photosynthetic activity, host protein, ETSA and net calcification compared to corals reared under low light and present pCO_2 (ANOVA pH:light p = 0.134, p = 0.087, p = 0.053 and p = 0.083, respectively).

Discussion – As expected, metabolic and growth rates were reduced under low light levels. However, contrary to the hypothesis, OA only minorly affected the coral metabolism and its negative effect was not observed under the lower light level. Although the combined effects of OA and decreased light availability could negatively affect coral energetic homeostasis[4], on the opposite, acidification had a positive effect on the metabolism of corals reared under low light conditions. Corals reared under acidified conditions showed an increase in maximum photosystem II efficiency. Under low light conditions, this increase in photosystem efficiency led to an increase in photosynthesis rates compared to the corals under present CO_2 level and low light conditions. Recent studies have shown autotrophs like zooxanthellae (coral symbiont)[5,6] and macroalgae[7] that have poor carbon concentration mechanisms can benefit from the enrichment in CO_2 under acidified conditions[8]. Moreover, the alga species *Padina pavonica*, showed increased maximum photosystem II efficiency under decreased light availability and OA[9]. The increased energetic input resulting from increase photosynthetic rates could have therefore compensated the increase energetic requirements of coral growth under OA. Our results suggest the combination of OA and low light availability will not have a compounding effect on the coral *A. solitaryensis* and might not limit the suitable depth range of corals in higher latitudes.

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