Title	The impacts of elevated temperature and ocean acidification on spawning and early life stages of corals(Abstract_論文要旨)
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Abstract

Title: **The impacts of elevated temperature and ocean acidification on spawning and early life stages of corals**

The inevitable increase in atmospheric carbon dioxide and consequent increase ocean warming (OW) and decrease in ocean's pH also known as ocean acidification (OA) is considered as a major threat in the early stages of corals. However, there are few studies that looked into its individual and combined effects from the timing of reproduction to juvenile stage that are important in structuring coral populations on the reef. This study aims to evaluate the effects OW and/or OA on early stages of corals in the tropical and subtropical reefs where majority of the corals exist. It is hypothesized that although corals are vulnerable to OW and maybe OA, some corals might have adapted or acclimatized to environmental extremes. The first study examined the effect of OW on the fecundity and reproductive timing of *Acropora digitifera.* Colonies exposed to +2°C one month prior to expected spawning showed that timing of spawning is 1 day advanced while volume and sperm density were reduced. The second study evaluated the optimum tolerance of early stages of corals to OW and OA in tropical (Philippines) and subtropical reefs (Okinawa), *Acropora tenuis* and *A. digitifera,* commonly found in both sites. Effects of OW (-3 to +6°C from ambient) and OA (pH: Control= 8.1-2, medium = 7.8, high= 7.6) on fertilization, embryonic development, survival and settlement were employed. Development of embryo is slower in colder (-3°C) and faster at OW (+3°C). OW reduced fertilization, survival and settlement in both species and sites, while OA had minimal effect. Fertilization, survival and settlement were lowest at +6°C for both sites. The third study examined the effects of OW and OA on post-settlement survival and growth of one-month old *A. digitifera* in Okinawa. One-month old coral juveniles were exposed to OW (control = 29±1 and high = 33±1°C) and OA treatment (pH: Control= 8.1-2, medium = 7.8, high= 7.6) combinations for 1 month. Survival was highly reduced by OW but not by OA while growth was reduced by OA. All of the juveniles exposed to OW died after 1 month. In addition to *Acropora* species, the fourth study used fungiid larvae which are solitary corals in Okinawan reef. Larvae of *Fungia fungites* and *Lithophyllon repanda* were introduced to OW (Control, +3°C, +6°C) and OA treatment (pH: Control= 8.1-2, medium = 7.8, high= 7.6) combinations for 8 days. *F. fungites* was neither affected by OA, OW nor its combination. Similarly, survival of *L. repanda* was not affected by OA however; it was significantly affected by OW. Temperature tolerance varies between species; *L. repanda* (+3°C) has lower tolerance than *F. fungites* (+6°C). Generally, elevated temperature reduces the success of early stages of corals more than OA (i.e., fertilization, embryogenesis larval survival and settlement) regardless of latitudinal stands with a tolerance of +3°C above ambient temperature. The negative effect of OA is more pronounced at post-settlement stage, when it started to calcify. In conclusion some species and cohort of species are more acclimatized or adapted to environmental extremes wherein pre-juvenile stage of corals exposed to an extreme pH (7.6) developed normally. Some coral larvae exposed to extreme temperature (+6°C = 34°C) survived such as *F. fungites* (Okinawa) and *A. tenuis* larvae (batch 2013 in Philippines) as well as. *A. digitifera* juveniles in Okinawa exposed to 33±1°C which survived 15 days of exposure. Therefore, under future global climate change scenario, reproductive timing and success will be affected as well as coral fecundity until post-settlement due OW while coral will grow slower due to OA.

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