ORIGINAL PAPER

Assessing coral growth at the coral nurseries in Chumphon Province, the Western Gulf of Thailand

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Abstract. Corals on shallow reef flats with 0.5-1.5 meters in depth in the Western Gulf of Thailand have a high potential for coral reef restoration projects. Those corals are adaptive to survive high environmental fluctuations such as temperatures, salinity, and sediment accumulation. This study aims to assess the coral growth after one year of transplant at coral nurseries. We selected coral fragments of dominant coral species (*Porites lutea, Pocillopora acuta Pavona decussata* and *Dipsastraea favus*) to assess the coral growth in the dome-shaped nursery in Chumphon Province, the Western Gulf of Thailand. Each coral fragment was collected from the shallow reef flat and reef slope to compare the growth rate on the dome-shaped nursery after one year of transplant. The result showed all the coral species from shallow reef flats were higher growth rate than coral from reef slope at all study sites. *Pocillopora acuta* and *Porites lutea* from shallow reef flat were significantly increased in growth rate compared to the reef slope. This result indicates that the corals from the shallow reef flat have the potential to be able to overcome the stressful environmental changing. Those corals can be the stock to manage the restoration project. Knowledge of coral tolerance in terms of species and reef areas is one factor in continuing to develop coral reef restoration in the future.

Keywords: coral bleaching, dome-shaped nursery, coral reef restoration, management, reef flat

1. Introduction

Coral reefs in the Indo-Pacific mostly have four coral reef zones such as reef flat, reef crest, reef slope, and back reef (Bellwood et al. 2017). Each reef zone has a different structure of reef characteristic of intra-zonal spatial organization, density and componence and size class distribution (Done 1982; Bellwood et al. 2018; Aunkhongthong et al. 2021). Reef flats are relative to the shallow reef zone, with a depth of about 0.5-1.5 meters. Corals and several marine organisms in this zone were lived in various environments such as a wide range of temperature, salinity, and sediment accumulation variations. Moreover, those organisms, including corals in shallow reefs flat can survive under the occasional exposure to the air during low tide. However, corals growth is limited in shallow reef flats (Thornborough and Davies 2011). Coral cover and/or diversity at reef flats often show a low level and are mostly dominated by a few characteristic species (Stephenson et al. 1931; Wells 1954; 1957; Spencer-Davies et al. 1971; Morrisey 1980; Bellwood et al. 2018). Thus, the high diversity of corals in the shallow reef, as mentioned above, depends on slope, wave exposure, and light (Wells 1954; Bellwood et al. 2018). Furthermore, Climate change is a serious issue that causes coral reef degradation and affects the utilization of coral reefs in fisheries, tourism, coastal prevention, etc. (Hughes et al. 2018).

Elevated sea temperature leads to coral bleaching due to thermal stress. For examples, the coral reefs in the Gulf of Thailand were extensively affected by the massive coral bleaching events in 1998 and 2010 (Yeemin et al. 1998; Yeemin et al. 2009; Sutthacheep et al. 2013), and corals are sensitive to the rising sea temperature only 1-2 degrees Celsius can caused the coral bleaching (Palumbi et al. 2014; Chakravarti et al. 2017; Torda et al. 2017; Hughes et al. 2018; Matz et al. 2018; Oliver et al. 2018). The mitigation activities have been created to solve the coral deterioration in decreasing habitat and species diversity. The coral reef restoration in Thailand has been operating for more than 30 years with several methods including coral transplantation, artificial reef, etc. to increase the survival rate and also potential for recruitment to settle on the artificial reef (Sirirattanachai et al. 1994; Thongtham and Chansang, 1999; Yeemin 1997; DMCR 2003; Aberson, 2005; Yeemin et al. 2006). Besides, reef restoration is not a priority management to mitigate the coral reef impact but the degradation of coral makes it undeniable (Suraswadi and Yeemin 2013). Corals on shallow reef flats in the Western Gulf of Thailand have a high potential for coral reef restoration projects because of their tolerance and adaptation for survival in high temperatures and environmental fluctuations. This initiative research project for coral reef restoration in Thailand is based on selecting stress-tolerant coral fragments and good traits for survival under the climate change crisis. The project established pilot nursery sites for innovative coral restoration projects in Thailand and studied biological, physiological, and ecological aspects of coral fragments in the pilot nursery sites and corals on shallow reef flats.

This study investigates the ability of coral growth to tolerate the thermal stress from shallow reef flats and reef slopes and to examine the potential of coral fragments to be selected for coral transplantation.

2. Materials and Methods

2.1 Study sites

This study is located at shallow reef flat and reef slope of Ko Rang Kachiu and Ko Ngam Yai in Mu Ko Chumphon National Park, the Western Gulf of Thailand (Figure 1).

2.2 Coral nursery design

Pilot nurseries were designed dome-shaped concreates that were built to be artificial reefs as a coral nursery plot. The pilot nursery structure was proposed to be an environmentally-friendly dome-shaped structure with gaps to reduce weight and increase areas for the nursery (Figure 2). Pilot nursery structures were placed at Ko Rang Kachiu and Ko Ngam Yai in March 2021.

2.3 Coral experiment

This experimental were selected dominants coral species in the Mu Ko Chumphon National Park. At Ko Rang Kachiu were selected *Porites lutea*, *Pocillopora acuta*, and *Dipsastraea favus*, while Ko Ngam Yai were selected *Porites lutea*, *Pocillopora acuta* and *Pavona decussata*. Each coral species was sampled from the shallow reef flat and reef slope. Coral fragments around 3 cm^2 high (branch) or surface area (massive) were collected. Coral fragments were attached to a terracotta pot 4x4 centimeters with 4 centimeters in diameter which were set up on dome-shaped nursery areas (Figures 2 and 3).

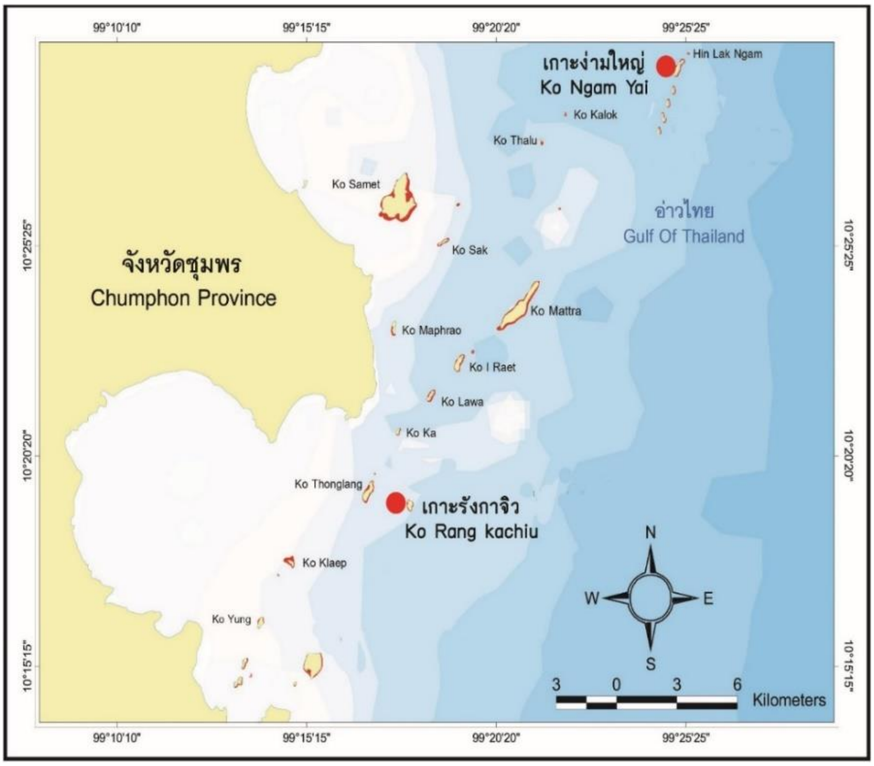


Figure 1. Map of study site at Chumphon Province

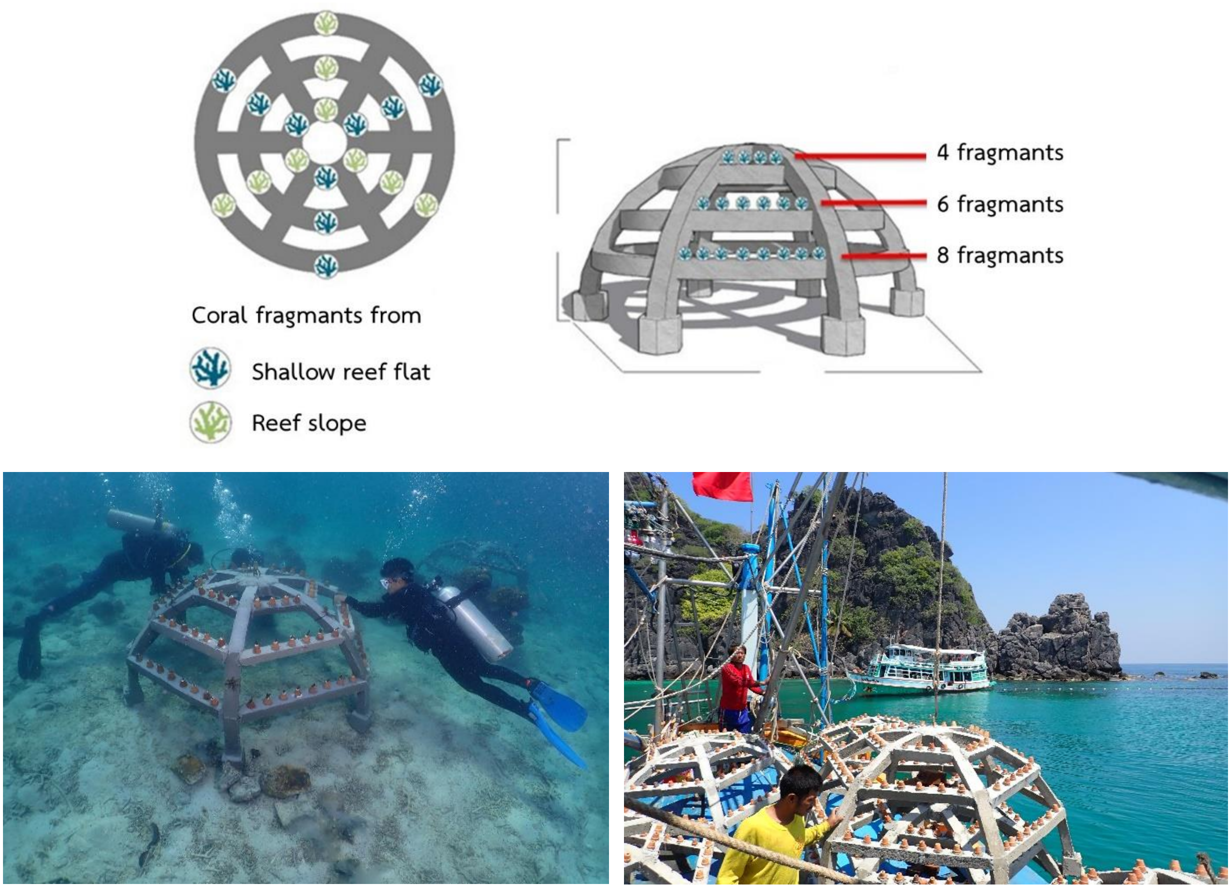


Figure 2. Design and installation of the pilot dome-shaped nursery areas

2.4 Data collection

Coral growth rates were measured by scuba divers. The coral size measurement has been done to observe coral growth rate with the scale to compare the size of coral fragments at the initial and after transplant one year by using a digital camera and were analyzed in laboratory (Lozano-Cortés and Berumen 2016).

2.5 Data analysis

T-test analysis was used to examine the difference in growth rates between coral fragments from the shallow reef flat and reef slope at each study site of Ko Rang Kachiu and Ko Ngam Yai.

3. Results

The result of the growth rate of coral on Ko Rang Kachiu shows in Figure 3. The coral growth rate of *Porites lutea*, *Pocillopora acuta*, and *Dipsastraea favus* from shallow reef flat were 3.51±0.06, 17.40±4.16 and 1.43±0.45 cm^2, respectively, while the growth rate of corals fragment from reef slope were 2.20± 0.6, 10.73±0.31 and 1.20±0.71 cm^2 respectively. At Ko Ngam Yai, coral growth rate had similar pattern to Ko Rang Kachiu (Figure 4). *Porites lutea*, *Pocillopora acuta* from shallow reef flat were significantly high growth rate compared with coral fragments from reef slope at all study sites (p<0.05). At the same time, *Dipsastrea favus* and *Pavona decusata* were similar trends with *Porites lutea*, *Pocillopora acuta*, but no significantly different were observed.

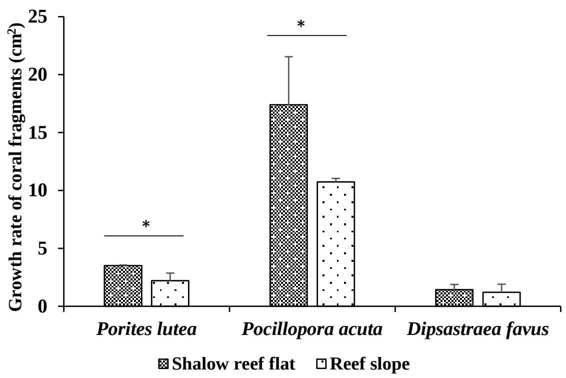


Figure 3. The growth rate of corals (cm^2) after one-year nursery at Ko Rang Kachiu (Mean±SD)

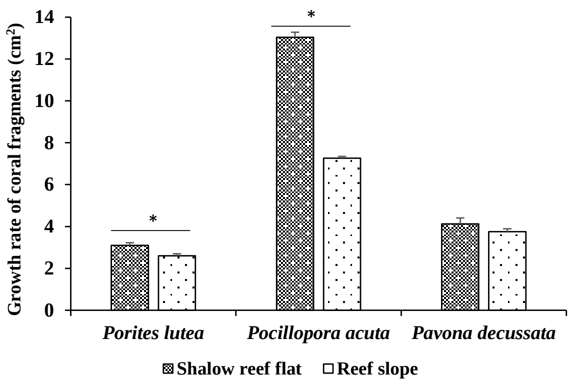
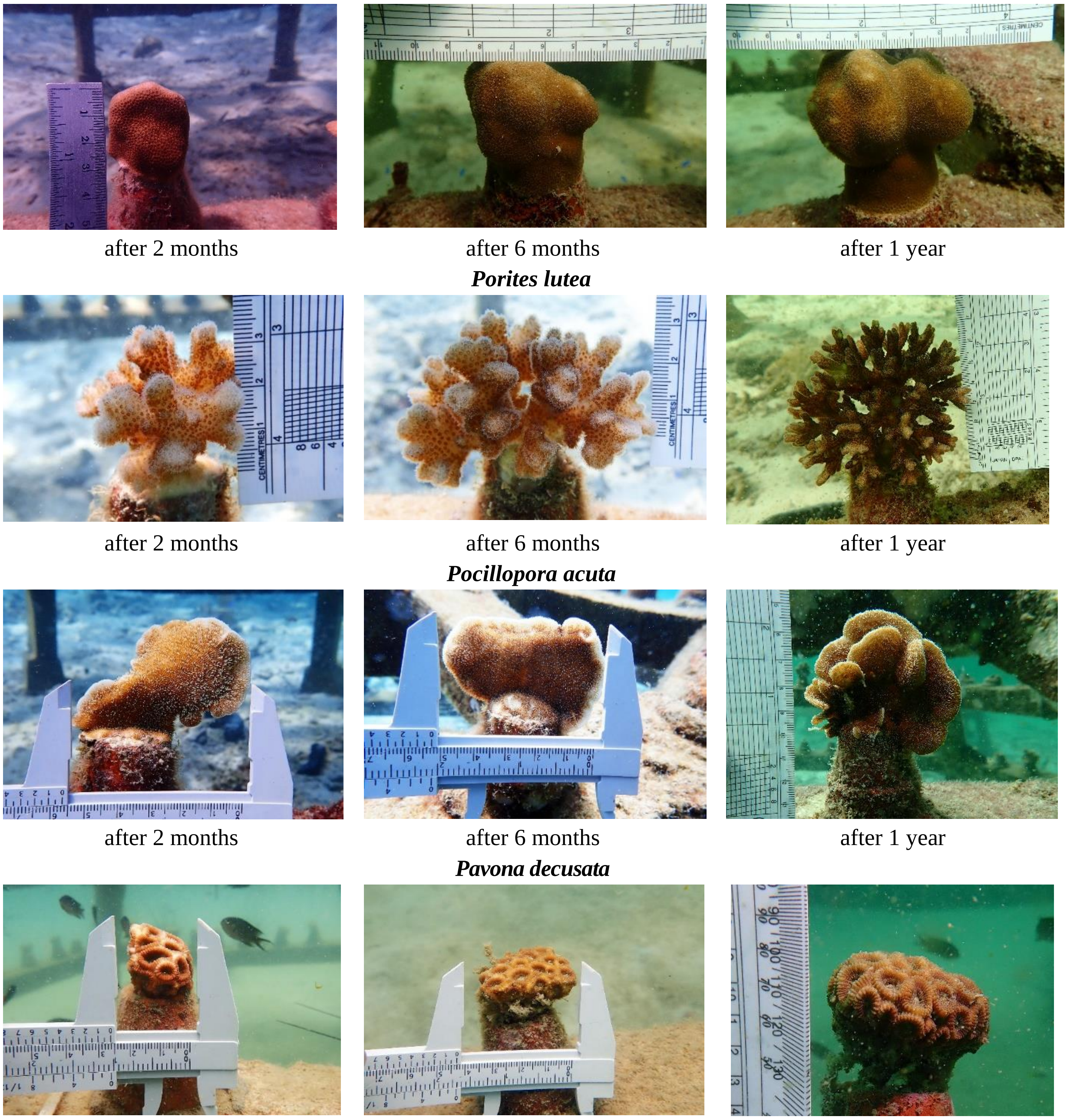


Figure 4. The growth rate of corals (cm^2) after one-year nursery at Ko Ngam Yai (Mean±SD)



after 2 months | after 6 months | after 1 year

Porites lutea

after 2 months | after 6 months | after 1 year

Pocillopora acuta

after 2 months | after 6 months | after 1 year

Pavona decusata

after 2 months | after 6 months | after 1 year

Dipsastraea favus

Figure 5. Assessing coral growth at the coral nurseries in Chumphon Province**.**

4. Discussion

The reef flat organisms are often covered by relatively high sediment with algal turfs (Purcell and Bellwood 2001), but it can support a density and diversity of corals which are depending on the geographic location and tidal regime (Done 1983; Wismer et al. 2009). The reef flat is the reef zone received the highest solar irradiance, supporting significant algal growth, calcification, and primary productivity (Bellwood et al. 2017). Based on our findings had shown that all coral fragments in dome-shaped nursery area at Ko Rang Kachiu and Ko Ngam Yai which were taken from parent colonies in shallow reef flat areas had higher growth rates than coral fragments taken from reef slopes. Corals in shallow reef flat show a high potential to overcome environmental stress (Thornborough and Davies 2011; Wells

1954; Bellwood et al. 2018; Hughes et al. 2018).

The active coral restoration in Thailand is helpful for the coral restoration and successful recovery of marine organisms in terms of population density and diversity. Hence, coral reef restoration has become the major conservation strategy in the global change crisis (Thongtham and Chansang, 1999; Yeemin 1997; Aberson, 2005; Yeemin et al. 2006; Chou et al. 2009; Suraswadi and Yeemin 2013). Several artificial reefs were designed to improve and developed to enhance coral reef resilience. However, the reef restoration should consider the tolerant coral species and the area of the coral colony where can be the coral stock to succeed in coral reef restoration projects.

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