ผลกระทบจากการครูดกินของปลาต่อการฟื้นฟูปะการังโดยการย้ายปลูกปะการังแบบอาศัยเพศ

Effect of reef fish grazing on coral restoration by transplanted coral from sexual reproduction technique

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บทคัดย่อ

วัตถุประสงค์ของการศึกษาเพื่อทำการทดลองครอบกรงกับปะการัง เพื่อประเมินผลกระทบจากการครูดกินของเม่นทะเลและปลาในแนวปะการังต่อการรอดและการเติบโตของปะการัง ที่เกาะแสมสาร จังหวัดชลบุรี โดยทำการทดลองในปะการังเขากวาง (Acropora millepora) และปะการังสมอง (Platygyra sinensis) ที่ได้จากการเพาะเลี้ยงแบบอาศัยเพศและปล่อยคืนสู่ธรรมชาติ เพื่อทดสอบสมมุติฐานว่าการป้องกันปะการังจากการครูดกินช่วยเพิ่มอัตราการเติบโตและการรอดชีวิตของปะการังที่ทำการย้ายปลูก จากการทดลองเป็นเวลา 4 เดือน พบว่าอัตราการรอดชีวิตของปะการังในกลุ่มทดลองที่ทำการครอบกรงและปล่อยเม่นทะเลลงไปด้วยสูงกว่าในกลุ่มควบคุมที่ไม่ได้ครอบกรงอย่างมีนัยสำคัญ แต่ไม่พบความแตกต่างอย่างมีนัยสำคัญเมื่อเปรียบเทียบอัตราการเจริญเติบโตของปะการัง อีกทั้งยังพบว่าอายุของปะการังที่ทำการปล่อยคืนสู่ธรรมชาติมีผลต่อการรอดและการเติบโตของปะการังแปรผันไปกับชนิดของปะการัง และพบอีกว่าการป้องกันปะการังจากการครูดกินอาหารโดยปลาในแนวปะการังส่งผลดีต่ออัตราการรอดของปะการัง แต่ในขณะเดียวกันก็เพิ่มปริมาณของสาหร่ายที่เป็นผู้แข่งขันกับปะการังด้วย อย่างไรก็ตาม การครอบกรงป้องกันปะการังเพื่อปล่อยปะการังคืนสู่ธรรมชาติในการฟื้นฟูแนวปะการังเป็นอีกทางเลือกหนึ่งในการปกป้องปะการังให้รอดและเติบโตดีขึ้น

คำสำคัญ : การครอบกรง, การย้ายปลูกปะการัง, การครูดกินอาหาร, สัตว์กินพืช, การสืบพันธุ์แบบอาศัยเพศ

Abstract

The purpose of this study was to test the direct effect of grazing of fish and urchins on outplanted coral growth and survival. Field experiments were conducted at Samea San Island, Chonburi Province, and all corals, Acropora millepora and Platygyra sinensis used in the experiments were cultured via sexual propagation. To test the hypothesis that the exclusion of grazing would result in increasing outplanted-coral growth and survivalship, fish exclusion cages were deployed for 4 months. The results showed that survival rated were significantly different among treatments. The survival rates of corals were high in cages with sea urchins. However, there was no significant difference in growth rates between treatments in any coral species. In addition, the variation of growth and survival of coral also found between different ages of corals due to coral species. Thus, this study showed that exclusion of fish had a positive effect on the survival of corals. In another hand, exclusion of herbivore also increasing the biomass of macroalgaes those competitive with corals, Therefore, for corals outplanting for reef rehabilitation purpose, rearing juvenile corals in cages may allow them to increase in sizes faster.

Keywords : caging, transplanted coral, grazing, herbivore, sexual propagation

1. Introduction

Degradation of coral reefs results from human-induced impacts such as dredging, sewage discharge, dynamite fishing, chemical pollution, oil spills, ship groundings, tourist damage and run off sediment, fertilizer and pesticides as a result of changing land use [1][2][3][4][5]. Recognition of the value of coral reefs, the development of marine parks in coral reef areas, and increased efforts focused on reef management have resulted in wide- spread interest in reef rehabilitation using coral transplantation as an aid to management degraded reef areas [6][8].

In general, transplanted corals are likely to be taken from adjacent undamaged or less damaged reef areas either through asexual or sexual reproduction techniques. The transplantation of corals by using asexual reproduction technique or fragmentation, which has been employed as the primary management tool for reef restoration is now regarded as one of the major conservation measures [9][10][11].Studies of coral transplantation have focused mainly on the fate of transplanted colonies, including their survival and growth rate and their reproductive ability [12][13][14]. In addition, some studies focused on the short-term changes in fish assemblage and benthic invertebrates after transplantation [15][16]. Yet, to determine the success of coral transplantation in the areas, other factors such as effects of corallivores and grazers on transplanted corals need to take into account.

Invertebrate and fish corallivores are recognized as having important effects on coral populations and growth [17]. Previous study demonstrated that grazing of predators had a strong effect on the recruitment success of corals. High numbers of grazers have shown the negative effects on coral recruits, and caused coral mortality at the early stages [18]. Other non-corallivores such as sea urchin can also have an effect on corals. Sea urchins act as both herbivores and bioeroders in reefs [19]. While sea urchin grazing removes competitive algae from corals, the excessive high numbers of sea urchins can cause excessive grazing resulting in severe bioerosion of corals [20]. High densities of sea urchins led to the decrease of coral recruitment, and sometimes decrease of live coral tissues due to their consumption [20][21].

Other factor that can influence the success of coral transplantation is macroalgae. Even though, macroalgae is an important component in reef communities. Its overgrowth can have a negative effect on coral population. An increase in dense of macroalgal mats can lead to direct contact with corals. Corals with close contact with algae can experience in growth and survival reduction [22][23]. However, the outcomes of coral-algal interaction also depend on the specific coral and algal species, habitat, and water quality [24]. To maintain healthy coral reefs, grazing by herbivores is an important process [25]. The grazers can minimize algal-coral interaction, and thus enhance in coral growth and survivorship [26].

At present, the factors affecting juvenile and adult coral survival after outplanting to the reefs are still poorly understood. Only a few studies were conducted to elucidate this [27][28]. In Thailand, so far no study has been done on monitoring the growth and survival rates of hatchery-reared-juvenile corals after transplantation. The unique of this study was those experimented corals were age-specific, which were cultivated via sexual propagation, and later were transplanted into reefs at Samea San Island, Chon Buri Province, Thailand. Our study was designed to test the direct effect of grazing of fish and urchins on outplanted coral growth and survivorship. Our hypothesis was that the exclusion of large invertebrates and fish would result in increasing outplanted-coral growth and survivorship. The purpose of this study was also to compare growth and survival rates of different coral ages that were either caged or uncaged to exclude fish or sea urchins.

2. Research Methodology

Experiments were conducted at Samea San Island, Chonburi Province. All corals used in the experimentation were cultured via sexual propagation. Gametes of Acropora millepora and Platygyra sinensis were collected during the spawning time in February 2010 and 2012 on reefs around Samea San Island. The gametes were transported to the coral hatchery on Samea San Island for further fertilization. After eggs were fertilized and become planulae, cotta tiles were placed in tanks, and used as settlement substrates. The planulae then settled on the tiles within 1 week after the fertilization. Tiles with juvenile corals were maintained in the hatchery with flow-through seawater system until those juvenile corals reach 1.8 and 2.8 years old.

The field experiments were conducted at a fringing reef at Samea San Island. Prior to the experimental trials, 12 concrete blocks in the size of 50X50X50 cm were placed on the reefs approximately 8 m depth. Each block was set about 10 m apart. To test the hypothesis that the exclusion of large invertebrates and fish would result in increasing outplanted-coral growth and survivorship, three treatments were set: no cage, fish exclusion cage, sea urchin plus fish exclusion cage. Cages used for fish exclusion and sea urchin plus fish exclusion were constructed and covered with mesh plastic nets with 1 cm^2 holes on their sides and tops to prevent grazing from sea urchin and fish. The cages were attached using monofilament line tied with iron bars hammered into the substrates. The difference between fish exclusion treatment and sea urchin plus fish exclusion treatment was that for the fish exclusion treatment, sea urchins (Diadema setosum) were left in the cages in the same density as they were found naturally while for the treatment of sea urchin plus fish exclusion, both fish and sea urchins were removed from the cages.

Prior to setting the cages, tiles with 1.8 and 3.8 years old Acropora millepora and Platygyra sinensis were randomly allocated to one of three treatments: no cage, fish exclusion cage, sea urchin plus fish exclusion cage. The tiles were vertically attached with the concrete blocks by using screws. Eight tiles were assigned for each concrete block. The tiles were photographed and re-examined monthly to determine the growth and survival rates. The experiments were run for 4 months. Height, width, and were coverd of corals on each tile photograph were analyzed using CPCe [29]. Survival of corals was also examined 4 months after deployment. One-way ANOVA test followed by Tukey pairwise mean comparison was used to test for a difference in growth and percent cover of corals between treatments.

3. Results

One-way ANOVA test showed that percent changes of surface areas of 1.8 and 3.8-year old Acropora millepora in cage with sea urchins were significantly greater than in either no cage or cage without sea urchin (Figure 1). However, percent changes of surface area of 1.8 and 3.8-year old P. sinensis was not significantly affected by any treatments.

Survival was significantly different among treatments. Corals both A. millepora and P. sinensis could survive 100% when they were in cages with sea urchins (Table 1). However, in the uncaged treatment and without sea urchin caged treatment, the survival rates of A. millepora were reduced lower than half. For Platygyra sinensis, they survived 100% in all treatments (Table 1). The survival rate was trend to positively relate to coral ages in the uncaged and was trend to negatively relate to coral ages in caged without sea urchin treatment (Figure 2).

There was no significant difference in growth rates between treatments in any coral species (Figure 3). However, the growth rate of corals was positively related to coral ages in uncaged treatments ($r = 0.07$, $n = 65$, $p = 0.05$) and was negatively related to coral ages in caged without sea urchin treatment ($r = -0.14$, $n = 46$, $p = 0.05$) (Figure 4).

Table 1 Percent survival of transplanted coral

	Control	Cage with sea urchins	Cage without sea urchins
A. millepora 1.8 yrs.	50	100	91.67
A. millepora 3.8 yrs.	94.12	100	50
P. sinensis 1.8 yrs.	100	100	100
P. sinensis 3.8 yrs.	100	100	100

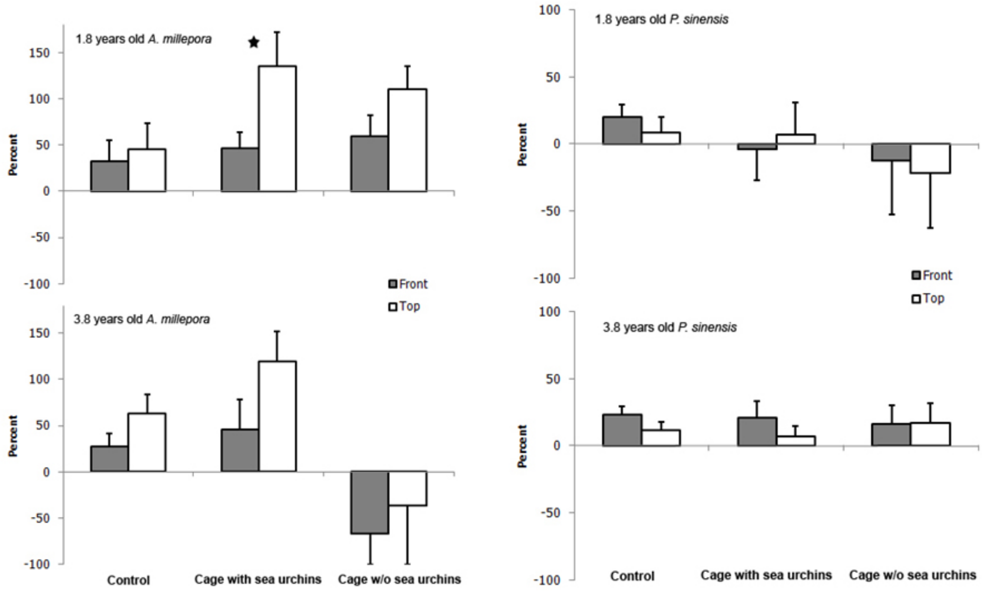

Figure 1 Percent change of surface area of transplanted corals

★ - Significant different

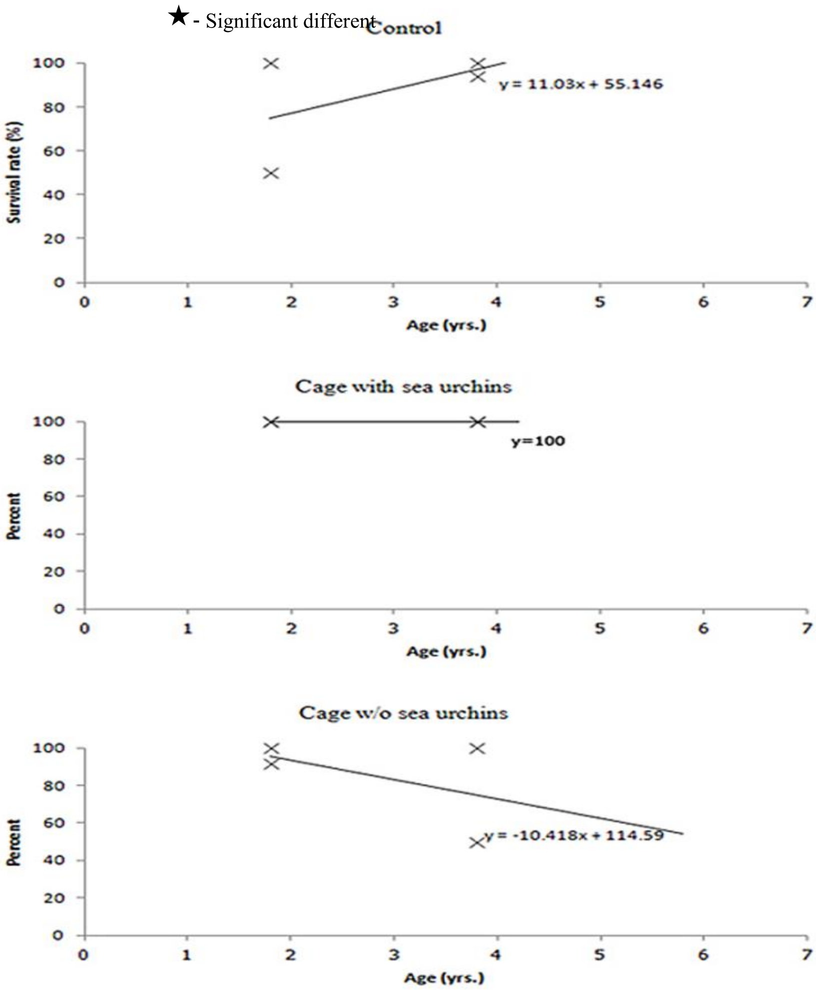

Figure 2 Relation of age and survival rate of transplanted corals

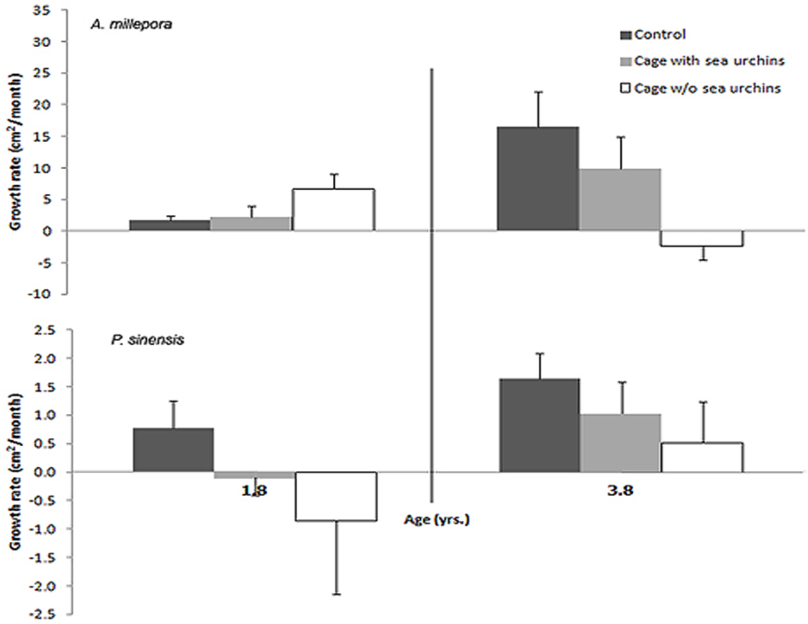

Figure 3 Growth rate of transplanted coral

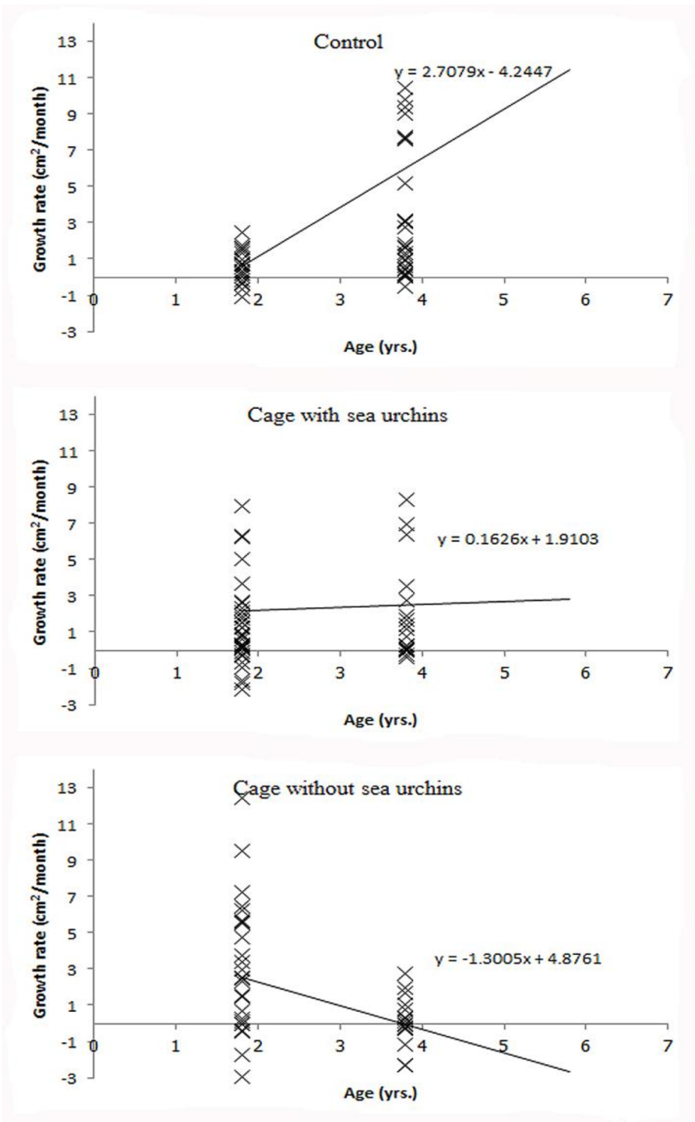

Figure 4 Relation of age and growth rate of transplanted corals

4. Discussion

Our study clearly showed that exclusion of fish had a positive effect on the survival of corals. Factors affecting juvenile and adult coral survival after outplanting to reefs can be both from grazers and algal biomass. Even though, the cage prevents grazers, the caging treatment is a mechanism to increase the algal biomass [28]. In this study, without sea urchins in the cages, the results showed that the Acropora millepora growth and survival could be affected by the amount of algal biomass. Several studies have demonstrated that algal competition can inhibit the growth of corals such as acroporid species [30][31]. However, some coral species such as Pocillopora damicornis showed no effects of macroalgal competition on their growth rate [31]. Similar to Tanner [31], in this study, Platygyra sinensis did not show the difference in growth and survival rates between caged and uncaged treatments. Thus, the susceptibility of corals to increased algal competition can be species-specific.

Grazing is an important process in reefs [32]. The presence of grazers is known to reduce the pressure of coral-algal interaction, limit the development of algal turf, and enhance coral recruitment [33][34]. However, several studies have shown that newly or young corals had high mortality rates due to the incident of grazing [18][20][35]. The exclusion of herbivores could increase survivorship by over 50% in some coral species [27] same as this study. Fish predators are often cited as a major cause of juvenile coral mortality [27]. In the area where fish predators are high, grazing can be intense, while at low density, fish predators have been proved to increase the survival rates and densities of juvenile corals [36][37].

Coral morphology can also have an influence on the effect of coral-algal competition. Previous studies found that corals with high perimeter-to-area ratio such as encrusting forms were more affected by the increase of algal biomass than that of in branching or massive forms. In this study, the growth by mean of increase of surface area of P. sinensis were negatively affected by increasing algal biomass, whereas percent change of areas of massive P. sinensis were not affected.

To enhance coral survival following outplaning to the reefs, the caging method to exclude macroinvertebrate grazers and fish is an option. Several studies reported survival rates of uncaged juvenile corals outplanting to reefs ranging between 0 to 17% [38][39][40]. When caging was deployed, the survival rates could be up to 33% [28]. Thus, the caging seems to be beneficial to coral survival and growth.

5. Conclusions

The results from this study and previous studies also showed that fish and sea urchins contributed to survival and growth of corals; however, the effect of grazing and the consequence of the algal biomass increase can be species-specific. Therefore, for corals out planting for reef rehabilitation purpose, rearing juvenile corals in cages for a while may allow them to increase in sizes faster, but how to control the algal biomass while caging needs to be considered.

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