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Abundance of coral recruits on settlement plate experiments from Mu Ko Angthong, the Western Gulf of Thailand

Wanlaya Klinthong[a], Makamas Sutthacheep[a], Wiphawan Aunkhongthong[a], Siriluck Rongprakhon[a], Chainarong Ruangthong[b], Thamasak Yeemin[a]*

[a]Marine Biodiversity Research Group, Department of Biology, Faculty of Science, Ramkhamhaeng University, Huamark, Bangkok 10240, Thailand
[b] Chumphon Marine National Park Operation Center 1, Department of National Parks, Wildlife and Plant Conservation, Chumphon Province, Thailand

*Corresponding author: *thamasakyeemin@hotmail.com*

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Abstract. facilitating coral recovery after natural and anthropogenic disturbances. Settlement plate experiments were used to study coral settlement and recruitment patterns. Studies on coral larval supply and recruitment patterns in Mu Ko Angthong are limited. Coral recruitment is a critical ecology process on tropical reefs to enhance coral populations following major disturbances. This study aimed to examine coral recruitment on the reefs at Mu Ko Angthong using the settlement plate experiments. The settlement plates were made from terracotta and submerged at the study sites from April 2016 to March 2018. The density of coral recruits on settlement plate experiments at Ko Sam Sao (West) (53.12±14.6 recruits/m^2, $p < 0.05$) was significantly higher than that at Ko Sam Sao (East) (12.50±8.7 recruits/m^2) and Ko Wua Kan Tang (3.12±1.56 recruits/m^2). Coral recruits mainly attached settlement plates on a horizontal angle following the oblique angle at Ko Sam Sao (East) and Ko Sam Sao (West), but not found coral recruit settled on the horizontal angle at Ko Wua Kantang. Coral recruits with four taxonomic compositions (*Pocillopora* spp., *Porites* sp., *Fungia* spp., *Goniastrea* spp.) and some unidentified coral recruits were found. *Pocillopora* spp. were the most dominant taxa of coral recruits on the settlement plate experiments at Ko Sam Sao (West). This study provides essential baseline scientific data to the understanding of coral recruitment patterns in Mu Ko Angthong. Filamentous algae were also the most dominant group on the settlement plates. A long-term monitoring program for coral recruitment in other island groups in the Western Gulf of Thailand is needed.

Keywords: coral, recruitment, settlement plate, larvae, Gulf of Thailand

1. Introduction

Coral reefs are the one significant ecosystem distributed in warm, shallow waters of tropical and subtropical seas. In coral reefs found high biological diversity due to complex ecosystems (Veron et al., 2015). Nowadays, coral reefs are present decrease the reef area from high sea surface temperature, increase solar irradiances (Lesser and Farrell, 2004), increased frequency and intensity of marine heatwaves (Heron et al., 2016; Eakin et al., 2019), nutrient input (Fabricius, 2005; Møller et al., 2015), microplastic and metal pollution (Moore, 2008; Prouty et al., 2013). These factors have induced more the occurrence and extreme of coral bleaching worldwide (Coles & Brown, 2003; Hughes et al., 2017, 2018). Coral recruitment is an essential ecological process in maintaining coral reef ecosystems and facilitating coral recovery after natural and anthropogenic disturbances (Ritson-Williams et al., 2009; Cooper et al., 2014; Cameron & Harrison, 2020).

Settlement plate experiments were widely used to study coral settlement and recruitment patterns. Moreover, the settlement plates are artificial substrates and coral restoration tools (dela Cruz & Harrison, 2020). Methods for observing coral settlement experiment were variety design to the reef substratum have been utilized, including plexiglass and PVC plates (Birkeland et al., 1981), terracotta tiles (Tomascik, 1991; Mundy, 2000; Doropoulos et al., 2015; Mwachireya et al., 2017), or settlement tiles cut from dead Acropora (dela Cruz & Harrison, 2020). The population method for plate attachment that has been used in coral recruitment studies on Western Pacific coral reefs is the steel mesh rack method (e.g., Wallace & Bull, 1981; Wallace, 1985; Harriott, 1995; Harriott & Fisk, 1987; Babcock, 1988; Fisk & Harriott, 1990; Sammarco, 1991; Harriott, 1992; Baird & Hughes, 1997; Dunstan & Johnson, 1998) Taiwan (Ho & Dai, 2014) and Thailand (Klinthong et al., 2013, 2014, 2015, 2018). However, Studies on coral larval supply and recruitment patterns in the Gulf of Thailand are very limited. This study aimed to examine coral recruitment on the reefs at Mu Ko Angthong using the settlement plate experiments at Ko Sam Sao (East), Ko Sam Sao (West), and Ko Wua Kan Tang in Mu Ko Angthong National Park, the Western Gulf of Thailand. In this study, we extend the knowledge of the density and composition of a coral recruit from larva settlement research by investigating coral settlement. Due to the angle of settlement plates relative to the substratum is also an important source of variability in studies of coral recruitment, we also observed the affected of the angle of settlement plates with coral recruit settlement (Sammarco 1991).

2. Materials and Methods

The coral recruit settlements were conducted to investigate the settlement of coral recruitment patterns on coral communities in Mu Ko Angthong, Surat Thani Province, the Western Gulf of Thailand. Three study sites were examined, i.e., Ko Sam Sao (East), Ko Sam Sao (West), and Ko Wua Kantang (Figure 1).

The settlement plates experiment was made from Terracotta plates (20x20 cm^2). Terracotta plates were submerged in the coral community using the settlement panel experiment made from steel at 2-5 m depth. We designed the settlement panel experiment to set up the tile at different horizontal, oblique, and horizontal angles. Eight terracotta plates per angle were randomly placed on the substrate in each study site from April 2016 to March 2018 using SCUBA diving (Figure 2).

At the end of the two-year experiment, we collected All settlement plates and fixed them in 10% formalin-seawater, labeled, and transported them back to the laboratory. The Terracotta plates were then bleached in a chlorine solution and air-dried for further identification of coral recruits. All coral recruits were counted and identified to genus level under a dissecting microscope.

Data statistical analyses were using the Kolmogorov-Smirnov test for checked normal distribution; square root transformation was performed when data were not normally distributed. A One-way ANOVA was used to test significant differences between total coral recruit densities and among study sites or in differences angle of terracotta plates, including test significant differences between densities of coral recruits in each genus in among study sites. Pairwise comparisons with post hoc Tukey's test were used to test the level of significant differences was considered significant.

3. Results

The total density of coral recruits (recruits per m^2) on settlement plates after two years is shown in Figure 3. Ko Sam Sao (West) shows the significant differences in mean density of coral recruits higher than those at Ko Sam Sao (East) and Ko Wua Kan Tang (53.12±14.6 recruits/m^2, $p < 0.05$). The effects of differences in settlement plate angle, coral recruits mostly settled on a horizontal angle following the oblique angle at Ko Sam Sao (East) and Ko Sam Sao (West), but not found recruit settle on the horizontal plate at Ko Wua Kantang. However, the settlement plate angle did not significantly different affect coral recruit settled (Figure 4). Four taxonomic compositions of coral recruits were dominated by *Pocillopora* spp., *Porites* sp., *Fungia* sp., *Goniastrea* sp., and some unidentified coral recruits. *Pocillopora* spp. were the most dominant taxa of coral recruits on settlement plates compared with all other taxa coral recruits at Ko Sam Sao (West) (35.94±11.15 recruits/m^2, $p < 0.05$). However, the abundance of a coral recruit from four major taxa was varied among Ko Sam Sao (East) and Ko Wua Kantang, but no significant differences were observed (Figure 5 and 6).

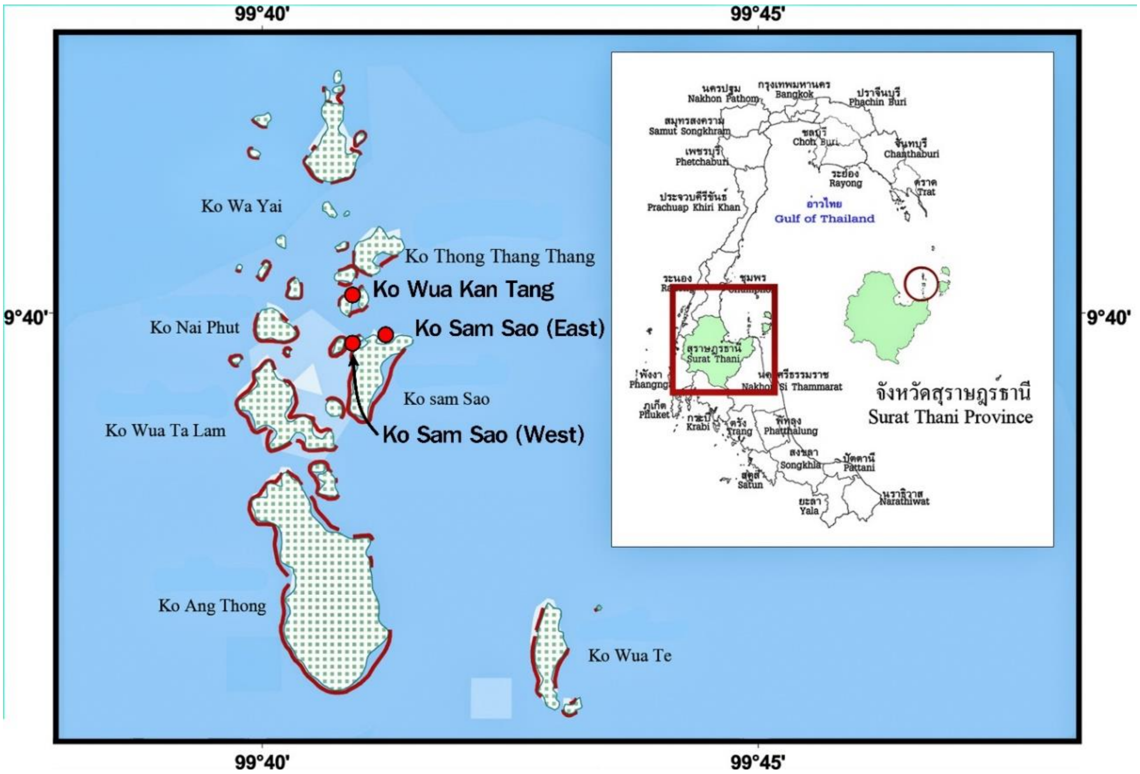


Figure 1. Map of the study site at Mu Ko Angthong, the Western Gulf of Thailand

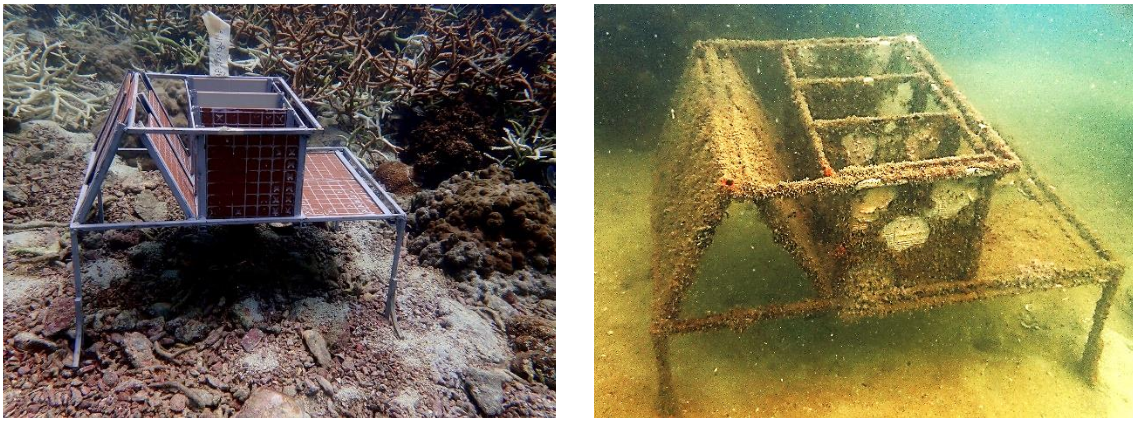
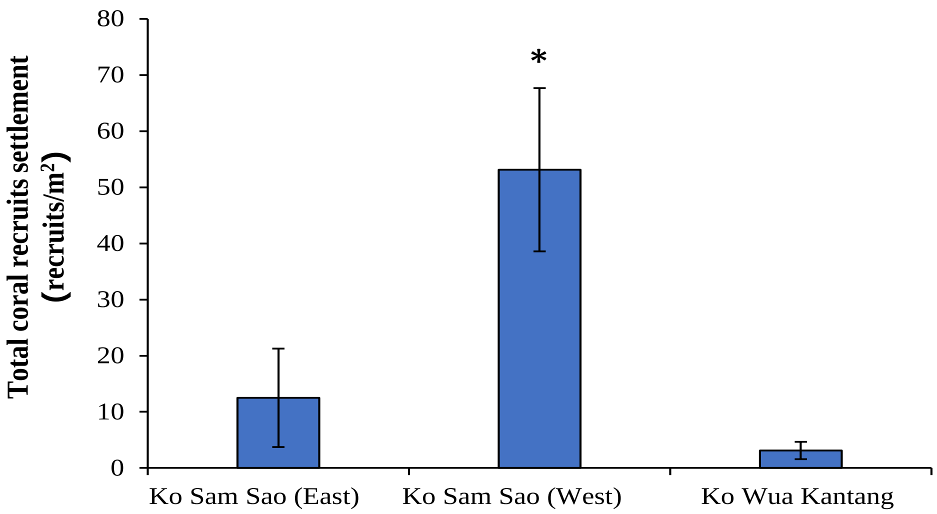
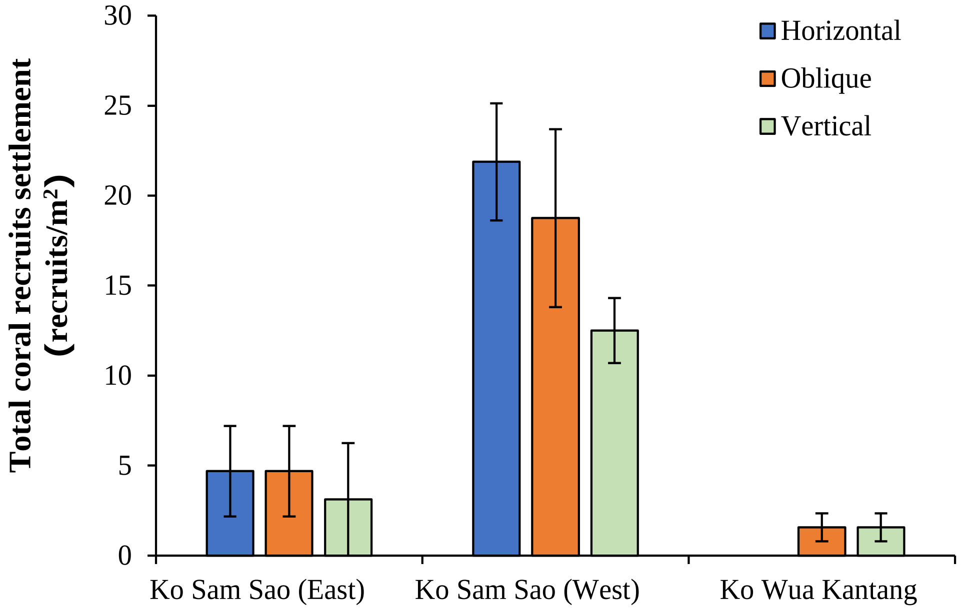


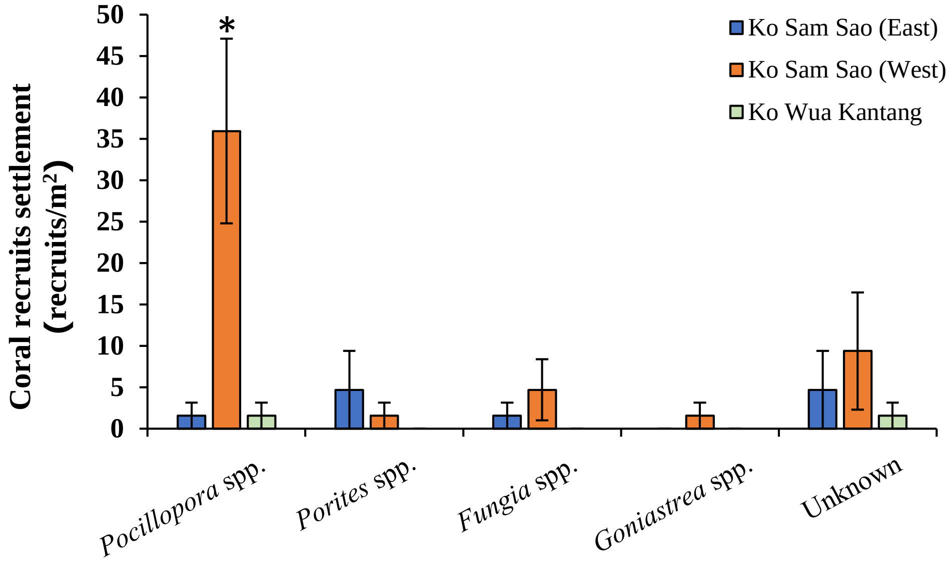
Figure 2. The settlement plate experiments at the study sites



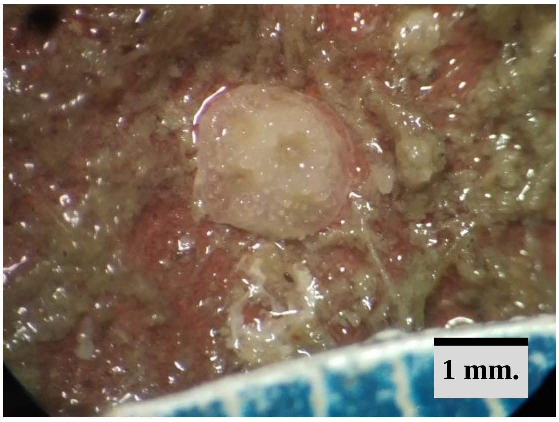
Figrue 3. Coral recruit densities on the settlement panels at three study sites from Mu Ko Angthong (mean ± SEM, $*p < 0.05$)



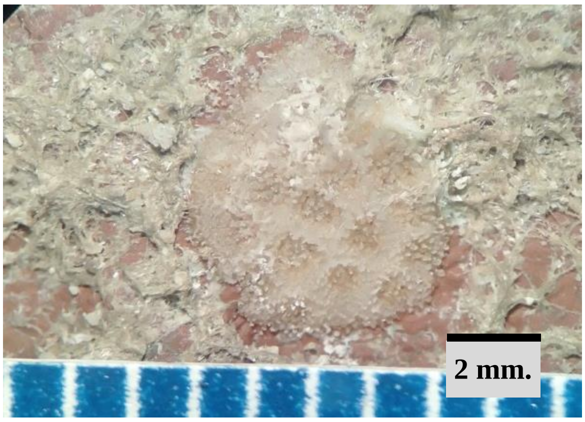
Figrue 4. Coral recruit densities on the settlement plates at three study sites from Mu Ko Angthong (mean ± SEM)



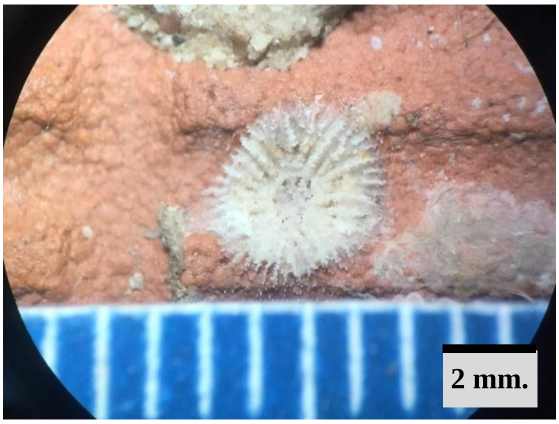
Figrue 5. Taxonomic composition of coral recruits on the settlement plate experiments at Mu Ko Angthong (mean ± SEM, *$p < 0.05$)



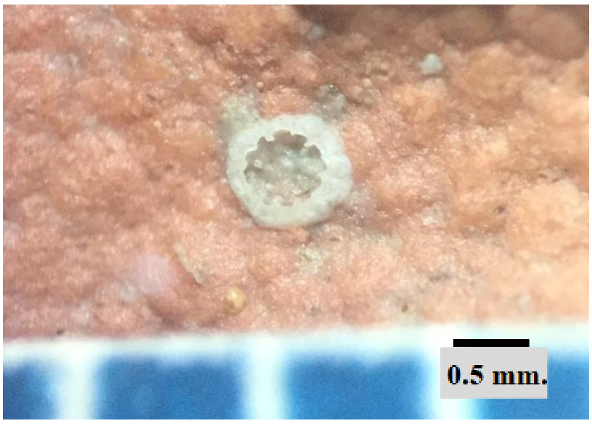
Pocillopora sp.



Porites sp.



Fungia sp.



Goniastrea sp.

Figrue 4. Dominant coral recruits on the settlement plates

4. Discussion

The natural recovery of the coral reef ecosystem following a disturbance depends on coral larval supply, successful settlement of larvae, and survival to adult reproductive age (Gilmour et al., 2013; Gouezo et al., 2019). This study has provided the first data on coral larval settled on experiment plate, which are essential baseline scientific data to understand coral recruitment patterns in Mu Ko Angthong. The number of larvae that directly determine terracotta plates in this paper can predict the post larva settled strategy of the coral more clearly than observed directly in natural ecosystem because the microscopic larvae are too small (1-10 mm in diameter) to census and tend to have cryptic settlement on the complex reef surfaces on the coral reef (Penin et al., 2010; Doropoulos et al., 2015; dela Cruz & Harrison, 2020).

After two-year experiment, coral recruitment rates varied significantly among the three study sites. Coral recruits attached on terracotta plates at Ko Sam Sao (West) were 4 and 17 times higher than Ko Sam Sao (East) and Ko Wua Kantang. The taxonomic composition of coral recruits at Ko Sam Sao (West) were the most abundant recruits during the study period by *Pocillopora* spp. up to 67%. The results of this study agree with the result by Ho and Dai (2014) that the coral recruits composition in the short-term survey was dominated by Pocilloporidae (52%-90%) and Acroporidae (10%-41%). Recruitment Comparison of the diversity of adult corals with the diversity of juvenile corals showed that Mu Ko Samet (Ao Kiew Na Nok and Ao Kiew Na Nai) are high degrees of self-seeding (Sutthacheep et al., 2020). Recruitments of coral have crucial connectivity with adult coral populations. It has been studied and assessed to identify self-seeding reefs and the level of connectivity among coral reefs (Selkoe &

Toonen, 2011; Feng et al., 2016). Coral reef connectivity and self-seeding of coral recruitment were varied among reef sites and are controlled by oceanographic conditions and larval supply sources (Kough & Paris, 2015).

The effect of terracotta plates angle in this research was variance to estimates of coral recruitment proved to but no significant difference among angle plates. However, coral larvae were mainly settled on the horizontal and following oblique, similar to the results of Mundy (2000), who found the coral recruit attached settlement plate angles between 0° to 40°. Nevertheless, our result shows that some coral recruits settled on the vertical angle plate. This result agrees with the result of Carleton and Sammarco (1987), who found the correlation between plate angle and coral recruit density significantly more recruits than expected on substrata angled between 61° and 90°. The results presented here also disagree with the suggestion by Sammarco (1991) that the optimum angle of settlement plates for coral recruitment settled between 37° and 45°.

Post-settlement of coral larvae mortality due to competition with algae and other benthos overgrowth for settlement space may also limit coral recruitment on the perfect substrate in the reef (Harriott and Banks 1995; Ho and Dai 2014). In our research, the filamentous algae were the most dominant group on the settlement plates, following coralline algae, bryozoans, polychaetes tube, barnacle, oyster, and sea sponge. These organisms often have higher growth rates and may quickly occupy the surface, thus prohibiting or excluding the settlement of coral recruits (Birkeland 1977; Ho and Dai 2014). While high post-settlement mortality remains a crucial challenge for coral restoration using (Randall et al., 2020) sexual production.

In conclusion, this study provides important baseline scientific data of coral recruitment patterns, composition, and substrates' angle in coral community structures. A long-term monitoring program for coral recruitment in other island groups in the Western Gulf of Thailand is needed to manage and considered a restoration tool for increase coral recruitment through this experiment.

Acknowledgments

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