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ORIGINAL PAPER

Juvenile coral communities in Mu Ko Chumphon and Mu Ko Angthong, the Western Gulf of Thailand

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Abstract: Investigating coral recruitment is one of the most effective strategies to understand the recovery potential of coral reef communities subjected to natural and anthropogenic disturbances. This research aimed to survey the density and diversity of juvenile corals at two Marine National Parks (MPAs) of the Western Gulf of Thailand. Seven study sites at Mu Ko Chumphon and six study sites at Mu Ko Ang Thong were investigated by random quadrats, 16x16 cm^2, to count and identify coral recruits (<5cm), while a belt transect was used to estimate the live coral cover. A total of 19 genera were identified among juveniles, being *Pocillopora* and *Favites* the most abundant. The highest and lowest percentage of live coral cover was found in Ko Ngam Noi and Ko Ngam Yai, respectively, both in Chumphon. The last also held the highest density of coral recruits. There was a significant negative correlation between live coral cover and recruit density. Simper analysis indicates around 78% of dissimilarity between the two MPAs. The low density of recruits at some sites might be an effect of high sedimentation. A high percentage of bare rock in Ko Ngam Yai may be skewing the correlation between recruit density and live coral cover. This study provides essential information for reef management and the proper application of coral restoration projects.

Key words: abundance, Gulf of Thailand, juvenile coral, recovery

1. Introduction

Coral reefs are recognized as very significant ecosystems that shelter thousands of species, providing food and livelihoods for coastal populations in tropical countries. Recently, coral reefs are facing threats from climate change such as ocean acidification, global warming, and other anthropogenic activities like overfishing, coastal development, and eutrophication, etc. (Hoegh-Guldberg et al., 2007). The recovery of reef ecosystems depends on disturbance regimes, local geomorphological and ecological characteristics, and anthropogenic influences (Graham et al., 2011).

Juvenile corals, or recruits, are small colonies between 0.5 and 5 cm in diameter and indicate coral settlement rates. The density of juvenile corals is one of the main parameters that can positively predict the recovery potential of coral reefs disturbed by mass bleaching events (Graham et al., 2015). Once reaching reproductive size, these colonies can exponentially speed up the recovery rates in coral reefs (Gilmour et al., 2013), creating an efficient, positive feedback loop that can result in rapid rates of coral cover expansion (Nyström et al., 2012).

Understanding the main processes driving coral community recovery is needed to properly predict ecosystems' responses to disturbances and manage impacts of habitats under increasing anthropogenic pressures. This study aimed to investigate juvenile coral diversity and density in two Marine Protected Areas (MPAs) in Thai waters.

2. Materials and Methods

The studies was conducted on coral communities in the Western Gulf of Thailand, comprising thirteen study sites from two groups of coral communities. Seven reef sites from Mu Ko

Chumphon (Ko Ngam Noi, Ko Ngam Yai, Ko Kula, Ko mattra, Ko I Raet, Ko Lawa, and Ko Rang Kachiu) and six reef sites from Mu Ko Angthong, Ko Sam Sao (W), Ko Sam Sao (N), Ko Sam Sao (E), Ko Wua Kantang, Ko Hindap and Ko Thaiphlao (Figure 1). The coral community surveys were conducted in 2018 at reefs varying from 1-8 m in depth. At each study site, quadrats (16x16 cm^2) were randomly placed on the substrate using SCUBA diving. The number of all visible coral recruits (≤ 5 cm in diameter) was counted and identified to genus level. Live coral cover at each study site was also quantified using two belt-transects of 50 x 1 m, and coral colonies (≥5 cm in diameter) were counted, and their coverage was quantitatively estimated.

The data of juvenile corals density and species diversity were analyzed using one-way ANOVA to detect a significant difference between the study sites. Where significant differences were found, the Tukey HSD (honestly significant difference) test was employed to determine which reef site(s) differed. Cluster analysis and the non-metric multidimensional scaling method were performed to categorize study sites based on Bray-Curtis similarity of juvenile corals density, using PRIMER version 7.0. The difference in the taxonomic composition of corals between Mu Ko Chumphon and Mu Ko Ang Thong was tested by analysis of similarities (ANOSIM), and the coral species were contributing most to the dissimilarity between the study sites were identified by similarity percentage (SIMPER) analyses. Pearson correlation analysis was also performed to determine the relationship between coral recruit density and live coral cover.

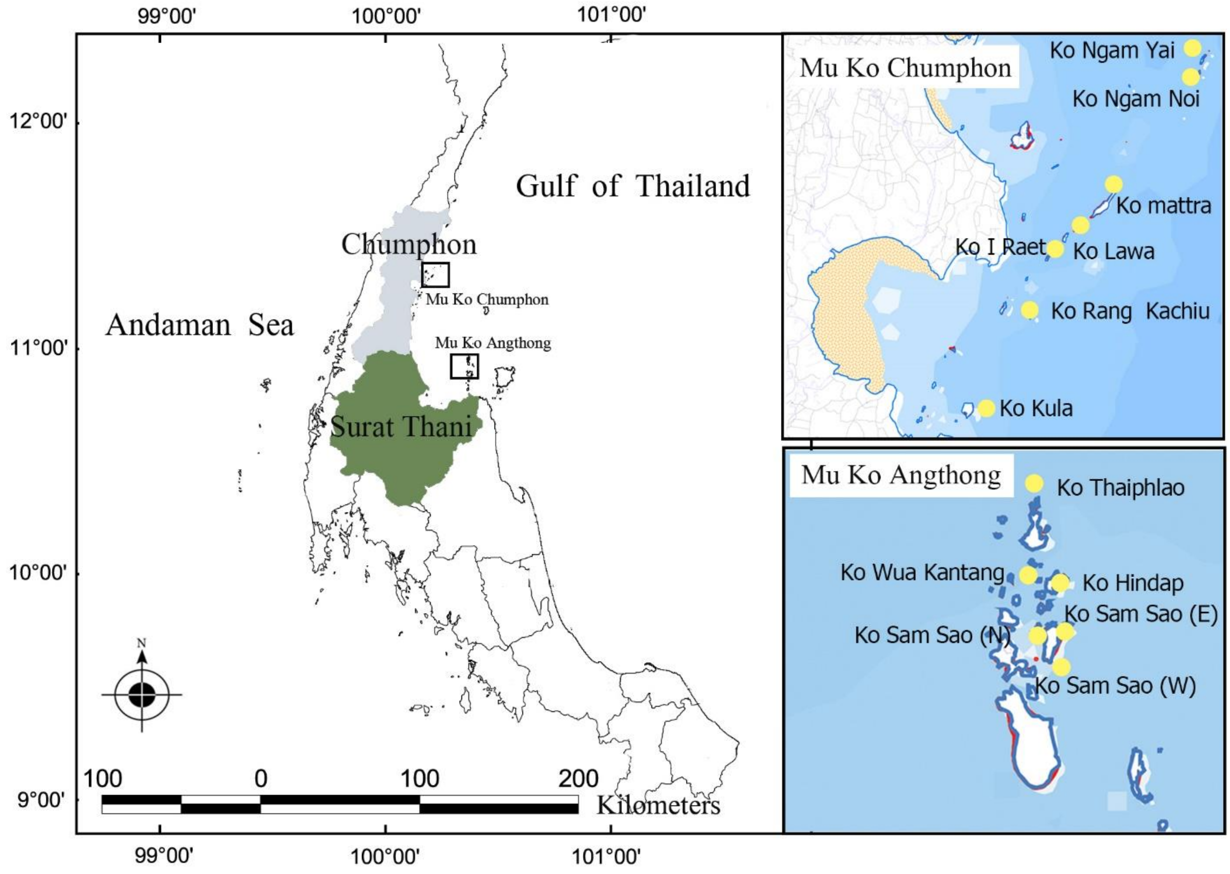

Figure 1. The location of study sites in Mu Ko Chumphon and Mu Ko Angthong

3. Results

The percentages of live coral cover ranged from 16.4±2.65 to 75.9 ±5.8 at Ko Ngam Yai and Ko Ngam Noi, respectively, both in Mu Ko Chumphon. The highest percentage of live coral cover in Mu Ko Angthong was found at Ko Wua Kantang (49.7±5.9), while the lowest one was observed at Ko Thaiphlao (35.4±4.2) (Figure 2).

Coral recruit densities varied from 2.1 to 32.0 recruits/m^2. The highest densities of coral recruits in Mu Ko Chumphon were found at Ko Ngam Yai (32.0±6.1 recruits/m^2), while the lowest density was recorded at Ko Rang Kachiu (2.3±0.4 recruits/m^2), and the highest density of coral recruits in Mu Ko Angthong was found at Ko Sam Sao (N) (6.67±0.8 recruits/m^2) while the lowest density was recorded at Ko Hindap (2.1±0.4 recruits/m^2) (Figure 3). The densities of juvenile corals at Ko Ngam Yai varied significantly among sites (one-way ANOVA, F = 122.109, $p<0.05$). A total of 19 genera of juvenile corals were commonly observed, the most abundant being *Pocillopora*, followed by *Favites* (Figure 4). The Shannon-Wiener index of diversity (H’) was significantly different among the study sites (one-way ANOVA, F = 14.937, $p<0.001$).

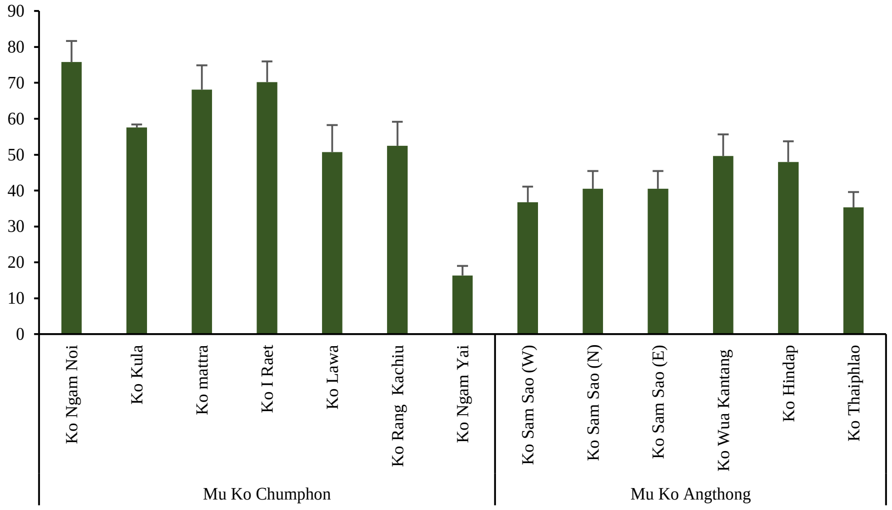

Figure 2. Live coral cover at the study sites (mean ± SD)

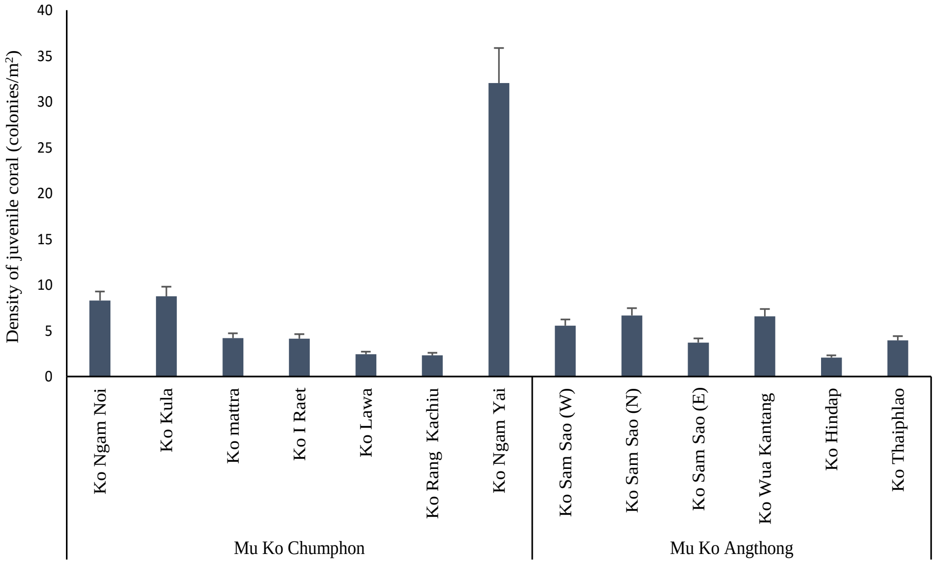

Figure 3. Density of juvenile corals (mean ± SD) on available substrate at the study sites

Figure 4. The density of juvenile corals genera at each study site

Analysis of Similarities (ANOSIM) indicated significant differences in the of juvenile corals between Mu Ko Chumphon and Mu Ko Angthong (R = 0.187, $p< 0.05$, Figure 5). The average similarity of juvenile corals within the areas varied from 21.70% in Mu Ko Chumphon to 32.95% in Mu Ko Ang Thong, whereas the dissimilarity between Mu Ko Chumphon and Mu Ko Angthong was 77.97% (Similarity Percentage (SIMPER) analyses, Table 1). Negative correlation between live coral cover and density of juvenile corals ($r=-0.49$, $p<0.01$, Figure 6)

Table 1. Similarity percentage (SIMPER) analysis of juvenile corals at the study sites

SIMPER	Contribution %
Mu Ko Chumphon and Mu Ko Angthong	
Pocillopora spp.	28.85
Favites spp.	19.75
Porites spp.	11.87
Pseudosiderastrea spp.	7.54
Fungia spp.	6.75

4. Discussion

The juvenile corals density in the Gulf of Thailand is usually lower than other reef sites in the Indo-Pacific region (Yeemin et al., 2009). This result showed that the densities of juvenile corals at Mu Ko Chumphon and Mu Ko Angthong varied from 2.1 to 32.0 juveniles /m2. Previous studies reported that several juvenile corals recorded in the southern Persian Gulf and Oman Sea had similar densities to those recorded elsewhere in the Indo-Pacific, ranging from 0.8 to 11 juveniles/m^2 (Hoey et al., 2011; Trapon et al., 2013). In the Red Sea, Glassom and Chadwick (2006) recorded 42-173 juvenile corals/m2, substantially higher than the 3.8 juveniles/m2. In this study, Ko Ngam Yai had a relatively high recruit density compared to other reef sites in the Gulf of Thailand. A high density of juvenile corals in some study sites, where low percent coverage of live coral was observed, maybe an effect of the influence of larval supply from nearby reefs. Low recruitment of scleractinian corals in Mu Ko Angthong, might be attributed to the reef degradation caused by sedimentation. Moeller (2016) highlighted that sedimentation effects could reduce recruitment success substantially, in addition, to also inhibit planula

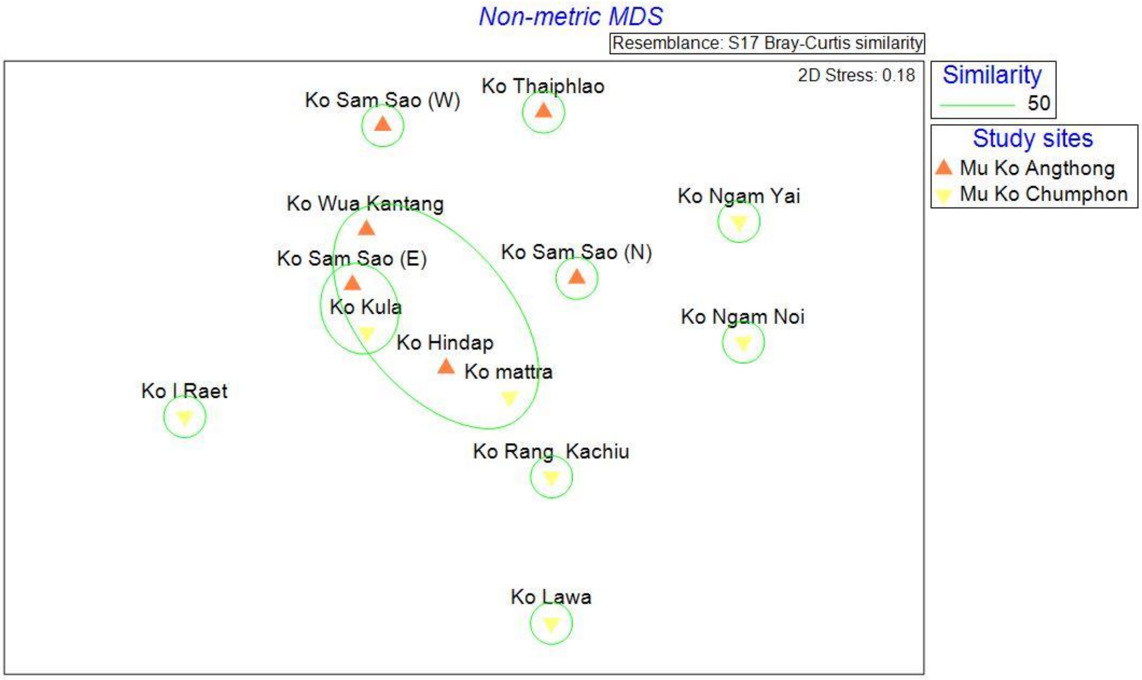

Figure 5. Two-dimensional Non-metric Multidimensional Scaling (nMDS) plot of the composition of juvenile corals at the study sites

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settlement on the substrate (Babcock and Davies, 1991). Several studies show that low recruitment rates may not be related to levels of coral cover or taxonomic composition (León et al., 2011). In this study, we suspect that other benthic species such as sponges and macroalgae could be potential factors affecting the coral recruitment due to stronger competition for a more restricted space on a high sedimentation substrate (Rützler, 2002). For example, several studies illustrated the competition between corals and macroalgae resulting in algal phase shifts over coral reefs (Gardner et al., 2003; McManus and Polsenberg, 2004; Maliao et al., 2008). However, the coral communities in the Gulf of Thailand can maintain their physical structures through the survival of resistant and tolerant coral species.

These resisting communities may provide larval supply to nearshore reefs along the Western Gulf of Thailand, ensuring connectivity between reefs and strengthening the coral communities in the Gulf of Thailand (Sojisuporn et al., 2010). Enhancing the survival rates of juvenile corals is essential for coral recovery following bleaching events (Shlesinger et al., 2016). Sediment originated from coastal development areas, and tourism related impacts should be carefully mitigated to allow passive coral reef restoration.

Several factors may influence spatial variation in juvenile coral density, such as larval supply from the parent colony in the reef, larval mortality, reef connectivity, settlement and post-settlement mortality, grazing, and sedimentation (Edmunds et al., 2018; Sutthacheep et al., 2018). The high recruit density in Ko Ngam Yai is skewing the data found here, which otherwise would show a slightly positive but not significant correlation between coral cover and recruit density. In addition, this site presents more substrate availability than the rest, with higher

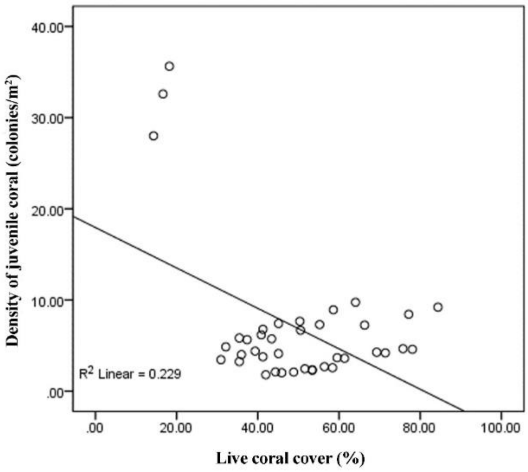

Figure 6. Relationships between the density of juvenile corals and live coral cover

percentages of bare rock. The relationship between the density of juvenile corals and substrates type may reflect that having more substrates to settle is a good indicator for connectivity between sites and the amount of larval supply from neighbor reefs. This study provides the necessary information to establish management plans for effective resource utilization in Mu Ko Chumphon and Mu Ko Angthong National Park.

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