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SCLERACTINIAN CORAL RECRUITMENT DENSITY IN COASTAL WATER OF BALOK, PAHANG, MALAYSIA

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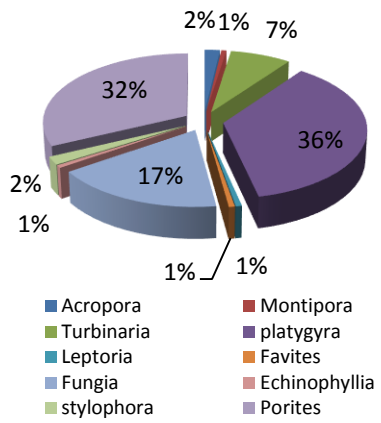
Graphical abstract



Abstract

Study on scleractinian coral recruitment is important in understanding the mechanisms that regulate their population and the resilience of coral reef communities to disturbance. This study aims to investigate temporal recruitment density of scleractinian coral at selected remote area in Balok, Pahang. Two types of settlement plates, which are terra-cotta tiles and artificial reef, were deployed at three stations to determine the recruitment density. The retrieval of the settlement plate was done at every three months interval started from March to September 2014. A total of 159 coral recruits were counted with mean recruitment densities on both terracotta tiles was 1.52 ± 0.65 and artificial reef plate was 4.37 ± 1.84 respectively. Recruitment was dominated by *Platygyra* (36%) followed by *Porites* (32%), *Fungia* (17%), *Turbinaria* (7%), *Acropora* (2%), *Stylopora* (2%), *Montipora* (1%), *Leptoria* (1%), *Favites* (1%) and *Echinophyllia* (1%). Kruskal - Wallis ANOVA test shown that recruitment densities varied significantly with plate's orientation ($p < 0.05$), but not with sampling stations, type of substrates and month retrieval. Artificial reef plate has better recruitment densities compared to terra-cotta tiles. Coral spat settlement and recruitment patterns were consistent with adult coral distributions. The percentage cover of adult coral varied within the three stations. A total of 33 coral genera from 13 families were recorded during coral video transect survey with Station 3 showed the highest H' (2.35). Meanwhile, Station 2 showed higher EH' indexes with 0.82. Therefore, results of this study is important because coral recruitment pattern reflect its adult coral population, and if it closely monitored and harvested sustainably, the survival of parent population could be increased for successful breeding.

Keywords: Scleractinian coral, recruitment density, coral spat, terracotta tiles, artificial reef plates

1.0 INTRODUCTION

Study on the temporal and spatial variation of scleractinian coral recruitment pattern is important in understanding the mechanisms that regulate coral reef populations [1]. In order to understand coral reef ecology, knowledge of recruitment pattern is needed

as they play important roles in promoting the recovery of coral reefs after disturbance [2].

Recruitment is simply defined as the number of new individuals that settle and survive until the time of observation, which reflects patterns of larva availability, larva substrate selection and post-settlement mortality rates.

Declining of coral reef ecosystem might be due to less attention given particularly on the fundamental of coral reef ecology, such as coral larvae study. In Malaysia, few studies were done previously regarding to colonization pattern of sessile benthic organism on artificial substrate at Payar Island, Langkawi [3]. However, those studies did not focus specifically on coral recruitment densities. Therefore, more information is needed on scleractinian coral population study, especially on coral larvae.

In particular, scleractinian coral recruitment is determined by biological factors, such as the amount of adult coral cover in populations, abundance and diversity of coral larvae, sedimentation and planktonic larval development [1]. Furthermore, coral settlement is also influenced by physical factor, such as hydrodynamic that related with wave and current pattern [4]. The relationship of those factors is important to determine the successful of coral settlement and recruitment at certain particular area.

Therefore in such situations, this study is crucial to describe coral recruitment pattern and processes within selected coral reef ecosystem such as Balok. By doing so, this study will fill the gap regarding to coral ecology understanding, reef resilience capacity and potential for natural recovery after disturbance. The objectives of this study are to investigate temporal pattern of coral recruitment density at selected area in Balok coastal waters and to compare different surface structure used in coral recruitment studies.

2.0 EXPERIMENTAL

2.1 Study Area

The study area is located in Balok, 10km up north from the east coast of Pahang State (Figure 1). Situated nearby to Kuantan port and Gebeng industrial area at the north, some areas contains stone shelf and home to some unexplored marine organism with the average depth around 7m to 15m depending on tides. In addition, this study area faced bimodal patterns of two monsoon periods; Northeast Monsoon from October to March and Southwest Monsoon from June to September [5]. Currently, the data and information on coral in this area is not well documented.

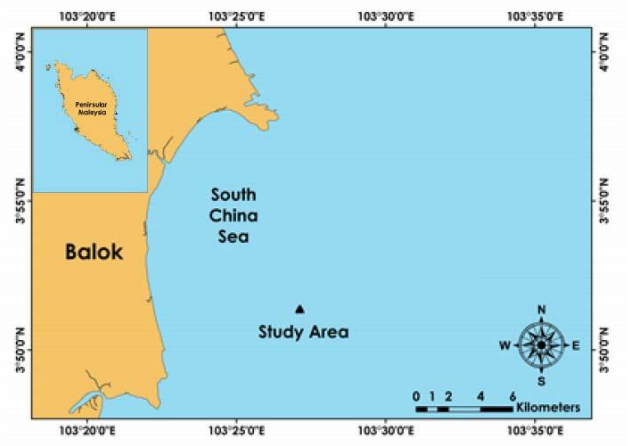


Figure 1 The map showing the location of study area in Balok, Pahang with Station 1 (St 1) : N 03° 51' 23.7", E 103° 27' 08.4", Station 2 (St 2) : N 03° 51' 21.6", E 103° 27' 07.6" and Station 3 (St 3) : N 03° 51' 23.3", E 103° 27' 06.1"

2.2 Scleractinian Coral Recruitment Density

This study was conducted at three station, namely station 1, station 2, and station 3 within 14 month period (July 2013 to September 2014). Two types of substrate (20 cm x 20 cm) were used; terracotta tiles and artificial reef plates. Artificial reef plate used has grooves and gaps which could mimic the natural rocks whereas terra-cotta tiles that have smooth surfaces. Both substrates were arranged settlement rack side by side and deployed at 10m to 15m depth. After 8 month leave in the water column, both substrates were retrieve back at every three months interval started from March to September 2014 by scuba diving. In laboratory, all samples were bleached with chlorine and dried in oven to remove organic matters. Observations on coral spats was made using Zeiss Stemi DV4 stereomicroscope. Coral spats then were counted and classified into 5 taxonomic categories to families level: Acroporidae, Pocilloporidae, Faviidae, Poritidae and Fungiidae [6]. Coral spats were photographed using Dino Lite Premier 2.0 digital microscope and scanning electron microscope model Hitachi S-2500 for detail identification. The juvenile coral were defined as colonies that have diameter less than 40mm, attached to the substrate and did not have the fractured surface characteristic of asexual recruits [1].

2.3 Adult Coral Community Structure

Benthic habitat composition was characterized at each station with respect to adults coral and other benthic taxa. This kind of information is important to see the relationship between recruitment and adult coral cover surrounding the study area [6]. In this study, Coral Video Transect (CVT) that adapted from the technique developed by the Australian Institute of Marine Science (AIMS) with some modification was used. An underwater video camera was used to record a narrow belt of the reef and the images were analyzed using

CPCe software to estimate the percentage cover of each adult coral community structure. Identification of adult corals and other benthic community structure were done based on the Coral Finder toolkit, reference book by Veron and Stafford Smith up to genus level [7]. Adult coral biodiversity was analyzed using Shannon-Weiner diversity index, genus richness and Shannon evenness.

2.4 Statistical Analysis

Variation of recruitment densities was examined between stations, length of plate's immersion (month), plate orientation and types of substrate. Data were transformed (log (n + 1) prior to analysis. Despite transformation, data were significantly non-normal (Kolmogorov Smirnov = 0.01). Therefore, non-parametric Kruskal-Wallis was used to test for differences or recruitment densities.

3.0 RESULTS AND DISCUSSION

3.1 Scleractinian Coral Recruitment Density

A total of 159 coral recruits were counted with mean recruitment densities on both terracotta tiles was 1.52 ± 0.65 and artificial reef plate was 4.37 ± 1.84 respectively . Recruitment was dominated by *Platygyra* (36%) followed by *Porites* (32%), *Fungia* (17%), *Turbinaria* (7%), *Acropora* (2%), *Stylopora* (2%), *Montipora* (1%), *Leptoria* (1%), *Favites* (1%) and *Echinophyllia* (1%) (Figure 2). *Platygyra* dominated recruits at all stations while *Porites* dominated recruits only at Station 2 (Figure 3). It can be suggested that turbid water condition in Balok suppresses recruitment densities. In addition, study done in Hawaii stated that higher sedimentation rate might results in reduction in larval recruitment on horizontal surfaces where sediment could accumulate [8]. Under turbid condition, coral larvae might not be able to settle and perhaps suffered due to early post-mortality. Recruitment densities of family Faviidae and Poritiidae increased significantly after 14 month of deployment at all stations except for family Acroporiidae. Besides, family Agariciidae and Dendrophyllidae also increased in recruitment density after 14 month deployment at station 2 and 3. Significant increase of Faviidae recruits could indicate the mass spawning event which begins somewhere in July 2013. Faviids is a broadcast spawner which release gametes during the mild spawning event. In addition, study conducted in Australia also shown that higher pigmented eggs of several Faviidae species were recorded during the mild spawning event compared to major spawning events [9]. Kruskal-Wallis test indicated that total recruitment densities varied significantly between position orientations (Figure 6) but not with station (Figure 4) types of substrate (Figure 5) and month of retrieval. Back position recorded higher recruit densities than front and side position with (Mann Whitney U = 6040, Z = -4.62 respectively, $\rho < 0.05$). It is observed that most of the upper surfaces of artificial reef were engulfed with sediment. Therefore, it can be speculated that coral larvae seek refuge and settle in the gap and holes available on artificial reef settlement plates. Besides, more recruitment on undersurface of settlement plate may due to higher competition with other fast growing sessile benthic organism which favour exposed surface [10].

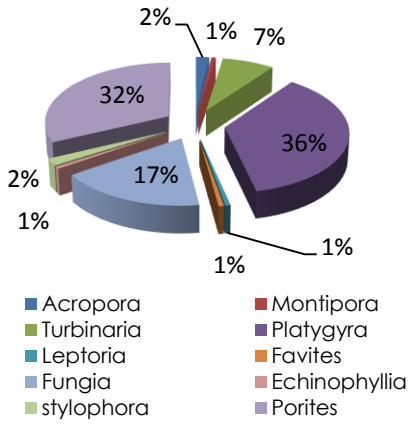


Figure 2 Percentage disribution of coral recruits density in selected area at Balok, Pahang

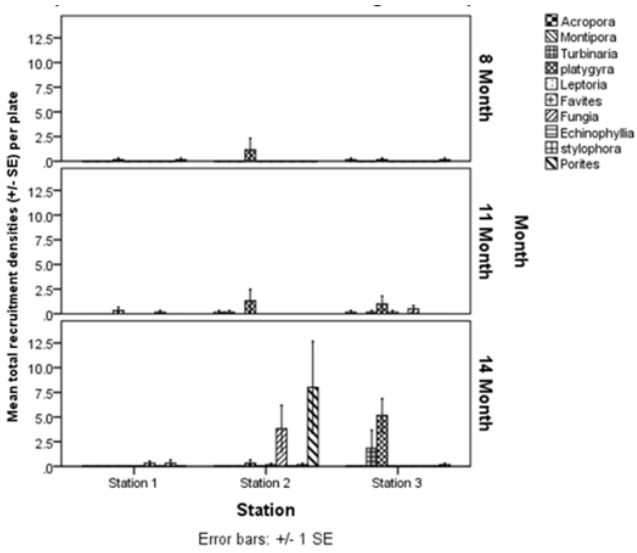


Figure 3 Total recruitment density based on coral genera in all station at Balok, Pahang

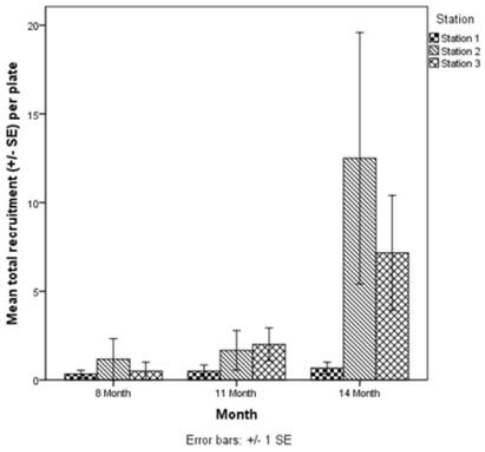


Figure 4 Comparison of recruitment densities based on station during settlement period

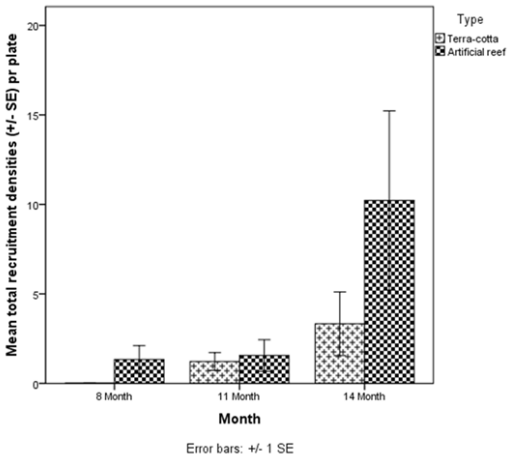


Figure 5 Comparison of recruitment densities on different types of substrate during settlement period

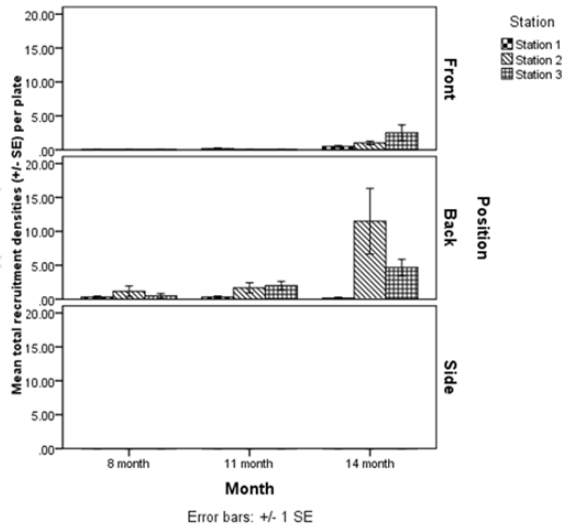


Figure 6 Comparison of recruitment densities on different plate orientation during settlement period

3.2 Adult Coral Community Structure

Thirty three coral genera from 13 families were recorded in the study area (Table 1). Station 1 recorded the highest abundance with 264 coral genera, followed by station 3 (238) and station 2 (89). Reef sites in Balok were located in undisturbed areas. However, they are located close to the mainland. Therefore, sediment runoff from terrestrial land coupled with strong wave action may increase the turbidity of the reef area. This condition may result in lower distribution and diversity coral coverage. Most of the areas surveyed were dominated by sponges and also abiotic benthic structure such as sand and rock. Besides, coral grows in patches and most reef sites dominated by massive coral such as Poritidae and Faviidae rather than Acroporidae. The study conducted at inshore continental shelf reefs of the Great Barrier Reef have shown that Porites genus was the major component of many coral communities [11]. One way ANOVA test showed that there was significant difference observed for coral diversity except genera richness and evenness. Station 3 has the highest diversity with 2.35 and station 2 recorded higher evenness index with 0.82 respectively (Table 2). Reef in remote areas experiences a less human disturbance, and may enhance coral community structure as a whole. Therefore, coastal water of Balok has relatively good diversity index due to having higher species diversity eventhough it has a relatively poor coral cover.

Table 1 Total abundance of coral genera based on Station (ST)

Family	Genera	Station 1	Station 2	Station 3
Acroporiidae	*Acropora*	+++	+	+
	Astreopora	-	-	+
	Montipora	-	+	+
Agariciidae	*Agaricia*	-	-	+
	Leptoseris	+	-	+
	Pachyseris	-	-	+
	Pavona	+	+	++
Dendrophylliidae	*Heteropsammia*	+	-	-
	Turbinaria	+	+	+
Euphyllidae	*Physogyra*	+	-	-
Faviidae	*Cyphastrea*	-	+	+
	Favia	+	+	+
	Favites	+	+	+
	Leptastrea	-	+	+
	Montastrea	-	-	+
	Oulastrea	-	-	+
	Platygyra	-	+	+
Fungiidae	*Cycloseris*	-	-	+
	Fungia	+	+	+
	Lithophyllon	+	+	+
	Podabacia	-	-	+
	Polyphyllia	-	-	+
Merulinidae	*oulophyllia*	+	-	-
Mussidae	*Lobophyllia*	+	-	-
	Symphyllia	+	-	+
Oculinidae	*Galaxea*	+	-	-
Pacilloporidae	*Stylopora*	+	-	-
Pectiniidae	*Pectinia*	-	+	+
	Mycedium	-	-	+
Poritidae	*Porites*	+++++	++	++++
	Goniopora	+	+	-
Siderastreidae	*Pseudosiderastrea*	-	+	+
	psammocora	-	+	+

+ = 0-25, ++ = 26-50, +++ = 51- 75, ++++ = 76-100, +++++ = < 100

Table 2 Shannon-Weiner diversity index (H') and evenness (EH') indexes among coral genera in Balok, Pahang

Station	S	H'max	H'	EH'
1	17	2.83	1.65	0.58
2	16	2.77	2.28	0.82
3	26	3.26	2.35	0.72

S = No. of genera
H'max = Ln (S), S = No. of species
H' = Shannon- Weiner Diversity Index
EH' = Shannon Evenness Index

4.0 CONCLUSION

The study has been carried out to investigate temporal pattern of coral recruitment density at 3 different stations in Balok coastal waters and to compare different surface structure (terracotta tiles and artificial reef plate). A total 159 coral spat were identified and 33 coral genera from 13 families were recorded in the study area. The result shown that recruitment of scleractinian coral larvae were consistent with distribution of adult coral with family Faviidae and Poritidae dominated at all station. The diversity index showed that station 3 recorded the highest diversity and distribution of adult coral compared to other station. In terms of surface structure, artificial reef plate has recorded the highest recruitment densities compared to terra-cotta tiles. It can be speculated that coral larvae might prefer rough surface rather than smooth due to the rough condition at coastal water of Balok. In term of plate orientation, back position recorded the highest recruitment compared to front and side position due to sedimentation effect and predation for space.

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