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Vertical distribution of zooxanthellate zoantharians on coral reefs of Terengganu Islands, Malaysia

Hin Boo Wee[1,*] , Hock Chark Liew, Zainudin Bachok[1,2], James Davis Reimer[1,3]

[1]Institute of Oceanography and Environment (INOS), Universiti Malaysia Terengganu (UMT), Terengganu, Malaysia

[2]School of Marine and Environment Sciences (SMES), Universiti Malaysia Terengganu (UMT), Terengganu, Malaysia

[3]Department of Biology, Chemistry & Marine Sciences, Faculty of Science, University of the Ryukyus, Okinawa, Japan

*Corresponding author. E-mail: takheru@gmail.com Tel: +60 (12) 443 8547

Abstract

This study investigated the vertical distribution of zooxanthellate zoantharian communities in the coral reef islands off the coast of Terengganu, Malaysia. The coral video transect (CVT) method was used to survey the zoantharians in four depth zones; 0-3 m, 3-6 m, 6-9 m and 9-12 m. The survey specifically focused on the two most common zooxanthellate genera, *Zoanthus* and *Palythoa*. The results showed that zoantharian colonies, especially genus *Zoanthus* spp. (r_s (35) =-0.333, p= 0.044) decreased in coverage with increasing depth of the coral reefs. Furthermore, both genera were more abundant at shallower reefs (<6 m from sea surface), and showed preference for particular substratum types. *Zoanthus* spp. were found most commonly on dead corals, whereas *Palythoa* spp. preferred boulders or rocks.

Key words: Zoantharians, video transect, coral reef, Malaysia

Introduction

Zontharians (Order Zoantharia) are common benthic marine organisms often found on shallow coral reefs in tropical and subtropical waters (Belford and Phillip, 2012, Burnett et al., 1997; Haywick and Mueller, 1997; Irei et al., 2011). However, they are less studied compared to scleractinian corals of the same subclass Hexacorallia (Reimer et al., 2008).

In recent years, studies on zoantharian molecular taxonomy and distribution have been increasing (e.g. Burnett et al., 1997; Irei et al., 2011; Rerimer et al., 2008; Reimer and Todd, 2009; Yang et al., 2013). However, there is a paucity of knowledge, particularly in the quantitative distribution of zoantharians (Belford and Phillip, 2012; Irei et al., 2011). Most records of zoantharians at reefs have been reported via observations during the collection of zoantharians specimens for identification or other biological studies (Karlson, 1983; Ono et al., 2005). Recently, a number of quantitative studies on the distribution of zoantharians have mainly focused at intertidal depths (Belford and Philip, 2012; Trivedi and Vachhrajani, 2014). However, aside from work by Irei et al. (2011) in subtropical Okinawa, such studies in subtidal coral reefs are still generally lacking.

To date, there has been no research focused specifically on zoantharians on Malaysian reefs, or in the Gulf of Thailand. Hence, this study aimed to 1) assess the vertical distribution of zoantharians at different depths on tropical coral reefs in Terengganu, Malaysia and 2) investigate the distribution of zoantharians compared to other benthos.

Materials and Methods

a) Study sites

The field surveys were conducted at coral reefs surrounding two small islands off Terengganu, Malaysia, namely Redang Island (5°46’39.85” N, 103° 0’33.56” E) (n= 6 sites), and Bidong Island (5°37'9.48"N, 103° 3'55.03"E) (n= 3 sites). In addition, a small rocky outcrop west of Redang Island, called Batu Bara (5°40'36.73"N, 102°49'31.13"E) was also examined (n= 1 site). A total of 10 field sites were investigated. The surveys were conducted between July 2013 and April 2014.

b) Field surveys

A modified Coral Video Transect (CVT) method (Liew et al., 2012) was used to estimate the vertical distribution and abundance of zoantharians and other coral reef benthos. A waterproof camera (Panasonic Lumix DMC-FT4) in an underwater housing (Lumix Underwater Casing) was used to record the coral reef. The recordings were made at High Definition 1080p resolution at 25 frames per second; the camera was held at 50 cm (±10cm) above the coral reef and running perpendicularly towards the shore at a rate of 5 m/minute. Videos were always recorded from deep to shallow.

Each field site had one transect and was represented as one replicate. Each transect was separated into four different depth zones. The transects length were not fixed, but ranged widely from 10m to 70m depending on the slope and coral reef cover while the video swath width was 33.5±4 cm. The video transect recordings were divided according to depth, with zone 1 (between 0 and 3 m), 2 (3-6 m), 3 (6-9 m), and 4 (9-12 m). A dive computer (Mares Puck Pro) was used to track the depth during the recording.

c) Data analyses

Recordings were viewed on a computer to extract frames for analyses, with 30 frames extracted from each recording spaced evenly. The benthic community cover for each frame was identified and analysed using the Coral Point Count with Excel extension (CPCe) software (Kohler & Gill, 2006). The benthos were classified into six major categories: zoantharians, live scleractinian corals, dead corals, algae, abiotic substrate (including sand, stones, etc.), and other organisms (soft corals, fish, sponges, giant clams, etc.). In addition, there were 24 minor categories within the major categories (Table 1).

Zooxanthellate zoantharians in this study were all identified as belonging to either the genera *Palythoa* (Fig. 1a,1b and 1e) or *Zoanthus* (Fig. 1c, 1d, and 1f). These two genera are known to be common in shallow coral reefs habitats of the Indo-Pacific (Burnett et al., 1997; Irei et al., 2011).

Non-parametric statistical analyses were used to analyse the data in this study using MiniTab17. The Kruskal-Wallis and Mann-Whitney tests were used to test for differences ($p < 0.05$) among and between groups. Spearman's rank-order correlation was used to identify the relationship between zoantharians and other coral reef benthos.

Results

There were a total of 37 video recordings made in this study. Recordings for 9-12 m were not made at one site in Redang and two sites in Bidong, due to the absence of coral reefs below 9 m depth.

The average benthic cover of total zooxanthellate zoantharians in this survey was 15.22% (±22.44%). The percentage benthic cover of *Zoanthus* spp. (13.80±22.08%) was significantly higher than *Palythoa* spp. (1.43±6.27%). A Mann-Whitney U test showed that median percentage cover of all zoantharians (1.67) and *Zoanthus* spp. (1.00) was not statistically different ($p=0.563$), whereas the median percentage cover of *Palythoa* spp. (0.00) was statistically different from that of total zoantharians ($p<0.001$). This indicates the dominance of *Zoanthus* spp. at the study sites.

Overall, zoantharians had the highest coverage percentage at depths between 3-6 m (24.36±30.20%), followed by 0-3 m (23.80±23.09%) (Table 1). *Zoanthus* spp. were commonly found at depths 0-3 m (19.47±24.04%) and 3-6 m (23.62±29.69%), while *Palythoa* spp. were most common at 0-3 m (4.33±11.82%). However, the Kruskal-Wallis test showed that there were no significant differences of percentage benthic cover for the total zoantharians (χ^2

(3) = 6.852, p=0.077), *Zoanthus* spp. (χ^2 (3) = 5.422, p=0.143) or *Palythoa* spp. (χ^2 (3) = 2.800, p=0.423) among depth zones.

Correlation tests were performed to determine the relationship between the depth zones with the percentage benthic cover of zoantharians. There were moderately significant, negative correlations between the depth zones with total zoantharians (r_s (35) =-0.420, p= 0.010) and *Zoanthus* spp (r_s (35) =-0.333, p= 0.044). However, percent coverage of *Palythoa* spp. had no significant difference with depth (r_s (35) =-0.262, p= 0.118).

Table 1. Coral video transect estimated relative abundance (%) of zooxanthellate zoantharians (*Palythoa* spp., *Zoanthus* pp.) and other coral reef benthic groups at Bidong and Redang Islands, Malaysia.

CATEGORIES	**DEPTHS (m)**							
	0-3		**3-6**		**6-9**		**9-12**	
RECORDINGS (n= 37)	10		10		10		7	
Zoantharian	23.80	±23.09	24.36	±30.20	±30.20	±13.06	1.76	± 3.23
Palythoa spp.	4.33	±11.82	0.74	± 2.01	± 2.01	± 0.53	-	-
Zoanthus spp.	19.47	±24.04	23.62	±29.69	±29.69	±13.12	1.76	± 3.23
Live Coral*	22.47	±11.07	27.20	±27.11	±27.11	±21.10	23.67	±16.31
Dead Coral*	20.85	±12.70	21.88	±14.86	±14.86	± 8.34	32.96	±14.26
Algae*	9.74	±12.72	14.36	±15.83	±15.83	±22.44	20.79	±21.69
Abiotic Substrate*	22.17	± 8.11	10.22	±19.39	±19.39	±18.56	19.19	±13.35
Other Organisms*	0.97	± 1.33	1.98	± 2.16	± 2.16	± 1.35	1.62	± 1.05
Shadow*	0.17	± 0.24	0.57	± 0.69	± 0.69	± 0.32	0.24	± 0.32

* The major categories above were further divided into minor categories as listed below:

Coral: branching and tabulate coral, encrusting and columnar coral, free-living and solitary coral, massive and sub-massive coral, plate and foliose coral

Dead Coral: dead coral, dead coral with algae

Algae: crustose coraline algae, *Lobophora*, other algae

Abiotic Substrate: boulders/ stones, rubble, sand

Other Organisms: anemones, giant clams, *Drupella*, echinoderms, soft corals, sponges, tunicates, fish, other organisms

Shadows: shadows

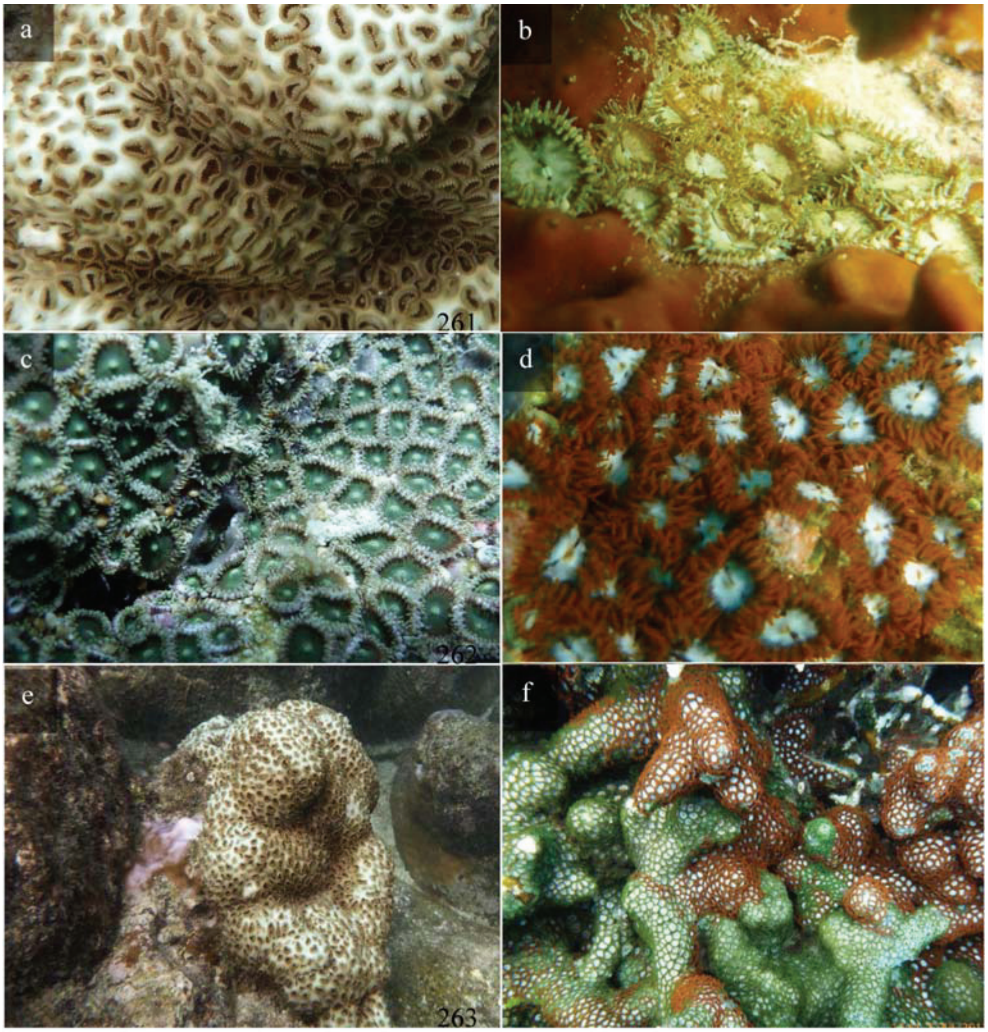

Fig . 1 (a-f): The two genera of zooxanthellate zoantharians in this survey; *Palythoa* spp. (a, b), and *Zoanthus* spp. (c, d) at Bidong and Redang Islands, Malaysia. *Palythoa* spp. were commonly found encrusting boulders near the intertidal zones (e). *Zoanthus* spp. colonies mat were observed to overgrow on dead branching corals (f).

Correlation tests between zoantharians and other coral reef benthos distributions were carried out. Percentage cover of zoantharians was shown to have statistically significant, moderate, positive correlation with dead corals (r_s (35) =0.404, p= 0.013). A moderately significant, negative correlation was also observed between zoantharians with dead coral covered with algae (r_s (35) =-0.353, p= 0.032), *Lobophora* spp. (r_s (35) =-0.357, p= 0.030), and other algae excluding *Lobophora* spp. (r_s (35) =-0.466, p= 0.004). *Zoanthus* spp. showed almost the same statistical significance and correlation as reported for zoantharians above, but no significant correlation with dead coral covered with algae (p= 0.217). *Palythoa* spp. had significantly strong, positive correlation with the presence of boulders or rocks on the reef (r_s (35) =0.524, p= 0.001).

Discussion

This is the first quantitative study on the distribution of zoantharians in Malaysia. When examining two genera of zoantharians, *Zoanthus* and *Palythoa*, *Zoanthus* spp. were found to have higher percentage cover compared to that of *Palythoa* spp. (Table 1). Furthermore, the mean percentage benthic cover of *Zoanthus* spp had no significant difference from the mean of all zoantharians. This indicates the clear dominance of *Zoanthus* spp. among zoantharians in the coral reef.

Zoantharians, especially *Zoanthus* spp., showed a decrease in benthic cover with an increase in depth, however this pattern was not statistically significant. This is probably due to the wide variation of coverage at shallower depths, particularly <6 m. In shallower areas, the abundance and density of zoantharians may be affected by environmental fluctuations in seawater temperatures, pH, salinity, and/or seasonal changes (Trivedi and Vachhrajani, 2014). This may cause variation in the abundance of zoantharians from low or untraceable coverage levels to levels dominating the entire reef. Alternatively, levels of disturbance (Karlson, 1983) or competition may also cause such variation. Regardless of the cause of the patchy zoantharian abundance, such zoantharian-dominated locations have previously been reported on, and are referred to as the ‘zoanthid zone’ in the Caribbean (Cooke, 1976; Karlson, 1988). On the other hand variations in benthic cover (including zoantharians) were smaller at depths >6 m. This may have been due to light level or the presence of silt and sand at deeper depths, as these environments have been shown to be not optimal for some species of zoantharians (Karlson, 1983).

Zooxanthellate zoantharian colonies often encrust on other benthic animals or attached to hard substratum, especially on rocks, boulders, coral rubbles or dead corals at shallow reef areas (Fig. 1e and

1f). *Zoanthus* spp. were found to be at shallower zones with the presence of dead corals and compete with algae for space to attach on dead corals (Birrell et al*.,* 2005; McCook, 1999). However, it has been theorized that *Zoanthus* spp. can maintain their dominance on shallow reefs by the presence of constant and intermediate levels of disturbances that creates bare substratum (Acosta et al., 2001; Karlson, 1983). *Zoanthus* spp. achieve dominance by attaching to dead corals, utilizing their coenenchyme as connective tissues on rubble (Fig. 1f). Under intermediate levels of disturbences, the coenochyme connects the polyps and the coral rubble or dead corals firmly together (Acosta et al., 2001; Karlson, 1983). This significantly reduces the competitiveness of other sessile organisms in such regions, and as zoantharians can easily colonize disturbed areas, it result in the domination of some shallow reef areas. Manipulative field experiments should be conducted to confirm or refute this hypothesis.

Additionally, *Palythoa* spp. were also found in shallow water, especially in the intertidal zone (Table 1) . Furthermore, *Palythoa* spp. were mostly found to be attached to boulders or rocks. The rock island Batu Bara had an extensive cover of *Palythoa* spp. on the rocky bottom at depths <6 m. *Palythoa* spp. present at other sites were observed to usually be attached to large boulders (Fig. 1e.). *Palythoa* spp. encrust their coenenchyme through the assimilation of carbonate sediment into their tissues to protect their soft tissues (Haywick and Meuller, 1997). This allows them to form extensive tight and rigid, yet spongy mats to survive in shallow tidal zones (Polak et al., 2011). Furthermore, with attachment on large hard substrates (large, heavy boulders), *Palythoa* spp. can colonize and dominate intertidal areas with high levels of wave action, yet prevent fragmentation (Acosta et al., 2001; Belford and Phillip, 2012; Polak et al., 2011; Tanner, 1997). Hence, *Palythoa* spp. are often found at shallow, intertidal areas of coral reefs with boulders or adjacent to rocky shores (Belford and Philip, 2012; Trivedi and Vachhrajani, 2014).

This study provides possible insights to the depth and substrate preferences of zooxanthellate zoantharians in the genera *Zoanthus* and *Palythoa* in Malaysia. As one of the major component of coral reefs, and with speculation that zooxanthellate zoantharians may be favoured under deteriorating environmental conditions (Cruz et al., 2014; Yang et al., 2014), more research on the ecology and abundance of these anthozoans are needed from different regions, especially from the understudied Indo-Pacific region.

Conclusions

Zooxanthellate zoantharians, especially *Zoanthus* spp., were commonly found on shallow reefs (depths < 6 m) surrounding the islands off the coast of Terengganu, Malaysia. *Zoanthus* spp. were found to be most common in areas with dead coral. On the other hand, *Palythoa* spp. were found to most commonly attach to large boulders. Future research should help confirm the preliminary field observations of this study.

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