THE SIGNIFICANCE OF ZOANTHARIANS IN CORAL REEF RESILIENCE

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"What is a scientist after all? It is a curious man looking through a keyhole, the keyhole of nature, trying to know what's going on."
~Jacques Yves Cousteau, Marine Explorer.

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This thesis undertook the initiative with lack of research on zoantharians in this region, to determine their significance in the coral reef resilience. Prior to answering the question, diversity as well as spatial and temporal distribution of zoantharians in Pulau Redang and Pulau Bidong were determined. The reef benthic communities reported in the distribution studies were then compared with the distribution of zoantharians to determine the resilience of the coral reef.

In this study, 31 specimens of zoantharian were collected and only 21 were identified. The speciemens were identified morphologically into different two genera, *Palythoa* and *Zoanthus*. For the genus *Palythoa* two species were identified, which were *Palythoa tuberculosa* and *Palythoa cf. toxica*, which both were only found at Pulau Redang. However for genus *Zoanthus*, two species were identified: *Zoanthus cf. sansibaricus* and *Zoanthus cf. vietnamensis*, were found in both Pulau Redang and Pulau Bidong. The explanation on the morphological characteristics of each species was presented and discussed accordingly. Another 10 specimens could only be identified until the genus level, of which all were *Zoanthus*.

Spatial distribution studies of zoantharians were focused on the two genera identified, *Zoanthus* and *Palythoa*, by looking at the depth preference (0-3 m, 3-6 m, 6-9 m and 9-12 m) and the variation of zoantharian cover among different reef sites (nine stations). The results showed both genera were more abundant at shallower reefs (<6 m from sea surface), and their percentage abundance, especially *Zoanthus* (r_s (35) =-0.333, p= 0.044), decreased relatively in coverage with increasing depth. Study of the variation of zoantharian cover among different stations were done at 3 m (±50 cm) depth. The percentage abundance of *Zoanthus* (14.84±23.70%) was found to be higher than *Palythoa* (0.83±2.26%) at all stations. Percentage cover of zoantharians varied among sites, which ranged from untraceable (0.00%) to 72.50%. Zoantharian zone was identified in the reef of Pulau Karah (72.50 ± 12.66%), as the reef was dominated by *Zoanthus* (probably single species). Zoantharians indicated preference for particular substratum types, *Zoanthus* spp. were found most commonly on dead corals, while *Palythoa* spp. were more common attached on boulders or rocks.

Temporal study of zoantharians in coral reefs were conducted with bimonthly revisits at six selected reef sites from July 2013 to September 2014. The survey was halted during North-East monsoon season from November 2013 to February 2014. The benthic cover of zoantharians, especially *Zoanthus*, were fairly constant throughout the sampling period (above 20%). However, their abundance reduced in March 2014 (18.30±15.19%) after the monsoon, indicate the impact of North-East monsoon to their distribution. Percentage cover of zoantharians increased relatively from May 2014 onwards. Percentage abundance of *Zoanthus* have negative correlation with percentage cover of live coral, dead coral, and algae (Spearman rho's correlation, $p<0.05$). Analysis of Similarity (ANOSIM) test showed that community structure of

reefs are fairly stable when zoantharian cover was moderate and high (>5% of total benthic cover). Nevertheless, if zoantharians were the dominant organism that cover the reef area, their percentage abundance might decrease due to the increasing of live coral cover.

In the distribution study, zoantharians were observed to have high abundance when other benthic covers, algae cover, and coral cover and diversity, were low. The competition between the zoantharians and algae on dead corals and open loose spaces (rubbles) suggest that zoantharians might be a phase in coral reef recovery. One year observation on coral reefs indicated dead corals, rubbles and even algae reduced in cover, with zoantharians replacing them. There were also inverse proportionate interaction of live coral and zoantharians cover, especially live coral cover increased during the monsoon season. These observations indicate that zoantharians played an important role in early stage of coral reef succesional recovery process, which contribute to the resilience of the reef.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu sebagai memenuhi keperluan ijazah Master Sains

KEPENTINGAN ZOANTHARIA DALAM DAYA KETAHANAN TERUMBU KARANG

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Tesis ini telah melaksanakan initiatif atas kekurangan kajian pada zoantharia di rantau ini, untuk menentukan kepentingannya dalam daya ketahanan terumbu karang. Sebelum ini, kepelbagaian dan taburan ruang dan masa zoantharia di Pulau Redang dan Pulau Bidong telah ditentukan. Taburan komuniti terumbu bentik kemudiannya dibandingkan dengan taburan zoantharia untuk menentukan daya ketahanan terumbu karang.

Dalam kajian ini, 31 spesimen zoantharia dikumpulkan dan hanya 21 dapat dikenal pasti. Spesimen dapat diasingkan melalui morfologi kepada dua genus yang berbeza, *Palythoa* dan *Zoanthus*. Untuk genus *Palythoa* dua spesies telah dikenal pasti, *Palythoa tuberculosa* dan *Palythoa cf. toxica*, yang kedua-duanya hanya dijumpai di Pulau Redang. Walau bagaimanapun, bagi genus *Zoanthus*, dua spesies telah dikenal pasti: *Zoanthus cf. sansibaricus* dan *Zoanthus cf. vietnamensis*, ditemui di kedua-dua pulau. Penjelasan kepada ciri-ciri morfologi setiap spesies ini telah dibentangkan dan dibincangkan dengan sewajarnya. 10 spesimen hanya dapat dikenal pasti sehingga tahap genus, yang mana kesemuanya adalah *Zoanthus*.

Kajian taburan zoantharia telah memberi tumpuan kepada dua genera yang telah dikenal pasti, *Zoanthus* dan *Palythoa*, dengan mengkaji kecenderungan kedalaman (0-3 m, 3-6 m, 6-9 m dan 9-12 m) dan variasi taburannya antara tapak terumbu karang (sembilan stesen). Hasil kajian menunjukkan kedua-dua genera lebih banyak ditemui di kawasan cetek terumbu (<6 m dari permukaan laut), dan taburan mereka, terutamanya *Zoanthus* (r_s (35) = -0,333, p = 0,044), menurun relatif kepada peningkatan kedalaman. Kajian variasi taburan zoantharia antara stesen berbeza telah dilakukan pada 3 m (±50 cm) kedalaman. Peratusan taburan *Zoanthus* (14.84 ± 23,70%) didapati lebih tinggi daripada *Palythoa* (0.83 ± 2.26%) di semua stesen. Taburan peratusan zoantharia berbeza antara tapak dari tidak dapat dikesan (0.00%) kepada 72.50%. 'Zon Zoanthid' telah dikenal pasti dalam terumbu Pulau Karah (72.50 ± 12.66%), kerana kawasan tersebut didominasi oleh *Zoanthus* (mungkin spesies tunggal). Zoantharia menunjukkan kecenderungan untuk bertapak di sesetengah substrat, *Zoanthus* spp. didapati paling biasa bertapak di batu karang yang telah mati, manakala *Palythoa* spp. di atas batu-bata.

Kajian tempoh zoantharia di terumbu karang telah dijalankan dengan lawatan semula setiap dua bulan di enam tapak terpilih dari Julai 2013 hingga September 2014. Kajian ini telah dihentikan semasa musim tengkujuh Timur Laut dari bulan November 2013 hingga Februari 2014. Taburan bentik zoantharia terutama *Zoanthus*, adalah agak tetap sepanjang tempoh kajian (melebihi 20%). Walau bagaimanapun, taburan mereka berkurangan pada Mac 2014 (18.30 ± 15.19%) selepas musim tengkujuh, ini menunjukkan kesan musim tengkujuh Timur Laut terhadap taburan mereka. Peratusan penutupan zoantharia meningkat secara relatif dari Mei 2014 dan seterusnya. Peratusan taburan *Zoanthus* didapati mempunyai korelasi negatif dengan peratusan

taburan karang hidup, karang mati, dan alga (korelasi Spearman rho, $p < 0.05$). Ujian 'Analysis of Similarity' (ANOSIM, Analisis Kesamaan) menunjukkan bahawa struktur komuniti terumbu stabil secara relatif apabila peratus penutupan zoantharia adalah sederhana dan tinggi (> 5% daripada jumlah penutupan bentik). Walau bagaimanapun, jika zoantharia adalah organisma yang dominan meliputi kawasan terumbu, kebanyakannya peratusan mereka berkurangan disebabkan oleh peningkatan secara langsung penutupan karang.

Dalam kajian taburan ini, zoantharia diperhatikan mempunyai taburan yang tinggi apabila taburan penutupan bentik yang lain, seperti alga, dan karang dengan kepelbagaiannya, adalah rendah. Pertandingan antara zoantharia dengan bentik lain untuk kawasan terbuka seperti karang mati dan timbunannya, mencadangkan bahawa mereka mungkin terlibat dalam fasa pemulihan terumbu karang. Pemerhatian selama setahun pada terumbu karang menunjukan bahawa karang mati, runtuhan karang dan juga alga berkurangan dari segi penutupan, dengan zoantharia menggantikan mereka. Terdapat juga interaksi berkadar songsang antara karang hidup dan zoantharia, terutamanya peningkatan penutupan karang hidup semasa musim tengkujuh. Pemerhatian ini menunjukkan bahawa zoantharia memainkan peranan yang penting dalam peringkat awal proses pemulihan berperingkat terumbu karang, yang menyubang kepada daya ketahanan terumbu karang.