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A BRIEF SURVEY OF CORAL SPECIES COMPOSITION IN PULAU TINGGI, JOHOR, MALAYSIA

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Abstract: Updating the status of coral species composition is important for long-term reef ecosystem management. The present study aims to determine the species composition of scleractinian hard and soft corals in the shallow water areas of Pulau Tinggi, Johor. About 1,494 coral colonies were surveyed at two selected reef sites: Kampung Pasir Panjang (Site A) and Kampung Sebirah Kecil (Site B). With images of close-up coral corallites, 41 species belonging to 24 genera and 10 families of corals were identified with genera *Goniastrea*, *Porites* and *Montipora* predominantly found in the study area. Overall, the data presented in this study helps to update the current species composition of corals in the marine protected area of Pulau Tinggi.

Keywords: Marine ecosystem, hermatypic coral, species diversity, offshore island, Marine Park, Peninsular Malaysia, Seribuat archipelago, South China Sea.

Introduction

Coral reefs are important as a food source and potential use for future medicine. The healthy coral reef provides livelihoods for poor local communities, ecotourism, and recreational opportunities. They protect our shores from high waves and coastal erosion. Coral reefs in Malaysia cover approximately 4,000 km^2 areas (Burke *et al*., 2011) and contain an estimated 501 hermatypic coral species (Waheed, 2016) which is equivalent to more than 60% of the world's described hermatypic corals (Veron *et al*., 2011). However, over 40% are exposed to numerous anthropogenic threats (Burke *et al*., 2011) with sedimentation being a major threat affecting reefs on the west coast of Peninsular Malaysia (Safuan *et al*., 2018; Akmal *et al*., 2018). On the east coast of the peninsular, extensive coastal development activities may contribute to the accumulated negative impacts on coral reefs (Toda *et al*., 2007; Shahbudin *et al*., 2017; Akmal *et al*., 2019).

Pulau Tinggi, situated on the east coast of Peninsular Malaysia is one of the Marine Parks under the state of Johor. It comprises a few smaller uninhabited islands, namely Pulau Ibul, Pulau Apil, Pulau Mentigi, Pulau Nanga, Pulau Penyembang, Pulau Simbang and Pulau Lanting. It is also relatively close to the mainland, located about 10.5 nautical miles off the southeast coast of Peninsular Malaysia. Consequently, coral reefs in Pulau Tinggi have also been subjected to pressure imposed by sedimentation due to land clearing for coastal development activities along the shoreline of the Peninsular (Harborne *et al*., 2000; Lee & Mohamed, 2011).

In terms of hard coral diversity surrounding this Marine Park, an earlier coral survey recorded 155 scleractinian coral species within reefs around Pulau Dayang, Pulau Pemanggil, Pulau Simbang and Batu Tikus (Harborne *et al*., 2000). Meanwhile, a study conducted by Azman *et al*. (2012) recorded 75 coral species with *Acropora* and *Porites* being dominant

in the waters around Pulau Tinggi. Based on extensive coral surveys by Lee *et al.* (2012), 229 species of scleractinian corals were recorded at Pulau Aur, Pulau Pemanggil, Pulau Besar, Pulau Tinggi and Pulau Sibu.

In Malaysia, most of the coral surveys have been carried out around the islands on the east coast of Peninsular Malaysia such as in Pulau Tioman and Pulau Redang (e.g., Khodzori *et al*., 2015; Kamarumtham *et al*., 2016; Shahbudin *et al*., 2017; Akmal *et al*., 2019; Akmal & Shahbudin, 2020; 2021). However, several reef surveys have been conducted in Pulau Tinggi (e.g., Harborne *et al*., 2000; Toda *et al*., 2007; Lee *et al*., 2012; 2022). It is also important to keep updating the current list of coral species within reefs in the peninsular region. Therefore, this study primarily aims to determine the species composition of scleractinian hard and soft corals in shallow water areas of Pulau Tinggi, Johor. The outcomes of this study would be valuable to the Marine Park and Resource Management Division, Department of Fisheries (DOF) and universities in updating coral inventories and providing an effective management plan to manage the coral reef ecosystem sustainably.

Materials and Methods

Study Area

Pulau Tinggi is located about 30 kilometres in linear distance from the mainland of Mersing, on the east coast of Johor, within the rectangle coordinates of 2° 15' 25.98'' N, 104° 05' 28.8'' E and 2° 19' 04.79'' N, 104° 09' 43.08'' E. It is a relatively large island with an estimated land area of 1524.18 hectares but sparsely inhabited. The topography of Pulau Tinggi is characterized by narrow coastal fringes, sharply rising to rocky ridges and escarpments (Azman *et al*., 2008). Previously in 1994, Pulau Tinggi and its surrounding waters up to 2 nautical miles were gazetted as a Marine Park under the Fisheries Act 1985. On 15 August 2013, the coastal waters of Pulau Tinggi (comprised of 13 main islands Pulau Tinggi, Pulau Rawa, Pulau Besar, Pulau Tengah, Pulau Hujung, Pulau Mensirip, Pulau Harimau, Pulau Goal, Pulau Mentigi, Pulau Sibu, Pulau Sibu Hujong, Pulau Aur and Pulau Pemanggil) had been declared as Sultan Iskandar Marine Park (SIMP) by His Royal Highness the Sultan of Johor. In this study, fieldwork was carried out between July and August 2019 at two reef sites nearby to Kampung Pasir Panjang (Site A) and Kampung Sebirah Kechil (Site B), Pulau Tinggi (Figure 1).

Coral Survey

At two selected survey sites, 10 transect lines, each 20 metres long were randomly laid down perpendicular to the shoreline. Direct observation was used for coral surveys along all transect lines during the lowest low tide at approximately one and a half hours of swimming. With the aid of an underwater camera, the stilt images of close-up coral corallites were also captured, enabling later identification and verification processes. The scleractinian hard corals were identified up to genera and species levels using the Indo-Pacific Coral Finder Toolkit (Kelly, 2009) and the books of Corals of the World (Veron & Stafford-Smith, 2000). The identified scleractinian hard coral species was further standardized with the most recent taxonomy of Scleractinia following the World Register of Marine Species (Hoeksema & Cairns, 2021). Meanwhile, the soft corals were identified following Fabricious and Alderslade (2001).

Results and Discussion

Checklist of Coral Species in Pulau Tinggi

Based on recent taxonomic classification, the current surveys have recorded a total of 41 species from 24 genera and 10 families of corals in Pulau Tinggi (Table 1). Out of these, 38 species were the scleractinian hard corals while 3 were the soft corals. The present result of this study also listed 2 rare species based on their abundance status retrieved from the website of Corals of the World (Figure 2) while 13 near threatened and 4 vulnerable species based on their conservation status retrieved from the website of IUCN Red List of Threatened

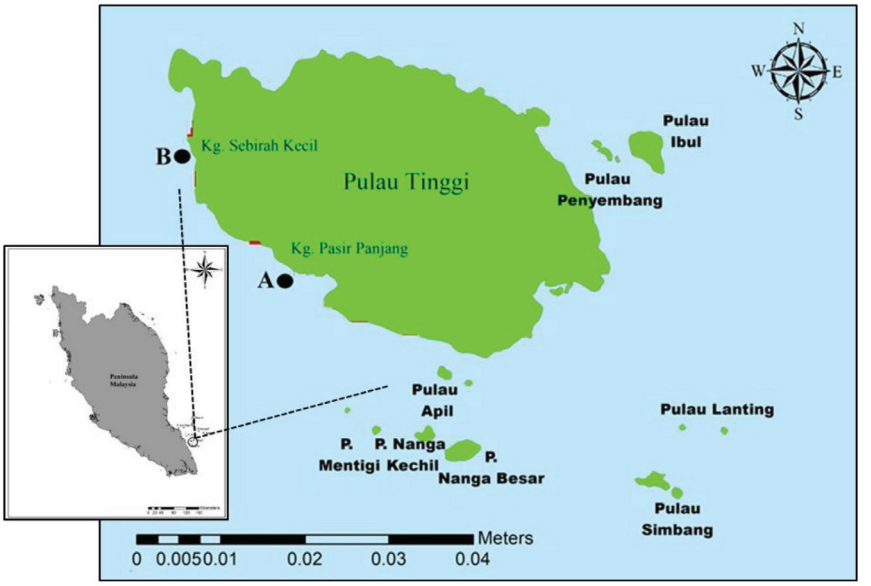

Figure 1: Map of the study area in Pulau Tinggi
A. Kampung Pasir Panjang (Site A), B. Kampung Sebirah Kecil (Site B)

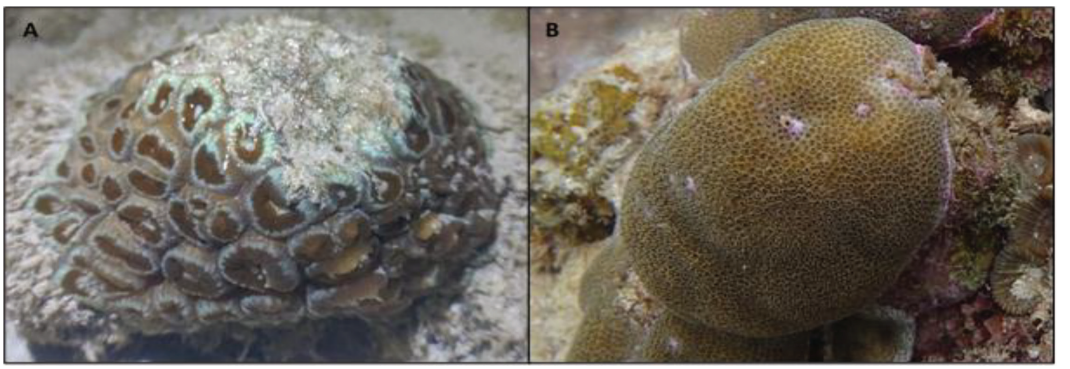

Figure 2: Rare coral species recorded in Pulau Tinggi, Johor
Dipsastraea truncata (Veron, 2000), B. *Porites solida* (Forskål, 1775)

Species. Most of the coral species recorded in this study are commonly found in shallow water areas of the Indo-Pacific. However, certain species were rare, near threatened and vulnerable in their status, thus requiring further protection and conservation efforts. This coral species list provides updated data and information to management personnel from the DOF, the Marine Park and Resource Management Division, and relevant authorities on the status of coral composition in Pulau Tinggi. Figure 3 shows some underwater pictures of the coral reef found in this study.

Figure 3: Some of the underwater pictures of the coral reef found in this study sites

Table 1: List of coral species recorded at Site A and B in Pulau Tinggi, Johor. Scleractinian hard coral species were updated according to the World Register of Marine Species (WoRMS). The abundance and conservation status for each species were referred based on the websites of Corals of the World (COTW) and IUCN Red List of Threatened Species

No.	Family	Genera	Species	COTW Status	IUCN Status
Scleractinian Hard Corals					
1	Acroporidae	*Acropora*	*Acropora digitifera* (Dana, 1846)	Common	Near threatened
2		*Montipora*	*Montipora digitata* (Dana, 1846)	Common	Least concern
3	Agariciidae	*Pavona*	*Pavona cactus* (Forskål, 1775)	Common	Vulnerable
4			*Pavona decussata* (Dana, 1846)	Common	Vulnerable
5	Dendrophylliidae	*Turbinaria*	*Turbinaria peltata* (Esper, 1792)	Common	Vulnerable
6	Euphylliidae	*Galaxea*	*Galaxea astreata* (Lamarck, 1816)	Common	Vulnerable
7			*Galaxea fascicularis* (Linnaeus, 1758)	Common	Near threatened

8	Merulinidae	*Dipsastraea*	*Dipsastraea maritima* (Nemenzo, 1971)	Uncommon	Near threatened
9			*Dipsastraea pallida* (Dana, 1846)	Uncommon	Least concern
10			*Dipsastraea speciosa* (Dana, 1846)	Common	Least concern
11			*Dipsastraea truncata* (Veron, 2000)	Rare	Near threatened
12			*Dipsastraea favus* (Forskål, 1775)	Common	Near threatened
13		*Leptastrea*	*Leptastrea purpurea* (Dana, 1846)	Common	Least concern
14		*Cyphastrea*	*Cyphastrea serailia* (Forskål, 1775)	Common	Least concern
15		*Favites*	*Favites abdita* (Ellis & Solander, 1786)	Common	Near threatened
16			*Favites halicora* (Ehrenberg, 1834)	Uncommon	Near threatened
17			*Favites flexuosa* (Dana, 1846)	Uncommon	Near threatened
18		*Coelastrea*	*Coelastrea aspera* (Verrill, 1866)	Uncommon	Near threatened
19		*Goniastrea*	*Goniastrea pectinata* (Ehrenberg, 1834)	Common	Least concern
20			*Goniastrea retiformis* (Lamarck, 1816)	Common	Least concern
21			*Gonistrea edwardsi* (Chevalier, 1971)	Common	Least concern
22			*Goniastrea stelligera (*Dana, 1846)	Common	Near threatened
23		*Platygyra*	*Platygyra sinensis* (Veron, 2000)	Uncommon	Near threatened
24			*Platygyra pini* Chevalier, 1975	Uncommon	Near threatened
25		*Leptastrea*	*Leptastrea pruinosa* Crossland, 1952	Common	Least concern
26	Fungiidae	*Ctenactis*	*Ctenactis echinata* (Pallas, 1766)	Common	Least concern
27		*Lithophyllon*	*Lithophyllon concinna* (Verrill, 1864)	Common	Least concern
28		*Fungia*	*Fungia fungites* (Linneaus, 1758)	Common	Near threatened

29	Lobophylliidae	*Acanthastrea*	*Acanthastrea echinata* (Dana, 1846)	Common	Least concern
30		*Lobophyllia*	*Lobophyllia agaricia* (Milne Edwards & Haime, 1849)	Uncommon	Least concern
31			*Lobophyllia recta* (Dana, 1846)	Common	Least concern
32	Pocilloporidae	*Pocillopora*	*Pocillopora acuta* (Lamarck, 1816)	Common	Least concern
33			*Pocillopora damicornis* (Linnaeus, 1758)	Common	Least concern
34		*Stylophora*	*Stylophora pistillata* (Esper, 1797)	Common	Least concern
35	Poritidae	*Porites*	*Porites lobata* (Dana, 1846)	Common	Least concern
36			*Porites lutea* (Milne Edwards & Haime, 1851)	Uncommon	Least concern
37			*Porites rus* (Forskål, 1775)	Common	Least concern
38			*Porites solida* (Forskål, 1775)	Rare	Data deficient
Soft Corals					
39	Alcyoniidae	*Lobophytum*	*Lobophytum* sp. 1	Not available	Not available
40		*Sarcophyton*	*Sarcophyton* sp. 1	Not available	Not available
41		*Sinularia*	*Sinularia* sp. 1	Not available	Not available

Coral Composition in Pulau Tinggi

A total of 1,494 coral colonies were surveyed in the study area (Figure 3). Overall, a total of 24 genera from 10 families, comprising scleractinian hard coral and soft coral were identified in this study. Of these, approximately 94% were the scleractinian hard corals while only 6% were the soft ones. *Goniastrea* (637 colonies/42.6%) had the highest coral genera found in Pulau Tinggi followed by *Porites* (291 colonies/19.5%) and *Montipora* (152 colonies/10.2%) (Figure 4).

Goniastrea comes from the most genus-rich family (Merulinidae) of reef-building corals in the Indo-Pacific region (Veron & Stafford-Smith, 2000). The massive to sub-massive growth forms of this genus help to prevent them from desiccation on aerial exposure to the reef flat (Brown *et al*., 2014). It is possible that this may lead to their adaptation in intertidal areas where they are frequently exposed during low tide (Smith, 2006; Syahrir *et al*., 2018). Besides, the genus *Porites* showed the second-highest coral colonies In Pulau Tinggi. The massive type of genus *Porites* is known as a stress-tolerator where they can adapt to the changes in environmental parameters such as currents, wave actions and fluctuation of suspended sedimentation (Edinger & Risk, 2000; Supriharyono, 2004; Syahrir *et al*., 2018).

Montipora also showed among the highest genera, where a species of *M. digitata* can be found abundant in the study area. The digitate and arborescent growth forms of this species help to tolerate extreme tidal conditions (Paper

et al., 2011). Previous studies also indicated that *Goniastrea*, *Porites* and *Montipora* are among the most dominant genera recorded on the east coast of Peninsular Malaysia (Toda *et al.,* 2007; Shahbudin *et al*., 2017) which is consistent with the results of this current study. Other scleractinian coral genera such as *Fungia* (5.2%), *Dipsastraea* (4.9%), *Pavona* (3.4%), *Platygyra* (1.4%), *Acropora* (1.2%), *Favites* (1.4%) and *Pocillopora* (1.2%) were also found distributed (>0.1%) in the study area of Pulau Tinggi.

In this study, soft corals from the family Alcyoniidae such as *Lobophytum* (61 colonies/4.1%) and *Sarcophyton* (22 colonies/1.5%) were also found common in the sampling area. Most coral colonies are large and can be found in certain micro areas along the transect lines. These soft corals were also highly resistant to wave and current fluctuations in the intertidal zone. Soft corals have a flexible structure that can withstand strong currents, waves and sediment (Fabricius & Alderslade, 2001). Hence, this might contributes to their survival on exposed reef sites in Pulau Tinggi, Johor.

Conclusion

This study updates our current knowledge of the coral species, which is important for the management and conservation efforts of the coral reef ecosystem in Pulau Tinggi and the marine ecosystem in Malaysia. Periodical monitoring must be conducted on the coral reef which is important for food resources and livelihoods of the coastal zone communities in Johor.

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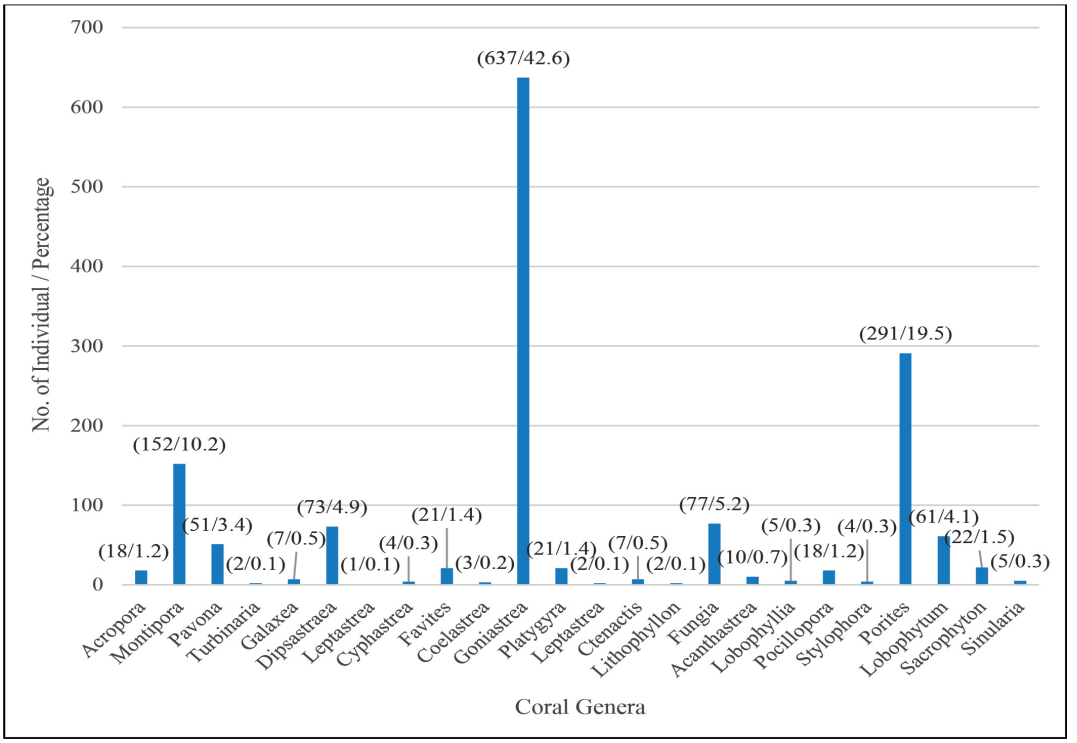

Figure 4: Total number and percentage cover of coral species recorded at Site A and B in Pulau Tinggi, Johor

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