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Diversity of Family Fungiidae in Malaysian Waters

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Abstract Diversity of the family Fungiidae was investigated in Malaysian waters during an expedition in 2004. From the samples collected on 18 reef locations around Malaysian waters, only 12 locations contained fungiid corals. From the locations that have fungiid corals, 11 species from five genera were recorded. They are *Fungia (Ctenactis) echinata*, *Fungia (Ctenactis) simplex*, *Fungia (Danafungia) scruposa*, *Fungia (Danafungia) danai*, *Fungia (Fungia) fungites*, *Fungia (Pleuractis) paumotensis*, *Fungia (Pleuractis) scutaria*, *Halomitra pileus*, *Sandalolitha robusta*, *Herpolitha limax* and *Polyphyllia talpina*. The diversity of the fungiid corals at Hempasan Dang Ajar and Terumbu Peninjau far outweighs all other sites with six different species at each location. Other locations have three species on average. Out of 11 species of Fungiidae coral, *Sandalolitha robusta* and *Herpolitha limax* are the most commonly found species. They are found on seven sampling locations each. The rarest species are *Fungia simplex*, *Fungia scruposa* and *Fungia paumotensis* which can be found at only one sampling location each. Other available species could be found at three locations on average. This study has reported higher number of fungiid species compared to previous studies done in Peninsular Malaysia but similar with the study done in Singapore.

Key words: Taxonomy, morphological features, fungiid corals, species, genera

Introduction

Coral Family Fungiidae derived their name from the Latin word *fungus*, which means mushroom, to describe the mushroom-like appearance of most specimens. The fungiid corals are commonly sited amongst the diverse growth of a coral reef community and are one of the most conspicuous groups of extant Indo-Pacific reef in Order Scleractinia. They are almost all distinctively solitary free-living coral, partially mobile and uniquely shaped. Most of the free-living fungiid are small in size to assist in their mobility. The most noticeable features of the mushroom corals are their immense polyp size. Indeed, the polyps of fungiids are among the largest known, with *Heliofungia* measuring over 50cm in diameter (Veron, 1993).

Peninsular and East Malaysia are situated on the Sunda Shelf in relatively shallow water. Coral diversity is relatively low on the west coast of Peninsular Malaysia's reef compared to the east coast of Peninsular Malaysia's reefs due to turbid conditions and muddy substrates (Chua & Charles, 1980). Malaysian reefs and their coral fauna have been reasonably well studied. Searle (1980) produced a key to 78 species of corals from Peninsular Malaysia, and this work has been updated and expanded by Betterton (1981). However, until relatively recently, very little was known about the life history and ecology of this fascinating group of corals from the Family Fungiidae, especially those distributed on the reefs located at the South China Sea.

This study aims to investigate the diversity of the Fungiidae from the reefs surrounding the South China Sea. Sampling was conducted during the Research on the Seas and Islands of Malaysia (ROSES) Expedition in 2004. This study also compares the diversity of Family Fungiidae sampled

during the ROSES expedition with other reef locations.

MATERIALS AND METHODS

Study sites

Research on the Seas and Islands of Malaysia (ROSES) Expedition was an ambitious project which aimed to explore the richness of Malaysia's marine realm for the Science of Biotechnology and Biodiversity. During the ROSES expedition, 18 reef locations were sampled. They are Pulau Perak, Pulau Jarak, Permatang Penyu (Vernon Bank), Terumbu Peninjau (Investigator Reef), Permatang Ubi (Ardasier Bank), Terumbu Laya (Dallas Reef), Pulau Layang-layang, Terumbu Matanani (Mariveles Reef), Terumbu Siput (Erica Reef), Terumbu Semarang Barat Besar (Royal Charlotte Reef), Terumbu Semarang Barat Kecil (Louisa Reef), Terumbu Permaisuri (Moody Reef), Terumbu Asun (Hardie Reef), Terumbu Dato' Landih (Aitken Reef), HEMPASAN DANG AJAR (Seahorse Breakers), Terumbu Sahab (Stigan Reef), Terumbu Saji (Herald Reef) and HEMPASAN BANTIN (Luconia Breakers). Most of these reefs are fringing reefs with gradual slope to a maximum depth of between 35-50m. The sites and their approximate coordinates are listed in Table 1 and mapped in Figure 1.

These reefs were relatively unstudied before as most of them occur too far off the coast to be accessible enough for elaborate research to be conducted. The reefs depth ranged from as low as 4m to a maximum depth of approximately 30m. Pulau Perak, which is situated west of Pulau Pinang and in the middle of the Straits of Malacca, is a 200m wide conical rocky island with the steep slope continuing underwater to a depth of about 50m. Pulau Jarak is also located in the Straits of Malacca.

Sampling method

The line transect method which covered between 100-150m by 2m swath per transect were conducted using SCUBA. The samplings were conducted from the base of the coral rich zone (~ 30 m) to shallow water (< 5 m). An initial descent was generally made to the base of the reef but occasionally the surveys started beyond the maximum depth of abundant coral growth. Distances of area surveyed were calculated and the numbers of same species were converted into Relative Abundance unit (individual per 100m²). The time constraint of the expedition (43 days) meant that sampling frequency on each reef is low on many occasions where some of the reefs were only sampled once. Field guides assisted identification was used underwater. However, a number of species were sighted which could not be identified, photographs were taken underwater or the samples were collected to be identified later in the laboratory.

Sample preparation and identification

Samples that were removed from the sea were washed with freshwater to eliminate some of the live tissues of the sample. It is more efficient to wash the samples with high pressurized jet of freshwater. This process could reduce part of the coral's organic materials. Samples that were washed are then dried under direct sunlight covered with newspaper. The newspaper acts as an absorber of the smell and has to be changed occasionally.

When the samples are dry, it is then left submerged in 5.25% solution of sodium hypochlorite or bleach solution that has been diluted with freshwater. Dilution ratios are bleach solution to freshwater, 1:4 for delicately structured samples and 1:2 for heavily calcified samples. Samples are left in said solution for 24 or 48 hours until they are white. Samples are washed with freshwater and dried under direct sunlight again. Dried samples are odourless and stored in a room with sufficient airflow to keep the samples safe from damage due to excess moisture.

All the sample corals were identified in the laboratory at Muka Head Marine Research Station,

Table 1. Reef locations and their approximate coordinates.

Location	Location (Sampling Site)	Approximate Coordinates	
Straits of Malacca	Pulau Perak	N 5° 41' 16.1" E 98° 57' 24.0"	
	Pulau Jarak	N 3° 58' 31.5" E100° 05' 39.1"	
South China Sea off the west coast of Sabah	Permatang Penyu (Vernon Bank)	N 5° 50' 03.5" E115° 06' 09.3"	
	Terumbu Peninjau (Investigaor Reef)	N 8° 07' 58.3" E114° 47' 56.6"	
	Permatang Ubi (Ardasier Bank)	N 7° 56' 42.3" E114° 26' 00.0"	
	Terumbu Laya (Dallas Reef)	N 7° 36' 40.7" E113° 44' 47.0"	
	Pulau Layang-Layang	N 7° 22' 47.6" E113° 50' 36.2"	
	Terumbu Mantanani (Mariveles Reef)	N 7° 58' 36.0" E113° 54' 07.8"	
	Terumbu Siput (Erica Reef)	N 8° 05' 57.1" E114° 07' 54.7"	
	Terumbu Semarang Barat Besar (Royal Charlotte Reef)	N 6° 20' 09.0" E113° 34' 36.1"	
	Terumbu Semarang Barat Kecil (Louisa Reef)	N 6° 20' 09.0" E113° 13' 48.2"	
	Terumbu Pemaissuri (Moody Reef)	N 5° 35' 29.8" E112° 32' 24.1"	
	Gugusan Beting Raja Jarom (North Luconia Shoals)	Terumbu Asun (Hardie Reef)	N 5° 50' 57.0" E112° 28' 09.1"
		Terumbu Dato' Landih (Aiken Reef)	N 5° 53' 22.7" E112° 32' 26.7"
Hempasan Dang Ajar (Seahorse Breakers)		N 5° 30' 14.6" E112° 34' 47.2"	
Terumbu Sahab (Stigan Reef)		N 5° 01' 15.4" E112° 28' 37.4"	
Terumbu Saji (Herald Reef)		N 4° 58' 30.6" E112° 36' 28.2"	
Gugusan Beting Patinggi Ali	Hempasan Bantin	N 5° 01' 22.9" E112° 38' 28.9"	

Universiti Sains Malaysia using taxonomic keys from various books such as Betterton (1981), Koh and Chou (1989) and Veron (1993). Samples were analyzed with the help of a magnifying glass although in some cases, the septa and costae features are too minute and the help of a dissection microscope is sought.

Physical and chemical data sampling

Physical (Temperature, salinity and dissolved oxygen) and chemical (nitrate and phosphate) data were collected throughout the expedition using Hydrolab Data Sonde 4, except for total suspended

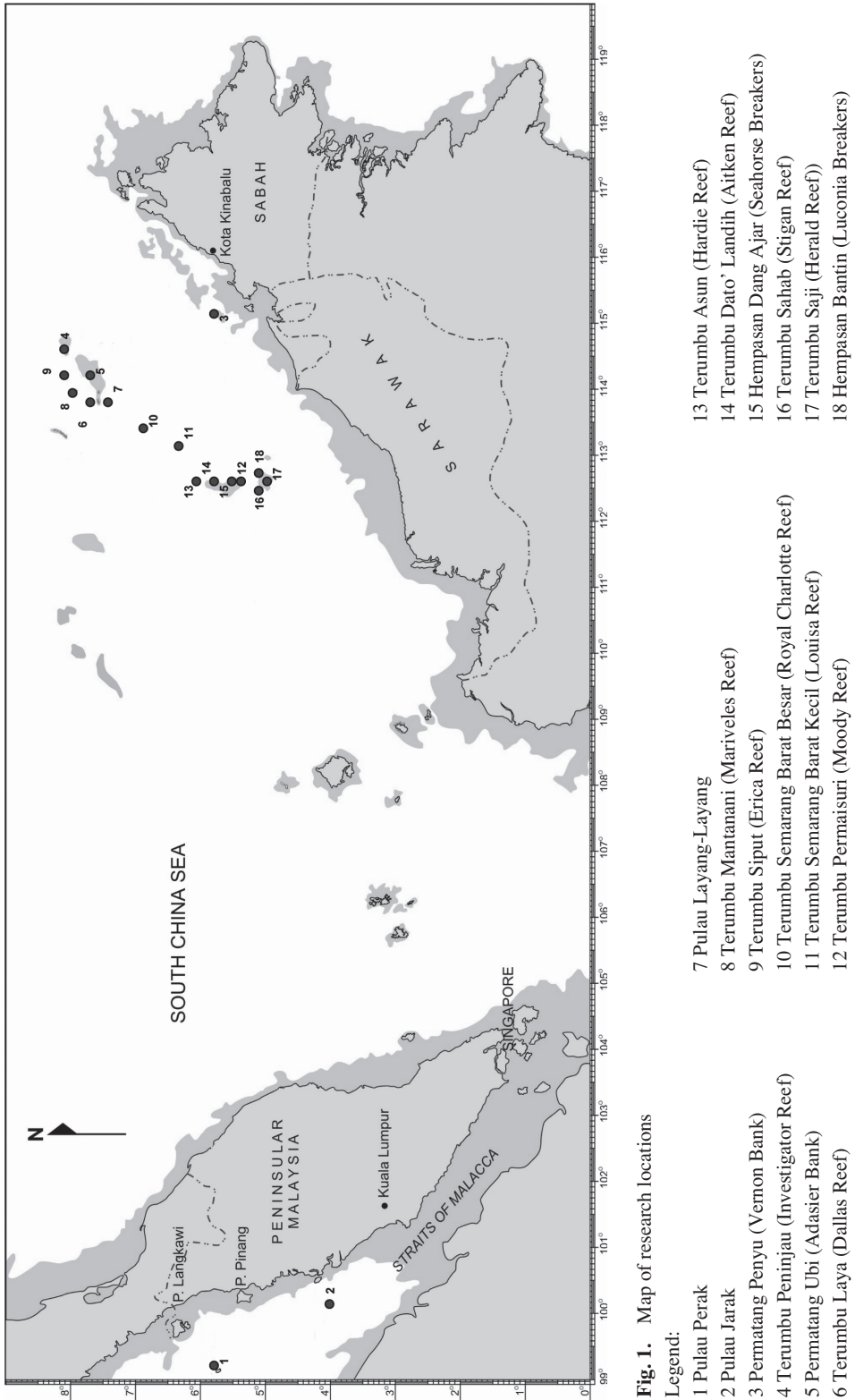


Fig. 1. Map of research locations

Legend:

- 1 Pulau Perak
- 2 Pulau Jarak
- 3 Permatang Penyau (Vernon Bank)
- 4 Terumbu Peninjau (Investigator Reef)
- 5 Permatang Ubi (Adasier Bank)
- 6 Terumbu Laya (Dallas Reef)
- 7 Pulau Layang-Layang
- 8 Terumbu Mantanani (Mariveles Reef)
- 9 Terumbu Siput (Erica Reef)
- 10 Terumbu Semarang Barat Besar (Royal Charlotte Reef)
- 11 Terumbu Semarang Barat Kecil (Louisa Reef)
- 12 Terumbu Permaisuri (Moody Reef)
- 13 Terumbu Asun (Hardie Reef)
- 14 Terumbu Dato' Landih (Aitken Reef)
- 15 Hempasan Dang Ajar (Seahorse Breakers)
- 16 Terumbu Sahab (Stigan Reef)
- 17 Terumbu Saji (Herald Reef)
- 18 Hempasan Bantin (Luconia Breakers)

solid measurement. Total suspended solid measurement was carried out based on AHPA (1992) by drying method at 103-105°C.

RESULTS AND DISCUSSION

Of all the 18 reef locations that were sampled, only 12 locations contained Fungiidae corals. The locations are Pulau Perak, Terumbu Peninjau (Investigator Reef), Permatang Ubi (Ardasier Bank), Terumbu Laya (Dallas Reef), Terumbu Matanani (Mariveles Reef), Terumbu Semarang Barat Besar (Royal Charlotte Reef), Terumbu Semarang Barat Kecil (Louisa Reef), Terumbu Permaisuri (Moody Reef), Terumbu Asun (Hardie Reef), Terumbu Dato' Landih (Aitken Reef), Hempasan Dang Ajar (Seahorse Breakers) and Hempasan Bantin (Luconia Breakers). The remaining six locations devoid of fungiid coral samples are Pulau Jarak, Permatang Penyu (Vernon Bank), Pulau Layang-layang, Terumbu Siput (Erica Reef), Terumbu Sahab (Stignan Reef) and Terumbu Saji (Herald Reef). The availability and the relative abundance of the species of corals according to the reef locations is shown in Table 2.

The diversity of the fungiid corals at Hempasan Dang Ajar and Terumbu Peninjau far outweighs all other sites with a record of six different species at each location, with 12 and 15 individuals per 100m², respectively. Terumbu Permaisuri, Terumbu Asun and Terumbu Dato' Landih have three different fungiid species each. Terumbu Matanani, Terumbu Semarang Barat Besar and Terumbu Semarang Barat Kecil each contain two different fungiid species while Pulau Perak and Terumbu Laya each contain one species. Figure 2 shows the number of fungiid species found at each reef location.

The results indicated that 11 species from five genera were found. Of the 11 species found, the most common was *Sandadolitha robusta* and *Herpolitha limax* - which was found on seven sampling locations. The rarest of the species was *Fungia simplex*, *F. scruposa* and *F. paumotensis*, which was found only on one location each.

Meanwhile, *F. fungites* was found in the Straits of Malacca - at Pulau Perak. No fungiids were found in Pulau Jarak. The low diversity of fungiids in the Straits of Malacca may be due to the higher total suspended solids and lower surface salinity (Table 3), compared to the reefs located at the South China Sea. However, *F. fungites* was also found at Terumbu Peninjau and Permatang Ubi (both of the Layang-layang group) in the South China Sea indicating the environmentally tolerant nature and wider distribution of the species.

Fungia echinata could be found at five locations. *Fungia scutaria* can be found at four locations. *Fungia fungites*, *Halomitra pileus* and *Polyphillia talpina* could be found at three locations each. *Fungia danai* could be found at two locations. Figure 3 summarizes the distribution of fungiid corals in the reef locations.

Five genera and 11 species have been recorded in this study and this reflects a lower diversity of fungiid corals compared to the 11 genera and 34 species of fungiid corals reported by Veron (1993) of the Indo-Pacific corals, and 6 genera and 13 species of fungiids by Koh and Chou (1989) from southern Singapore. Veron (1993) had reported a high diversity of Fungiidae corals because the area covered in his work is very wide (Indo-Pacific) compared to this study which only covered the Straits of Malacca and the central of South China Sea. The low diversity of fungiids in Malaysian waters may be due to the limited numbers of samplings being carried out as well as the sampling coverage for each sampling locations during the expedition.

Table 2. The relative abundance of the species of fungiid corals according to reef locations.

Location	Site Number	Location (Sampling Site)	Species (number of individuals per 100m ²)											Total number of species			
			Fungia echinata	Fungia simplex	Fungia danai	Fungia scruposa	Fungia fungites	Fungia scutaria	Fungia paumotensis	Holmitra pileus	Sandalolitha robusta	Herpolitha himax	Polyphyllia talpina				
Straits of Malacca	1	Pulau Perak	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1
	2	Pulau Jarak	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	3	P. Penyu	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
South China Sea off the west coast of Sabah	4	T. Peninjau	2	1	-	-	3	-	-	-	-	5	3	1	1	6	
	5	P. Ubi	2	-	-	-	2	-	1	-	-	-	5	-	-	4	
	6	T. Laya	-	-	-	-	-	-	-	-	-	-	4	-	-	1	
	7	P. Layang-layang	-	-	-	-	-	-	-	-	-	-	-	-	-	0	
	8	T. Matanani	1	-	-	3	-	-	-	-	-	-	-	-	-	2	
	9	T. Siput	-	-	-	-	-	-	-	-	-	-	-	-	-	0	
Gugusan Beting Raja Jarom (North Luconia Shaols)	10	T. Semarang Barat Besar	-	-	-	-	-	-	-	-	6	1	-	-	2		
	11	T. Semarang Barat Kecil	-	-	-	-	-	1	-	-	1	-	-	-	2		
	12	T. Permaisuri	-	-	3	-	-	-	-	-	1	-	-	1	3		
Gugusan Beting Patinggi Ali (South Luconia Shaols)	13	T. Asun	-	-	-	-	-	-	5	-	2	1	-	-	3		
	14	T. Dato' Landih	-	-	-	-	-	1	-	1	-	-	-	1	3		
	15	H. Dang Ajar	1	-	3	-	-	3	-	1	2	2	-	-	6		
Gugusan Beting Patinggi Ali (South Luconia Shaols)	16	T. Sahab	-	-	-	-	-	-	-	-	-	-	-	-	0		
	17	T. Saji	-	-	-	-	-	-	-	-	-	-	-	-	0		
	18	H. Bantin	1	-	-	-	-	-	-	1	1	1	3	-	4		
Total number of location			5	1	2	1	3	4	1	3	7	7	3	7	3		

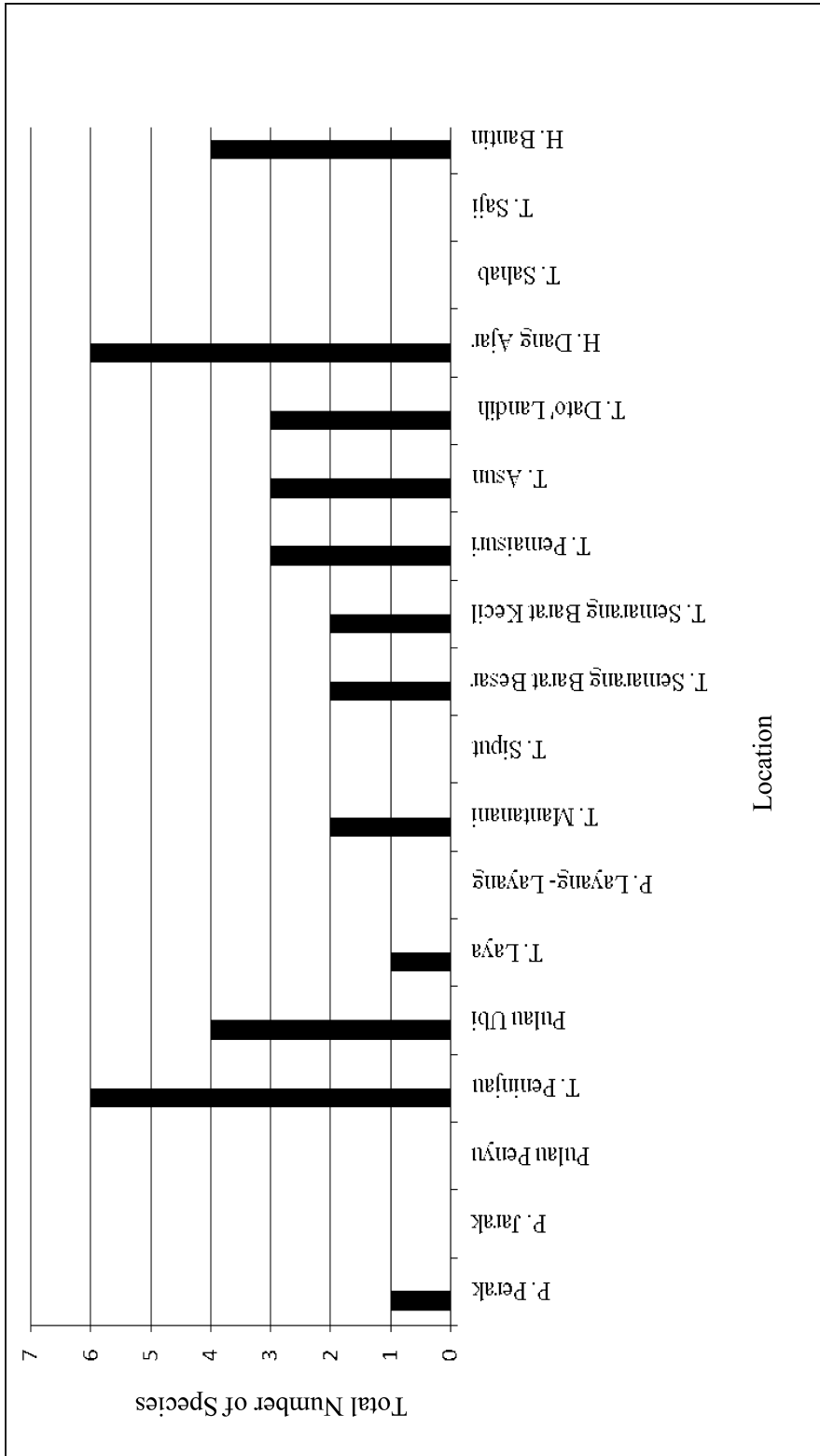
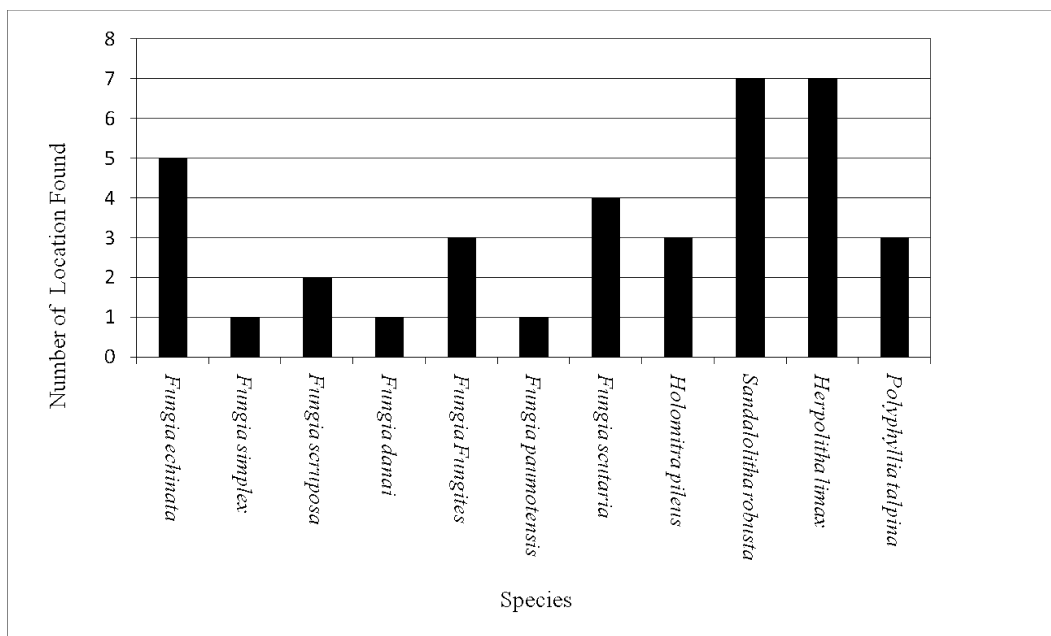


Fig. 2. The number of fungiid coral species found in the reef locations.

Table 3. Data of physical and nutrient parameters obtained from Hydrolab Data Sonde 4A during the sampling.

Location	Sampling Site	Temperature °C	Salinity (ppt)	pH (units)	D.O (mg/L)	Total suspended Solid (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
Straits of Malacca	Pulau Perak	29.26	30.21	8.28	5.42	43.89	0.13	0.01
	Pulau Jarak	29.69	30.05	8.29	5.43	48.67	0.13	0.02
South China Sea off the west coast of Sabah	Permatang Penyu	29.04	33.97	8.28	5.38	22.17	0.08	0.04
	Terumbu Peninjau	29.24	33.83	8.06	5.58	21.68	0.08	0.01
	Permatang Ubi	29.56	33.76	8.06	5.56	19.32	0.06	0.01
	Terumbu Laya	29.34	33.75	8.07	5.59	21.45	0.09	0.02
	Pulau Layang-layang	29.51	33.73	8.07	5.59	20.17	0.09	0.02
	Terumbu Mantanani	29.60	33.78	8.06	5.56	24.81	0.09	0.02
	Terumbu Siput	29.44	33.83	8.06	5.59	23.56	0.09	0.01
	Terumbu Semarang Barat	29.49	33.89	8.30	5.71	21.95	0.00	0.03
	Terumbu Semarang Barat Kecil	29.46	33.86	8.30	5.69	14.65	0.04	0.03
Gugusan Beting Raja Jarom	Terumbu Permaisuri	30.35	33.84	8.21	6.06	22.08	0.04	0.01
	Terumbu Asun	29.01	33.98	8.28	6.05	20.47	0.09	0.01
	Terumbu Dato' Landih	28.92	33.92	8.28	6.05	22.56	0.04	0.00
	Hempasan Dang Ajar	29.73	33.57	8.27	6.05	18.64	0.04	0.02
Gugusan Beting Patinggi Ali	Terumbu Sahab	30.61	33.54	8.20	6.08	19.54	0.02	0.05
	Terumbu Saji	29.37	34.00	8.29	6.11	19.67	0.07	0.06
	Hempasan Batin	30.30	33.21	8.20	6.18	19.50	0.04	0.06

**Fig. 3.** The total number of locations where fungiid coral were found.

Numbers of species (11 species) found in this study was very similar to the study done by Koh and Chou (1989) which identified 13 fungiid species belonging to five genera. Out of the 11 species recorded in this study, there were only six species which have been reported in southern Singapore. *Lithophyllon undulatum* was unique and only reported in Singapore and has not been reported by Veron (1993) during his survey covering all the reefs in Indo-Pacific. More research work is needed to map the distribution patterns of Fungiidae corals in the future.

Table 4. Comparison of the species of fungiid corals reported by other authors

Genus	Species	Authors					
		This study	Veron, 1993	Searle, 1980	Betterton, 1981	Koh & Chou, 1989	Scott, 1984
<i>Cycloseris</i>	<i>Cycloseris costulata</i>		√				
	<i>Cycloseris cyclolites</i>		√				
	<i>Cycloseris erosa</i>		√				
	<i>Cycloseris patelliformis</i>		√				
	<i>Cycloseris sommervillei</i>		√				
	<i>Cycloseris marginata</i>		√				
	<i>Cycloseris vaughani</i>		√				
<i>Diaseris</i>	<i>Diaseris distorta</i>		√				
	<i>Diaseris fragilis</i>		√				
<i>Heliofungia</i>	<i>Heliofungia actiniformis</i>		√				
<i>Fungia</i>	<i>Fungia fungites</i>	√	√	√	√	√	
	<i>Fungia horrida</i>		√				
	<i>Fungia klunzingeri</i>		√				
	<i>Fungia scruposa</i>	√	√				√
	<i>Fungia corona</i>		√				
	<i>Fungia danai</i>	√	√		√		
	<i>Fungia valida</i>		√				
	<i>Fungia repanda</i>		√	√	√		√
	<i>Fungia scabra</i>		√				√
	<i>Fungia concinna</i>		√				√
	<i>Fungia granulose</i>		√				
	<i>Fungia scutaria</i>	√	√		√		
	<i>Fungia moluccensis</i>		√				√
	<i>Fungia paumotensis</i>	√	√				√
	<i>Fungia echinata</i>	√	√	√	√		√
	<i>Fungia simplex</i>	√	√				
		<i>Fungia actinoformis</i>			√	√	√
<i>Herpolitha</i>	<i>Herpolitha limax</i>	√	√	√	√	√	
	<i>Herpolitha weberi</i>		√				
<i>Polyphyllia</i>	<i>Polyphyllia talpina</i>	√	√	√	√	√	
<i>Halomitra</i>	<i>Halomitra pileus</i>	√	√				
<i>Sandalolitha</i>	<i>Sandalolitha robusta</i>	√	√		√		
<i>Lithophyllon</i>	<i>Lithophyllon edwardsi</i>		√				√
	<i>Lithophyllon undulatum</i>					√	
<i>Podabacia</i>	<i>Podabacia crustacea</i>		√	√	√	√	
<i>Zoopilus</i>	<i>Zoopilus echinatus</i>		√				
Total No. of Species		11	34	7	10	13	1

However, the number of fungiid species recorded in this study is higher compared to the studies by Searle (1980) and Betterton (1981), where only 7 and 10 species, respectively, were reported in their studies. This was because the reefs surveyed by the two scientists above were on the west and east coast of the Peninsular Malaysia, which were subjected to more tourism activities compared to the isolated reefs surveyed in this study. The high tourism activities had led to degradation in water quality (Ridzwan and De Silva, 1984). In addition, the reefs (Pulau Tioman and Johor Archipelago, located at east coast of Peninsular Malaysia; and Pulau Song-song, Pulau Pinang and Pulau Tikus, located at the Straits of Malacca) surveyed by Searle (1980) and Betterton (1981) were located very near the coastal areas, which were subjected to high sea traffic as well as discharge from the mainland, which had degraded the water quality of those reefs. Degradation of water quality eventually led to the degradation of the coral communities in the coral reef ecosystem.

The number of fungiid species recorded in this study is also higher compared to the study done by Scott (1984), where he has reported conspicuous absence of fungiids in the waters of Hong Kong except for one species, *Lithophyllon edwardsi*. Table 4 summarizes the comparison of this study with other studies on Fungiidae corals.

Limited dive per reefs were carried out during this expedition and this is insufficient to produce a comprehensive quantitative data of the surveyed reefs. More emphasis on the quantitative data will be carried out on selected reefs in the future expedition, as well as expanding the geographical area for the similar study on Fungiidae corals.

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