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A preliminary study of the coral community on artificial and natural substrates

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Abstract. A preliminary study of the coral communities on a submerged concrete pillar and on the adjacent reef slope was carried out at Pulau Hantu (1° 13.6′N, 103° 45′E), Singapore. Coral cover on the pillar was almost twice that on the slope. Of the 27 species recorded on the pillar, 6 were records new to Singapore. They were *Acropora aculeus* (Dana), *A. cytherea* (Dana), *A. valida* (Dana), *Agaricia incrustans* Bernard, *Psammocora digitata* Milne-Edwards & Haime and *Montastrea curta* (Dana). Only 12 coral species occurred on the slope. The greater colony number, coral size range and depth distribution range on the pillar, all indicated that it was a better substrate for coral settlement than the reef slope itself.

INTRODUCTION

Pulau Hantu (lat. 1° 13.6′N, long. 103° 45′E) is an uninhabited twin-island group 10 km south of the Singapore mainland. It was reclaimed in 1974 and transformed into a picnic resort. The reclamation covered the entire reef flat but stopped approximately 20 m before the reef slope. A concrete jetty supported by vertical concrete pillars was built at the same time on the north-eastern part of the island. Good coral growth was observed on these pillars. This preliminary study is based on the distribution of corals on one such pillar and comparison is made with the distribution of corals on the natural reef slope adjacent to it.

MATERIALS AND METHOD

On either side of the jetty is a triangular configuration of 3 vertical concrete pillars. The pillar selected for study was located on the right side of the jetty

facing the sea. It is square in cross-section with each side measuring 30 cm in width. A grid measuring 50 cm by 30 cm and divided into 15 squares of 100 sq cm each was used to determine areal coverage of individual coral colonies on all 4 sides of the pillar along its entire length from mean low water level to the bottom. The depth at which individual colonies occurred was also recorded. A one-metre belt transect was established on the slope adjacent to this pillar. Here, a 1-metre square grid divided into 100 squares of 100 sq cm each was used to measure areal coverage of coral colonies at different depths along the entire reef slope. No coral growth was observed on this part of the reef flat, hence comparison was made only between the reef slope and the colonies as the authors were interested only in surface area coverage. The reef profile was easily determined by using the jetty as a convenient horizontal reference (Fig. 1).

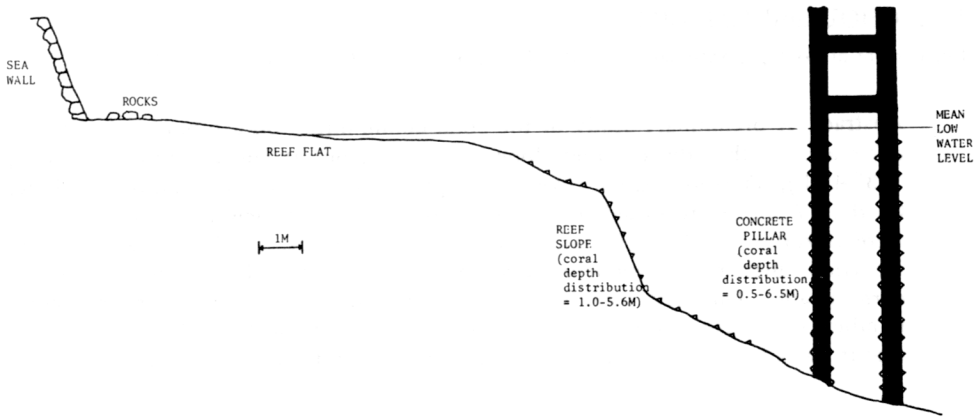

Figure 1. **Profile of study site and depth distribution of corals.**

RESULTS

The results are presented in Table 1. They indicate that coral growth in terms of species diversity, percentage cover, colony number, size range and depth range was better on the concrete pillar than on the reef slope.

Twenty-seven species of coral belonging to 20 genera occurred on the pillar compared with 12 belonging to 11 genera on the slope. Nine of the 12 species found on theslope were massive in form, one encrusting – *Montipora striata* Bernard, and 2 leafy – *Merulina ampliata* (Ellis & Solander) and *Pectinia lactuca* (Pallas). A wider variation in growth forms was represented by the corals present on the concrete pillar. Of the 27 species, 14 were of the massive form, 6 branching, 3 leafy, 3 encrusting and one, *Tubastrea aurea* (Quoy & Gaimard) forming small plocoid clumps.

Only 3 species, *Diploastrea heliopora* (Lamarck), *Favia favus* (Forskal) and *Symphyllia nobilis* (Dana) present on the reef slope, were absent from the concrete pillar. The rest of the 9 species found on the slope were also

present on the pillar. Eighteen of the 27species present on the pillar were not represented on the slope.

Six species, *Acropora aculeus* (Dana), *A. cytherea* (Dana), *A. valida* (Dana), *Agaricia incrustans* Bernard, *Psammocora digitata* Milne-Edwards & Haime and *Montastrea curta* (Dana), which are recorded for the first time in Singapore waters, were all present on the man-made concrete pillar.

Percentage coral cover on the pillar (30.91%) was almost double that on the slope (19.05%). The number of colonies (128) on the 7.8 m^2 of area surveyed on the pillar was almost 4 times that (33) on the 7 m^2 surveyed on the slope. Colony density on the pillar amounted to 16.4 per m^2 while that on the slope 4.7 per m^2. This indicated a greater establishment rate on the pillar than on the reef slope. However, it should be noted that the value on the pillar was inflated by the 2 ahermatypic species, *Dendrophyllia nigrescens* (Ehrenberg) and *Tubastrea aurea,* which formed a total of 49 colonies. Both were absent from the reef slope. If these 2 species were not taken into account, then the colony number on the pillar is reduced to 79 and the colony density to 10.1 per m^2. These values still remain more than twice that of the reef slope.

The size range was greater on the pillar (2–1599 cm^2) than on the slope (20–1295 cm^2). Even when the 2 ahermatypic species were not taken into consideration, the lower limit of the size range on the pillar remained less than that on the slope. While the smallest colony on the slope was 20 cm^2 *(Pectinia lactuca),* 2 other hermatypic species on the pillar, *Acropora cytherea* and *Favites abdita* (Ellis & Solander), had smaller colonies occupying lower values of 6 cm^2 and 14 cm^2 respectively.

Corals occupied a wider depth range on the pillar (0.5–6.5 m) than on the slope (1.0–5.6 m). While the 2 ahermatypic species reached depths of 6.3 and 6.5 m, other ahermatypic species on the pillar like *Monipora striata, Agaricia incrustans* (Quelch), *Fungia fungites* (Linne), *Porites lutea* Milne-Edwards & Haime and *Trachyphyllia geoffroyi* (Audouin) reached depths of more than 6 m which was greater than the depth limit of 5.6 m on the slope. The ahermatypic coral, *Montipora striata,* occupied the greatest depth range (0.5–6.2 m) while the ahermatypic coral, *Tubastrea aurea,* occupied the next greatest depth range (0.8–6.3 m) on the pillar. On the slope, the greatest depth range (1.0–5.6 m) was occupied by *Favia speciosa* (Dana).

DISCUSSION

The vertical concrete pillar served as a better substrate for coral settlement than the natural reef slope. The reef slope substrate was of fine, soft sand which did not favour coral settlement. The physical conditions of the reef slope could have been affected by the reclamation as coral growth on both

Table 1. Comparative analysis of coral distribution between reef slope and vertical concrete pillar at Pulau Hantu, Singapore.

Species	REEF SLOPE (area surveyed = 7 sq m)					CONCRETE PILLAR (area surveyed = 7.8 sq m)				
	Presence (+)	% Cover	Colony No.	Size range (sq cm)	Depth range (metres)	Presence (+)	% Cover	Colony No.	Size range (sq cm)	Depth range (metres)
Pocilloporidae										
Pocillopora damicornis (L.)						+	2.65	11	10–528	0.5–4.3
Acroporidae										
* *Acropora aculeus* (Dana)						+	0.55	1	432	0.8
* *A. cytherea* (Dana)						+	4.21	6	6–1235	3.6
* *A. valida* (Dana)						+	1.05	2	80–736	3.8
Montipora efflorescens Bernard						+	0.43	2	120–216	2.2–3.6
M. striata Bernard	+	2.05	3	48–1085	2.0–5.4	+	9.46	17	80–1500	0.5–6.2
Agariciidae										
* *Agaricia incrustans* (Quelch)						+	0.22	1	168	6.0
Siderastreidae										
* *Psammocora digitata* M.Ed. & H.						+	0.95	2	144–600	4.2–4.6
Fungiidae										
Fungia fungites (L.)						+	0.03	1	20	6.3
Poritidae										
Porites lutea M.Ed. & H.	+	3.59	5	120–896	1.2–3.2	+	1.82	5	72–600	2.2–6.2
Faviidae										
Cyphastrea chalcidicum (Fors.)						+	0.04	1	30	2.8
C. microphthalma (Lam.)						+	3.11	5	45–1599	0.8–5.6
Diploastrea heliopora (Lam.)	+	0.43	1	300	4.6					
Favia favus (Fors.)	+	0.82	2	270–300	1.0					
F. speciosa (Dana)	+	1.64	5	20–500	1.0–5.6	+	0.24	3	42–80	3.8–5.4
Favites abdita (E. & Sol.)	+	1.62	3	342–450	2.0–5.0	+	1.13	6	14–324	0.6–4.2
Goniastrea pectinata (Ehr.)						+	0.07	1	56	4.5
G. retiformis (Lam.)	+	1.44	2	500–510	1.8–3.6	+	0.24	2	48–140	2.1–3.2
Hydnophora exesa (Pallas)	+	0.42	1	300	3.8	+	0.37	1	289	3.4
H. rigida (Dana)						+	0.38	1	300	2.7
* *Montastrea curta* (Dana)						+	0.44	2	90–255	2.0–3.5
M. valenciennesi (M.Ed. & H.)	+	0.51	1	360	2.2	+	0.08	1	64	4.5
Platygyra sinensis (M.Ed. & H.)						+	0.18	2	48–90	0.5–1.5
Trachyphyllidae										
Trachyphyllia geoffroyi (Aud.)						+	0.04	1	32	6.0
Oculinidae										
Galaxea fascicularis (L.)						+	0.33	1	255	1.7
Merulinidae										
Merulina ampliata (E. & Sol.)	+	3.78	3	150–1295	2.2–4.6	+	0.36	1	280	4.5
Mussidae										
Symphyllia nobilis (Dana)	+	1.07	1	750	3.2					
Pectiniidae										
Pectinia lactuca (Pallas)	+	1.68	6	20–500	1.0–5.0	+	0.51	3	24–300	3.5–5.8
Dendrophylliidae										
Dendrophyllia nigrescens (Ehr.)						+	1.70	11	15–360	4.0–6.5
Tubastrea aurea (Q. & Gai)						+	0.32	38	2–80	0.8–6.3
	12	19.05	33	20–1295	1.0–5.6	27	30.91	128	2–1599	0.5–6.5

*indicates new record for Singapore

the flat and slope was personally observed to be richer prior to reclamation. This part of the reef flat observed in the present study had no coral growth at all. Studies on other Singapore reefs (Chuang 1977; Chou & Teo 1983) show that the coral community on reef flats although poorly represented is never completely absent. The percentage cover and species diversity on this part of the reef slope is also poor compared to the other reefs investigated in the earlier-mentioned studies.

The coral community on the man-made concrete pillar was more encouraging. The species diversity, variation in growth form, as well as the growth of the 6 species which had never been recorded before in these waters, showed that substrate suitability was a determining factor, especially in view of the proximity of the 2 study sites. In terms of species diversity and coral cover, the coral community on the pillar was comparable to that of the natural reef of Pulau Salu (Chou & Teo 1983). Although a few species reached depths in excess of 6 m from the mean low water level, most of the growth occurred above this depth.

The size range indicated that more young colonies, excluding the 2 ahermatypic species, were being established on the pillar than on the slope. Over the 11-year period since its construction, the older established colonies were growing to larger size on the pillar than on the slope. This again shows that the former is a better substrate than the latter.

From this study, the construction of artifical reefs in these waters will have to be based on a similar design involving vertical pillars reaching up to the mean low water tide level as most of the coral growth occurred at depths not exceeding 6 m below the low water level.

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