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ECOLOGY OF SINGAPORE AND MALAYAN CORAL REEFS - PRELIMINARY CLASSIFICATION

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ABSTRACT

Available data on temperature, light and salinity off reef flats, particle size and organic matter of overlying sediments on reef flats on adjacent islands south of Singapore indicate fairly constant physical conditions. Great expanses of intertidal reef flat on these islands have bare areas, and also areas with submarine monocotyledon Enhalus acoroides or with brown alga Sargassum. Different areas support different coral faunas. The subtidal fringing reefs of adjacent islands south of Singapore rest on consolidated sediment and have a steep slope, while those of most islands off the east coast of the Malay Peninsula rest on gradually sloping loose sand or on exposed igneous rocks with a different coral fauna.

From the sheltered geographical position and the absence of algal ridge, coral reefs off Singapore are comparable to the leeward reefs of other parts of the world. They differ from those in the Bay of Batavia in Indonesia, and from the usual Pacific and Caribbean reefs in not showing a distinct zonation. Different areas on fringing reefs and reef flats studied do not fit into existing systems of regions, facies or zones. A simple scheme of preliminary classification for the purpose of studying local reefs is presented. This scheme comprises four intertidal reef "types", namely Sargassum reef, Enhalus bed, reef flat with pot-holes and reef flat without pot-holes, and four subtidal reef "types", namely slope reef, patch reef, buttress reef and rock reef. Altogether 45 genera and 102 species of scleractinian corals from the different reef "types" are recorded.

KEY WORDS: Reef, Corals, Scleractinians, Ecology, Invertebrates, Sponges, Echinoderms, Molluscs, Marine Algae

ECOLOGY OF SINGAPORE AND MALAYAN CORAL REEFS - PRELIMINARY CLASSIFICATION

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Introduction

Singapore and Malayan coral reefs are fringing reefs comprising a thin superficial layer of coral material resting on various substrata. On islands off Singapore there are very gradually sloping and almost level intertidal reef flats of varying widths bordered by very steep subtidal reef slopes. There is no noticeable zonation, as is a prominent feature of many reefs in other parts of the world (1-3). On the other hand, most islands off the east coast of the Malay Peninsula have a steep intertidal beach and a more gradual subtidal reef slope of rock or sand, again without zonation.

This study presents some physical and biological characteristics of the environment and the species composition of the coral community occurring on the different types of reef. A preliminary classification of the reef types off Singapore and Malay Peninsula is suggested.

Materials and Methods

Singapore corals for this study were collected mainly from four small southern islands, now already reclaimed or being reclaimed, namely Pulau Hantu (Lat. $1^{\circ} 13.6'N$. Long. $103^{\circ} 45'E$.), Pulau Sudong ($1^{\circ} 12.5'N$. $103^{\circ} 44'E$.), Pulau Salu ($1^{\circ} 13'N$. $103^{\circ} 42.5'E$.) and Raffles Light ($1^{\circ} 9.7'N$. $103^{\circ} 44.5'E$.). Malayan corals were collected mainly from the west side of Pulau Tioman ($2^{\circ} 50'N$. $104^{\circ} 10'E$.), west side of Pulau Perhentian Besar ($5^{\circ} 54'N$. $102^{\circ} 45'E$.) and from the northeast side of Pulau Penang ($5^{\circ} 45'N$. $103^{\circ} E$.).

Collection of corals was made by skin diving and SCUBA diving to 20 m (meters). Identification of bleached corals was made by comparison with named materials of Singapore origin mostly in the U.S. National Museum, Yale Peabody Museum and other institutions.

Sea temperatures were measured with a Model 44 "Thermistemp tele-thermometer" of the Yellow Springs Instrument Co. Inc., Ohio, U.S.A., light intensity by an "EEL" underwater photometer of Evans Electroselenium Ltd., Halstead, England, and salinity by the Knudsen chlorinity method.

Particle-size analysis by Buchanan's method (4) was carried out on samples of overlying sediments dug out at ebb tide to a depth of 3 cm (centimeters) from the reef flats of P. Sudong and P. Salu. The metal sieves used had mesh sizes of the Wentworth grade classification (details in Fig. 1). Organic matter in aliquots of the same samples was determined by Walkley and Black method (4) as organic carbon, chromic acid oxidation values.

Observations

Preliminary scheme of reef types

Preliminary study of corals and their habitats indicates that Singapore and Malayan coral reefs may be divided into two main categories - reef flat and reef slope types. The reef slope is of two kinds - the steep slope of the islands off Singapore and the gradual slope of the Malayan east-coast islands. The steep slope of Singapore reefs rests on either consolidated sediments or exposed igneous rock. On the Malayan gradual reef slope, semi-consolidated materials support a buttress reef, loose sandy materials, and a patch reef.

In Singapore the reef flat may support areas with the brown algae *Sargassum* spp., areas with the monocotyledon *Enhalus acoroides* Rich. ex Stud. or areas with no vegetation. This "open flat" may be without corals. The "open flat" with living corals exists as variants with and without pot-hole-like depressions which are visually very distinctive. The scheme is summarized in Fig. 2.

The slope reef and reef flat types are common on islands off Singapore. They are rare on the east-coast islands off the Malay Peninsula, one example being the southwest side of Pulau Sribuat ($2^{\circ} 41'N$. $103^{\circ} 54'E$.). Patch reef is an exclusively Malayan reef type and is probably as common as the rock reef, which is rare off Singapore. Buttress reef is rare on east-coast islands of the Peninsula and absent off Singapore.

The width of the slope reef is the slope profile of the island and its length is the island circumference. Similarly the width of the patch reef is the profile distance of the subtidal slope to a depth of about 20 m, coral growth below this depth being poor. The length of the patch reef may equal the circumference of the island. The different reef flat types can each measure about 1 sq. km (kilometer) on a large reef flat of P. Sudong.

Some factors of the coral environment

The low spring tides of the semidiurnal tidal regime of Singapore that occur during the day almost invariably do so in the early morning and late afternoon. On the islands off the east coast of the Malay Peninsula low tides are also very rare during the middle of the day and then usually during the northeast monsoon or cool season, when the sky is overcast. Consequently the emerged corals are rarely exposed to the full energy of the tropical midday sun.

Around the coral islands off Singapore salinity fluctuates between 28.5 and 31.3 ‰. Sea temperatures vary between 27.6 and 30.8°C, judging from irregular records during 1975 and 1976, with no significant difference between surface and bottom temperatures.

The fall in underwater light intensity with increasing depth at 1210 and 1302 hours at two stations north and south of P. Hantu on a cloudy day on November 14th, 1973 is apparent from the following averaged values in lux taken at depths of one meter intervals from the surface to 15 meters: 20000, 18100, 16600, 13400, 8000, 6000, 4800, 3000, 2000, 1200, 1000, 800, 480, 280, 200, 120 and 70.

Particle-size analyses of sediment samples from the reef flat at P. Sudong and P. Salu show that the Enhalus bed contained the largest amount of silt and clay with particles smaller than 65 µm weighing 2.35 gm per 25 gm dry weight compared with 1.47 gm of the open flat with no corals. Clay fraction with particles below 3.9 µm in diameter on the Enhalus bed is about four times that of the open flat. Sediment particles larger than 0.3 mm in diameter vary with sampling localities on the same island and also from island to island (Fig. 1).

Organic carbon on Enhalus bed was about double that of any other reef flat area (Table 1).

Some characteristics of reef types

Slope reef. This subtidal reef has a base of consolidated sediment supporting a superficial layer of corals, which is usually complete in the upper part but may have gaps with no coral growth

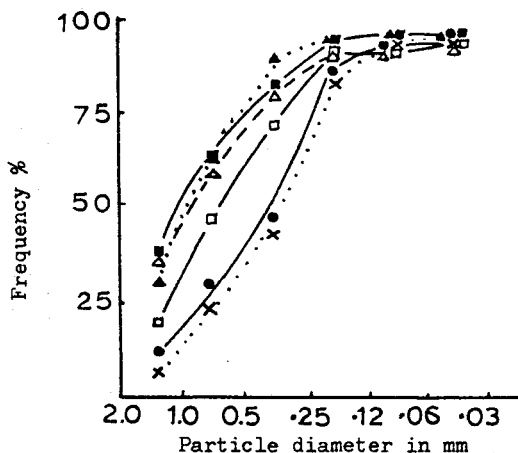


Fig. 1. Cumulative curve of particle diameter of overlying sediment on reef flat.

- Pulau Sudong sites:
 ▲ Sargassum reef, □ flat without pot-holes,
 ● Enhalus bed, × flat without corals.
 Pulau Salu sites:
 ▲ Sargassum reef, ■ flat without pot-holes.

near the lower margin.

The community is the richest in genera and species in Singapore (Table 2). The family Faviidae with 25 species has the most numerous representatives. Fungiidae with 12 species is the next largest. While the upper part of the slope is usually occupied by representatives of a large number of families, along the middle and lower parts there may be gaps free from attached corals. In these gaps, usually filled with coral debris and occasionally some coarse sand, are found local aggregations of unattached fungiid corals of the genera Fungia, Herpolitha and Polyphyllia. Members of these genera also occur in crevices between other corals or lying partly on top of other live corals.

Table 1. Organic carbon, chromic acid oxidation values of reef types of P. Sudong and P. Salu.

Reef type	Organic carbon (milligrams)
P. Sudong:	
<u>Enhalus</u> bed	0.20
Reef flat without corals	0.11
Reef flat without pot-holes	0.11
<u>Sargassum</u> reef type	0.09
P. Salu:	
<u>Sargassum</u> reef type	0.09
Reef flat without pot-holes	0.07

Although most coral species appear to colonize all parts of the slope indiscriminately, some genera have been found to be localized but without consistent signs of zonation. More Acropora species occur on the slope reefs of islands, the further out these are from Singapore.

Sargassum is rare except at the boundary with Sargassum reef flat. Gorgoniid Mopsella occurs on sides of the dead part of some corals and on the under surface of an overhang. Crinoids, sea-urchin Diadema setosum (Leske) and sponge Petrosia testudinaria (Lam.) are common along the upper part of the slope.

Rock reef. One example is the east side of Raffles Light, where the huge boulders provide upper and lateral surfaces for attachment of corals. It is an impoverished version of the slope reef with fewer than half of the coral species of the latter represented. Almost every available family is represented except the Fungiidae, the majority of whose members live unattached. The genera Euphyllia, Seriatopora and Alveopora are also noticeably absent.

Macrophytes are rare, as are soft corals. Colonies of the hydroid Aglaophenia cupressina Lamouroux are common.

Sargassum reef flat. On many islands off

Table 2. List of Scleractinia from the following reef types off Singapore: 1=slope reef, 2=rock, 3=Sargassum reef, 4=flat without pot-holes, 5=flat with pot-holes, 6=Enhalus bed, and off the Malay Peninsula: 7=patch reef, 8=rock, 9=buttress reef. Alphabetized genera under families in taxonomic order of Wells (5).

	1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9	
THAMNASTERIIDAE																				
<i>Psammocora contigua</i> (Esp.)	+		+	+	+						<i>Porites convexa</i> Verrill								+	+
<i>P. togianensis</i> Umbgrove	+	+									<i>P. lobata</i> Dana	+								
POCILLOPORIDAE																				
<i>Pocillopora damicornis</i> (L.)	+		+								<i>P. lutea</i> M.-Ed. & H.	+	+	+	+					+
<i>P. eydouxi</i> M.-Ed. & H.	+										<i>P. nigrescens</i> Dana	+								+
<i>Seriatopora hystrix</i> Dana	+		+								<i>P. solida</i> Forskal	+	+	+	+					+
<i>Stylophora mordax</i> (Dana)	+										FAVIIDAE									
<i>S. pistillata</i> (Esper)	+										<i>Caulastrea furcata</i> Dana	+								+
ACROPORIDAE																				
<i>Acropora appressa</i> (Ehr.)	+										<i>Cyphastrea chalcidicum</i> (Fors.)	+	+	+	+					+
<i>A. arbuscula</i> (Dana)	+										<i>C. microphthalma</i> (Lam.)	+								
<i>A. brachiata</i> (")	+										<i>C. serailia</i> (Forskal)	+	+							
<i>A. disticha</i> (Brooks)	+										<i>Diploastrea heliopora</i> (Lam.)	+	+							+
<i>A. echnidnea</i> (Dana)	+										<i>Echinopora horrida</i> (Dana)	+								+
<i>A. gracilis</i> (")	+										<i>E. lamellosa</i> (Esper)	+								+
<i>A. guppyi</i> (Brooks)	+								+		<i>Favia fava</i> (Forskal)	+		+						+
<i>A. nobilis</i> (Verrill)	+								+		<i>F. fragilis</i> (Dana)	+	+	+	+					+
<i>A. reticulata</i> (Brook)	+								+		<i>F. pallida</i> (")	+	+	+	+					+
<i>A. tenuis</i> (Dana)	+								+		<i>F. speciosa</i> (")	+								+
<i>A. tubicinaria</i> (Dana)	+								+		<i>F. valenciennesii</i> (ME. & H.)	+	+	+						+
<i>A. vaughani</i> Wells	+								+		<i>Favites abdita</i> (E. & Sol.)	+	+	+						+
<i>Astreopora myriophthalma</i>	+								+		<i>F. virens</i> (Dana)	+	+	+	+					+
<i>Montipora digitata</i> Dana	+								+		<i>Goniastrea benhami</i> Vaug.	+	+	+						+
<i>M. foliosa</i> (Pallas)	+								+		<i>G. mantonae</i> Crossland	+	+	+						+
<i>M. informis</i> Bernard	+								+		<i>G. pectinata</i> (Ehr.)	+	+	+	+					+
<i>M. laevis</i> Quelch	+								+		<i>G. retiformis</i> (Lam.)	+	+	+	+					+
<i>M. prolifera</i> Bernard	+								+		<i>Hydnophora exesa</i> (Pallas)	+								+
<i>M. verrilli</i> Vaughan	+								+		<i>H. microconus</i> (Lam.)	+								+
AGARICIIDAE																				
<i>Pachyseries levicollis</i> (Dana)	+								+		<i>H. rigida</i> (Dana)	+	+							+
<i>P. rugosa</i> (Lamarck)	+								+		<i>Leptastrea ehrenbergiana</i>	+								+
<i>P. speciosa</i> (Dana)	+								+		<i>L. purpurea</i> (Dana)	+								+
<i>Pavona carinata</i> Bruegg.	+								+		<i>Leptoria phrygia</i> (El. & Sol.)	+								+
<i>P. crassa</i> Dana	+								+		<i>Ulasteria crispata</i> (Lam.)	+	+	+	+					+
<i>P. frondifera</i> Lamarck	+								+		<i>Platygyra daedalea</i> (E. & S.)	+	+	+	+					+
<i>P. praetorta</i> Dana	+								+		<i>P. lamellina</i> (Ehr.)	+	+	+	+					+
SIDERASTREIDAE																				
<i>Anomastreaa tayamai</i> (Y. & S.)	+								+		<i>P. rustica</i> (Dana)	+								+
FUNGIIDAE																				
<i>Cycloseris cyclolites</i> (Lam.)	+								+		<i>P. sinensis</i> (ME. & H.)	+								+
<i>Fungia actiniformis</i> Q. & G.	+								+		<i>Trachyphyllia geoffroyi</i>	+	+	+	+					+
<i>F. concinna</i> Verrill	+								+		OCULINIDAE									
<i>F. danai</i> M.-Ed. & H.	+								+		<i>Galaxea fascicularis</i> (L.)	+	+	+						+
<i>F. echinata</i> (Pallas)	+								+		MERULINIDAE									
<i>F. fungites</i> (L.)	+								+		<i>Merulina ampliata</i> (E. & S.)	+								+
<i>F. paumotensis</i> Stutch.	+								+		<i>Scapophyllia cylindrica</i>	+								+
<i>F. repanda</i> Dana	+								+		MUSSIDAE									
<i>F. scabra</i> Doderlein	+								+		<i>Lobophyllia cytherea</i> (Dana)	+	+	+						+
<i>F. somervillei</i> Gardiner	+								+		<i>L. hemprichii</i> (Ehr.)	+	+	+						+
<i>Hermolitha limax</i> (Esper)	+								+		<i>Symphyllia nobilis</i> (Dana)	+	+	+						+
<i>Parahalomitra robusta</i> (Quel.)	+								+		PECTINIIDAE									
<i>Podabacia crustacea</i> (Pallas)	+								+		<i>Mycedium tubifex</i> (Dana)	+								+
<i>Polyphyllia talpina</i> (Lam.)	+								+		<i>Oxypora lacera</i> (Verrill)	+	+							+
PORITIDAE																				
<i>Alveopora excelsa</i> Verr.	+								+		<i>Pectinia lactuca</i> (Pallas)	+	+							+
<i>Goniopora columna</i> Dana	+								+		CARYOPHYLLIIDAE									
<i>G. fruticosa</i> Sav.-Kent	+								+		<i>Euphyllia fimbriata</i> (Spen.)	+								+
											<i>E. glabrescens</i> (Cham. & Eys.)	+			+	+				+
											<i>Plerogyra sinuosa</i> (Dana)	+								+
											DENDROPHYLLIIDAE									
											<i>Dendrophyllia nigrescens</i>	+	+							+
											<i>Tubastrea aurea</i> (Quoy & G.)	+	+							+
											<i>Turbinaria crater</i> (Pallas)	+								+
											<i>T. peltata</i> (Esper)	+		+						+

Singapore the Sargassum reef flat begins at the top of the slope reef. There is no clear demarcation, since, where the top end of the slope reef has a gradual slope or terrace, tall Sargassum plants become attached to the corals to a depth of about 2 m below the low water of spring tides.

The small gradient typical of Sargassum beds is illustrated when a profile length of up to 300 m or more may correspond to only about 40 cm in vertical height from about -0.1 m at the seaward end to about 0.3 m at the shore end with respect to the British Admiralty Chart Datum. It usually lies on a slightly lower level than the open flat and allows water to a depth of about 20 cm to remain in between the coral heads during a low spring tide.

The Sargassum cover of this reef type is almost complete near the seaward edge during the cool months but may be sparse during the warm months due to annual cyclic changes. During the former the plants at the seaward edge measure up to 2 m in length and weigh up to 250 gm, while at the shore end, 40 cm or less and 100 gm or less. Besides Sargassum a great variety of other algae occur. These include Turbinaria ornata Agardh, Cystoseira prolifera Agardh, Padina commersonii Bory, Halimeda opuntia Lamouroux, Eucheuma sp., Colpomenia sinuosa (Roth) Derbes & Solier, Dictyosphaeria favulosa (Agardh) Decn., etc. in that order of abundance. Padina tends to appear more prominent at the shore end where the Sargassum becomes less luxuriant.

The predominant corals of the Sargassum flat include the faviids Favia favus, F. fragilis, F. valenciennesii, Favites virens, Cyphastrea chalcidicum, all the four local species of Goniastrea, Platygyra daedalea, P. lamellina, P. rustica, Trachyphyllia geoffroyi, and the fungiid Fungia actiniformis, F. echinata, Herpolitha and Polyphyllia. More corals occur per sq. m at the seaward end, where they also attain a larger size, than at the shore end. Here there are only small colonies of about 15 cm diameter or less of Goniastrea mantonae and Platygyra daedalea, and Porites solida.

Prominent invertebrates, especially near the seaward end, include alcyonaceans Lobophytum, Sarcophyton, Nephthea, etc., sponges Ircinia ramosa (Keller), Orina sagittaria (Sollas), Coelocarteria singaporensis Carter, Spirastrella vagabunda Riley, Suberites inconstans Dendy, Cinachrya australiensis (Carter), etc., portunid crabs of the genus Thalamita, holothurians Holothuria vagabunda Selenka, Actinopyga lecanora (Jaeger), Opheodesoma grisea (Semper), asteroid Calcita novaeguineae Mueller & Troschel, gastropods Lambis lambis (L.), Turbo bruneus Roeding, Pyrene fulgurans (Lam.), bivalves Tridacna crocea Lam., Lithophaga nasuta (Philippi), L. teres (Philippi), and tunicate Polycarpa sp.

Reef flat without pot-holes. This either starts off immediately shoreward from the top of the slope reef or continues shoreward from the inner end of the Sargassum reef flat. It usually lies on a slightly higher level with respect to the tidal level than the latter. The gradient is very slight: a profile distance of 300-400 m may correspond to a vertical height of only 50 cm.

The usually firm substratum has a few isolated plants such as Halophila ovalis, Cymodocea rotundata, and a few algae such as Avrainvillea erecta, stunted Cystoseira prolifera, Turbinaria ornata and Padina commersonii.

The coral community here is an impoverishment of the Sargassum flat with still fewer species and fewer numbers per sq. m. Species that occur in the inner region of Sargassum flat are usually represented. However, there are species that are commoner and apparently best suited to the environmental conditions here. These include several faviids, such as Favia favus, Favites virens, all local species of Goniastrea, Leptastrea purpurea, Oulastrea crispata, majority of Platygyra species, fungiid Fungia actiniformis, Montipora digitata, M. laevis and Euphyllia glabrescens. As on the Sargassum flat, the number of species and the density of colonies decrease shorewards.

On the relatively bare flat, the sponge Adocia dendyi, the crab Pilumnus vespertilia

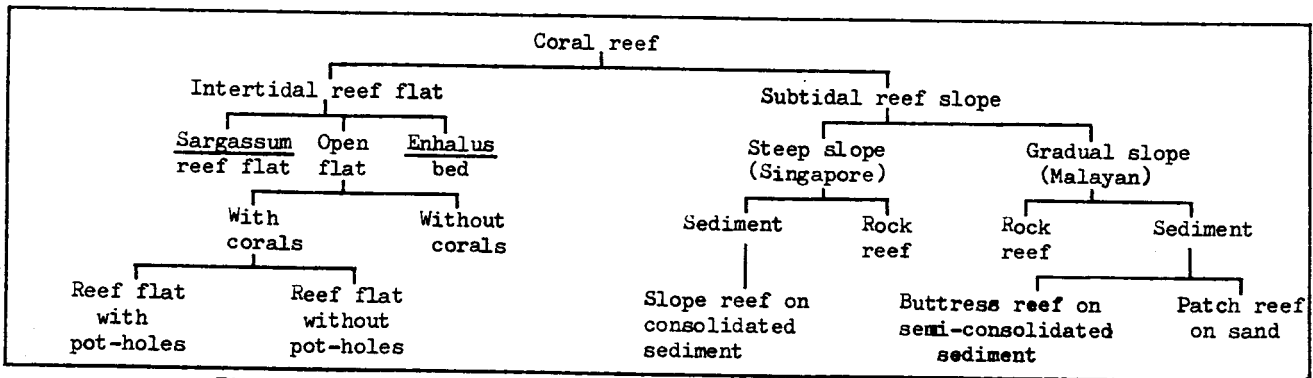


Fig. 2. A scheme of reef types off Singapore and the Malay Peninsula.

(Fabricius), naticid gastropod Polynices mam-
milla (L.) and bivalve Chama reflexa Reeve occur
(6).

Reef flat with pot-holes. This variant has
depressions, 2-4 sq. m in area and 30 cm
deep, which hold water at ebb tide. It occurs
in the less compacted sedimentary substrate,
especially where the tidal current is strong. It
either begins immediately from the top end of the
slope reef or continues shoreward from another
reef flat type.

The coral community is not strikingly dif-
ferent in species composition except for the
presence of Polyphyllia talpina, but is striking
in the larger growth size of most individuals and
in offering very different habitat conditions to
other organisms.

In the pot-holes are found usually several
algae of the Sargassum reef flat, Thalamita crabs,
small coral fishes and several sponges.

Enhalus bed. This occurs only on large reef
flats and usually lies on a slightly lower tidal
level with resultant standing water of 10 cm or
so remaining during a low spring tide. In the
thick growth of Enhalus acoroides, 15 individuals
of which may occur in 1 sq. m, occasional Cymo-
docea rotundata and Halophila ovalis are found.

The few corals present grow to a much larger
size than those at the shore end of other reef
flat types. Typical associated invertebrates in-
clude synaptid Opheodesoma grisea and crab Hyas-
tenus sebae Butlandijk.

Patch reef. Inside Tekek Bay of P. Tioman,
patch reefs occur as oval to rectangular units,
3-20 meters across, separated by bare sand or
sandy mud several m wide. Each comprises up to
several dozen species of corals. A continuous
patch reef also occurs from the mouth of the bay
inwards to the shallow end. Some of the corals
form pinnacles up to 4 meters high with oyster
Pycnodonte hyotis (L.) and anemone Stoichactis
attached.

The coral communities, variable in species
composition, abound in long-branched Acropora
species, such as A. arbuscula and A. nobilis.
However, almost pure stands of the above two
species, of Psammocora togianensis, Porites
nigrescens and octocorallian Heliopora coerulea
(Pallas) have been observed. The fungiids Cyclo-
series cyclolites and Parahalomitra robusta occur.

Macrophytes, sponges, crinoids and crabs are
not conspicuous. Heart urchin Lovenia elongata
(Gray) and crown-of-thorns starfish Acanthaster
planci (L.), and giant clam Tridacna squamosa
Lam. are common.

Rock reef. The Malayan version has more
Acropora species but differs from patch reef in

lacking long-branched species. Alcyonacean
Millepora platyphylla, Pycnodonte hyotis and Tri-
dacna maxima (Roeding) share the rock face.

Rock faces on a sandy bottom in exposed lo-
calities do not support vigorous growth of corals
possibly due to abrasion by sand grains and other
suspended particles under wave action, which is
severe in stormy weather on such coasts.

Buttress reef. The sole example seen on the
northeastern side of P. Penang, frequently lashed
by strong waves of long wavelength, comprises
several buttresses, each 2-3 m wide, gradually
narrowing and sloping seawards. These alternate
with sandy gullies, about 2 m wide.

The coral community abounds in short-branch-
ed Acropora species and Montipora foliosa. Some
Padina is present. Invertebrates are inconspic-
uous except for holothurians and sea-urchins.

Discussion

For the two Singapore localities studied in
detail, factors such as temperature, salinity,
organic carbon and the tidal regime vary little
and provide fairly constant physical conditions
all the year round. From their sheltered geo-
graphical position, the coral reefs south of Singa-
pore may be compared to the leeward reefs of other
parts of the world (1).

The fringing reefs off Singapore and the
Malay Peninsula are narrow, compared to the barr-
ier, fringing and atoll reefs usually discussed.
The corals and associated organisms are varied
and rich in genera and species. Coralline algae
are inconspicuous and the algal ridge is absent
as is usual for reefs in the monsoonal regions
(1). There is no distinct coral zonation, unlike
reefs in the Bay of Batavia (7). The great ex-
panse of the intertidal reef flats, however, al-
lows some differentiation into types according
to the main associated submarine plants.

Although the list of corals in Table 2 is in-
complete in that it does not cover the entire
Malayan region, it shows that slope reef of Singa-
pore has a varied coral fauna and is almost as
rich in coral genera as the Marshall Islands, the
Great Barrier Reef and Palau Islands (8). The
number of species on slope reef exceeds that of
patch reefs of the east-coast islands of the Ma-
lay Peninsula and also that of reefs in the Bay
of Batavia (7). The number of species here re-
corded from islands off the east coast exceeds
that recorded from the west coast of the Malay
Peninsula (9). This is possibly due to the clear-
er water off the east coast. The families Acro-
poridae and Fungiidae are especially poor in
species in the west compared to the east coast.

The slope reef surface is sheltered from
storm waves, and tall, fragile colonies of such
species as Plerogyra sinuosa, Lobophyllia

cytherea and Euphyllia fimbriata form. In places large areas have been seen where these tall corals are damaged or fallen, perhaps as a result of erosion or possibly through human agencies. When the reef slope is covered with massive hard corals like Diploastrea heliopora or Porites lutea, each of which can grow to several sq. m in area, it is resistant.

The reef flat of Singapore and the Malay Peninsula, with its periodic emersion during low water spring tides and consequent possible drenching in rain-water or exposure to direct sunlight, is not conducive to good coral growth. This is apparent from the reduced number of intertidal species compared with the larger number of more vigorous corals tolerant of exposure on Heron Island in the Great Barrier Reef.

The simple scheme of preliminary classification of Singapore and Malayan reefs presented is not intended for general application. The term "type" is used in a non-committal sense, to avoid the special implications of other terms such as region (10), facies (7) or zones (2). The narrow and small reefs growing in relatively sheltered environments do not lend themselves to incorporation into existing systems. The scheme presented here may prove useful for the study of local reefs.

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