

Coral communities of the Namsu Islands (Gulf of Siam, South China Sea)

Yu. Ya. Latypov

Institute of Marine Biology, Far East Science Center, Academy of Sciences of the USSR, Vladivostok 690022, USSR

ABSTRACT: Fringing reefs of the Namsu Archipelago (Gulf of Siam) were studied using quadrat and transect techniques. Five zones were distinguished which may be compared with or related to boat channel, inner and outer reef flat, reef slope and sloping platform. The degree of affinity of communities in different zones was analyzed. On the basis of variations in quantitative distribution of the corals, 3 groups of scleractinian corals were separated in terms of ecological requirements: species widespread from intertidal zone down to a reef slope; species of the lower part of a reef slope; and species inhabiting the sloping platform. In the reef studied, 133 species of Scleractinia (36 genera) and Hydrocorallia (1 genus) were found.

INTRODUCTION AND REEF MORPHOLOGY

The Namsu Archipelago (9°40' N, 104°21' E) includes 21 islands and rocks forming 2 groups separated by a ca 1-mile-wide pass (Fig. 1). The islands consist of acid and basic effusive, effusive-sedimentary and sedimentary deposits of the Middle Paleozoic. Tufas and tuff conglomerates predominate. Recent deposits on beaches and isthmuses are of block-and-boulder, boulder-and-pebble and sand substrata, sometimes with a considerable admixture of shell and coral debris.

Underwater slopes of the islands are fringed with block-pebble deposits replaced with increasing depth by shingle, gravel and finally coarse sand intermingled with abundant organic detritus. At a depth of 6 to 10 m (50 to 100 m from the shore line), the slightly inclined sloping platform is covered by silty sand and fine-grained silt deposits with a considerable admixture of organic detritus. The reefs and corals here have not previously been studied. Five different zones with scleractinian communities and considerable growth of the hydroids *Millepora platyphylla* and zoanths *Zoanthus* sp. have been distinguished in the reef structure (Fig. 2 to 5).

From a morphological standpoint, the first zone ('algal-coral') starts from the intertidal zone. It includes separate scleractinian colonies, mostly of massive encrusting form. *Millepora* and *Zoanthus* form crustose colonies; sparse growths of *Turbinaria* and the alga

Laurencia inhabit rocky substrata and blocks. This zone is 11 to 20 m wide and up to 2 m deep.

The second morphological zone ('polyspecific settlement') is formed mostly by assemblages of polyspecific

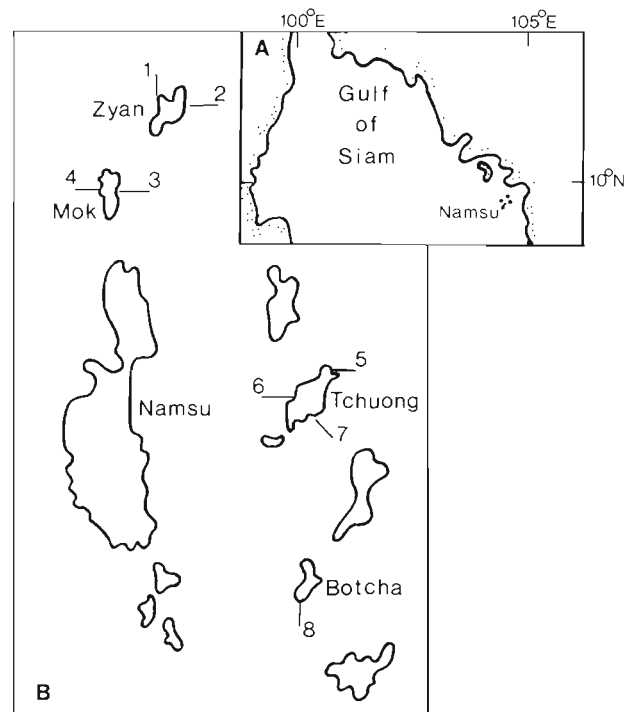


Fig. 1. (A) Location of Namsu Islands in the Gulf of Siam. (B) Location of the reefs and transects (1 to 8)

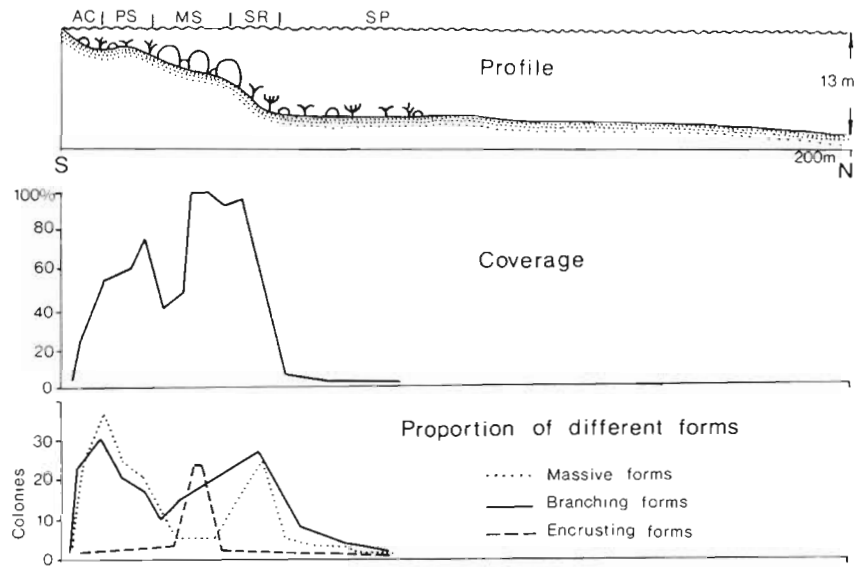


Fig. 2. Cross section on the reef Zyan (Transect 1)

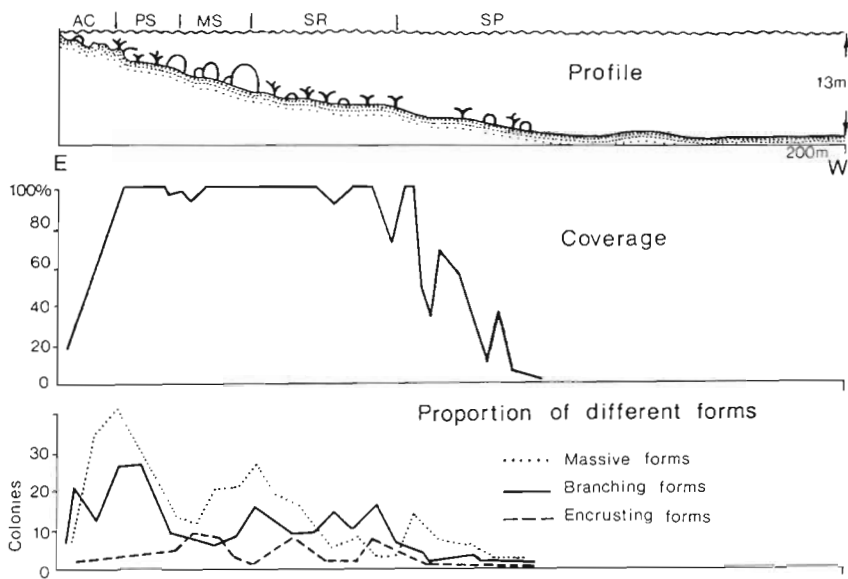


Fig. 3. Cross section on the reef Mok (Transect 4)

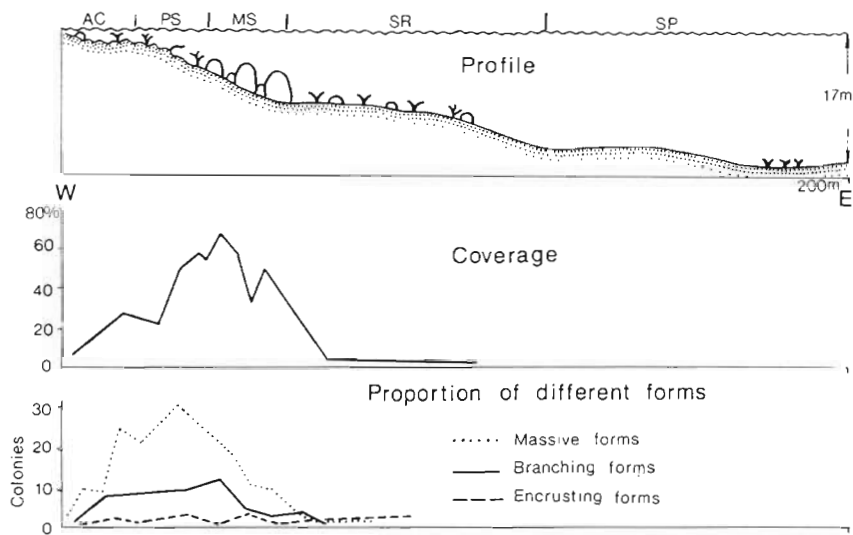


Fig. 4. Cross section on the reef Tchuong (Transect 5)

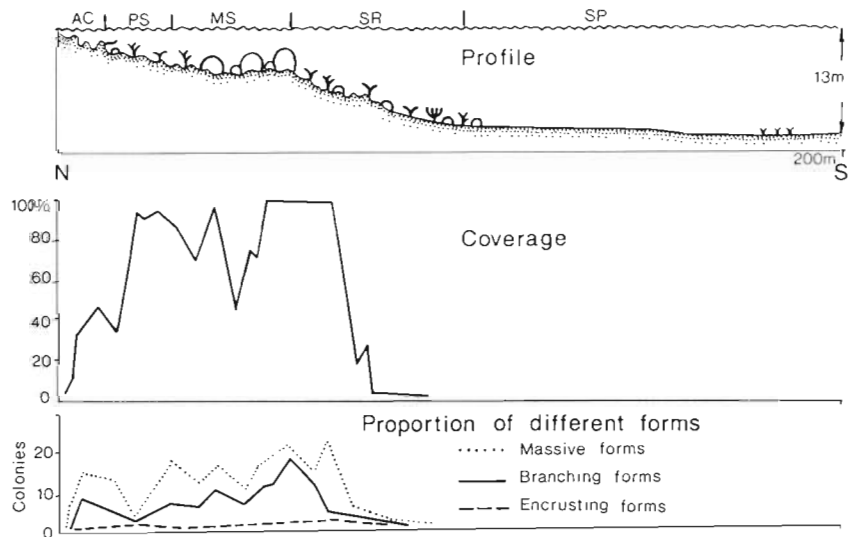


Fig. 5. Cross section on the reef Botcha (Transect 8)

scleractinian colonies of different growth forms with encrusting and weakly branched colonies of *Millepora*, sometimes also with *Zoanthus*. The substratum of the second zone contains boulders and pebbles of terrestrial origin, coral and shell debris. It is about 20 m wide and 3 m deep.

The third zone ('monospecific settlement') where corals are dominant, is almost completely formed by a monospecific population or by 2 to 3 scleractinian species. The substratum consists of dead coral colonies, coral debris, overgrown pebbles, and organic detritus of various origin. The zone is 15 to 30 m wide and 2 to 7 m deep.

The fourth zone, of Alcyonacea and coral, occupies the well-differentiated reef slope, inhabited by separate scleractinian colonies, soft corals and Gorgonacea attached to hard portions of a generally silty substratum. The zone is 20 to 60 m wide and 6 to 13 m deep.

The fifth zone lies on the sloping platform and is characterized by single colonies of Alcyonacea, Scleractinia and Gorgonacea mixed with a few solitary corals. Sparse growth of algae *Halophila* occurs frequently here.

MATERIALS AND METHODS

The distribution of scleractinian corals was studied quantitatively by the transect and quadrat techniques of Loya & Slobodkin (1971), Maragos (1974), Maragos & Jokiel (1976), and Bouchon (1981) on 8 cross-sections of the islands mentioned above (Fig. 1). The profile of each transect was established and the boundaries of biological zones marked. The coverage of the substratum was studied according to Maragos & Jokiel

(1976) with the number of dominant taxa (genera and species) registered. The proportion of massive, branching, and encrusting coral forms was recorded for every m^2 of transect. Qualitative samples of Scleractinia were taken in every physiographic zone. The coefficient of affinity between different zones, and between sides of the reefs (i.e. between different transects on the same island), was evaluated using Jaccard's index (1902). Scleractinia species were identified by the author using descriptions of Crossland (1952), Chevalier (1971, 1975), Veron & Pichon (1976, 1979, 1982), and Veron & Wallace (1984).

RESULTS

Eight transects were run from the islands, on both inner and outer sides of the archipelago (Fig. 1). Namsu Island, the largest in the archipelago, was not surveyed. Its reefs are apparently unrepresentative because of severe anthropogenic impact. All the reefs studied have generally the same morphological structure and zonation. The fringing reefs form a crust covering the substratum at a distance of 50 to 100 m from the shore around the islands and sea rocks.

A total of 133 species belonging to Scleractinia (36 genera) and Hydrocorallia (1 genus) were sampled during the study (Table 1). Species diversity and the degree of similarity between coral communities in different zones made it possible to distinguish 4 Scleractinia assemblages in the Namsu Archipelago reefs: (1) a community of the 'boat channel', (2) a community of the 'reef flat', (3) a community of the reef slope, and (4) a community of the sloping platform. The reef morphology terms and the principles of zonation

Table 1. Distribution of scleractinian corals on the reefs of Namsu Islands. Numbers represent the morphological zones of reefs where each species was found

Species	Transect no.							
	1 Zyan North	2 Zyan East	3 Mok East	4 Mok West	5 Tchuong East	6 Tchuong West	7 Tchuong South- east	8 Botcha
<i>Psammocora contigua</i> (Esper 1797)	1 3 4 5	2 3	1		1	1	1	1
<i>P. profundacella</i> Gardiner 1898	3 4 5					3 4		2
<i>P. digitata</i> Edwards & Haime 1851	4 5							
<i>Pocillopora damicornis</i> Linnaeus 1758	4 5	1 2 3 5	1 2	1 2 3	1 2	1	1 2 3	2 3
<i>P. verrucosa</i> Ellis & Solander 1834	1 5	1 3	2	1 2 3		2		3
<i>P. woodjonesi</i> Vaughan 1918			2				1 2	
<i>Acropora palifera</i> (Lamarck 1816)						1	3	1
<i>A. rotumana</i> (Gardiner)				2	1		1 3	1 3
<i>A. robusta</i> (Dana 1846)					1		1 3	1 3
<i>A. danai</i> (Edwards & Haime 1860)						1		
<i>A. nobilis</i> (Dana 1846)		2 3						
<i>A. formosa</i> (Dana 1846)					2	2 3	1 2 3	3
<i>A. valenciennesi</i> (Edwards & Haime 1860)								3
<i>A. vaughani</i> Wells 1954	4		2 3				3	
<i>A. aspera</i> (Dana 1846)			1		1			
<i>A. hyacinthus</i> (Dana 1846)							2 3	
<i>A. cytherea</i> (Dana 1846)	1 3			1 2 3 4	1		3	1 2
<i>A. surculosa</i> (Dana 1846)	4	1 4						
<i>A. millepora</i> (Ehrenberg 1834)	1 3	1 2 3	1 2	1 2 3 4		1	1 2 3	1 2 3
<i>A. delicatula</i> (Brook 1891)		4						
<i>A. tenuis</i> (Dana 1846)	1 2	4	1					
<i>A. cerealis</i> (Dana 1846)					2		3	
<i>A. nasuta</i> (Dana 1846)	1 2 3		1 2		2	2		
<i>A. diversa</i> (Brook 1891)		2 3	2	3	2	2		1 2
<i>A. valida</i> (Dana 1846)	1 2							
<i>A. humilis</i> (Dana 1846)		1 2	1			1	1 2 3	
<i>A. digitifera</i> (Dana 1846)	3	4	1	1 2	1		1 2 3	1 2
<i>A. divaricata</i> (Dana 1846)	3		2 3	1 4				2 3
<i>A. florida</i> (Dana 1846)	2 3	2 3		2 3	2	2 3		
<i>Astreopora ocellata</i> Bernard 1896	4	4 5	2 3		3	3	3 4	
<i>Montipora tuberculosa</i> (Lamarck 1816)						1 2 3		
<i>M. elschneri</i> Vaughan 1907	4							
<i>M. marshalensis</i> Wells 1954	2 3	4	1 2 3	3			3	
<i>M. turgescens</i> Bernard 1897	4	1 3			1 3			
<i>M. angulata</i> (Lamarck 1816)		1 3		1 2		2	3	
<i>M. venosa</i> (Ehrenberg 1834)			2 3				3 4	
<i>M. hispida</i> (Dana 1846)	1 2 3 4	1 2 3 4	1	1 2 3 4 5	2 3	1 2 3	1 2 3	3
<i>M. informis</i> Bernard 1897			5				3 4	
<i>M. subtilis</i> Bernard 1897		5						
<i>M. foliosa</i> (Pallas 1766)		3		3	3	2	2 3	
<i>Pavona cactus</i> (Forskål 1775)		5						
<i>P. frondifera</i> Lamarck 1801								2 3
<i>P. clavus</i> (Dana 1846)	3 4	4					3	3
<i>P. decussata</i> (Dana 1846)	3 4	2 3 4	2 3	1 3 4 5		3	2 3 4	3
<i>P. minuta</i> Wells 1954		1 2	2	2			3	
<i>P. explanulata</i> (Lamarck 1816)	3 4	4					3	3
<i>P. maldiviensis</i> (Gardiner 1905)		4	3	3				
<i>Leptoseris esplanata</i>				5	4			
Yabe & Sugiyama 1936								
<i>Pseudosiderastrea tayamai</i>					4			4
Yabe & Sugiyama 1936								
<i>Coscinarea columna</i> (Dana 1846)	5			4	2 3		4	
<i>Fungia fungites</i> (Linnaeus 1758)		4						
<i>F. danai</i> Edwards & Haime 1851							3 4	
<i>F. paumotensis</i> Stutchbury 1833	4 5	4 5		5	3 4		4	

Table 1. Continued

Species	Transect no.							
	1 Zyan North	2 Zyan East	3 Mok East	4 Mok West	5 Tchuong East	6 Tchuong West	7 Tchuong South- east	8 Botcha
<i>G. fascicularis</i> (Linnaeus 1797)	1 2 3 4				1		3 4	
<i>Lobophyllia hemprichii</i> (Ehrenberg 1834)	2 3	3	2 3	4	3	3	3	2 3
<i>L. corymbosa</i> (Forskål 1775)		5	2 3 4	3 4 5				
<i>L. costata</i> (Dana 1846)	3							
<i>L. hattai</i> Yabe, Sugiyama & Eguichi 1936	1 2 3 4	1 2 3 4 5		1	2 4	3	2 3	3 4
<i>Symphyllia recta</i> (Dana 1846)	1 3				2			1 2
<i>S. radians</i> Edwards & Haime 1849	1 3 4	1 2 3 5		1 4	1	3	3	
<i>S. valenciennesi</i> Edwards & Haime		5			1	2		
<i>Euphyllia fimbriata</i> (Spengler 1799)			3					
<i>Plerogyra sinuosa</i> (Dana 1846)			3		2 3			
<i>Turbinaria peltata</i> (Esper 1794)	3 4 5	1 2 3 4 5		1 4 5	2 3 4	3 4	3 4	3 4
<i>T. frondens</i> (Dana 1846)	3	2	2 3	1 4	2		3	
<i>T. reniformis</i> Bernard 1896	3	3	1 2 3		2 3	3	3	3
<i>T. mesenterina</i> (Lamarck 1816)	4	3 4	1			2 3	2 3 4	
<i>T. crater</i> (Pallas 1766)	3 4 5	1 2 3	2 3 4			3		3 4
<i>T. contorta</i> Bernard 1896						3		
<i>T. radicalis</i> Bernard 1896	4	5						
<i>T. patula</i> (Dana 1846)		1 2						
<i>T. stellulata</i> (Lamarck 1816)						3		
<i>Heteropsammia cochlea</i> (Spengler 1781)			5		4 5	5	5	5
<i>Bathyactis palifera</i> Lamarck 1816			5		4 5	5	5	5
<i>Heterocyathus aequiscostatus</i> Edwards & Haime 1849			5		4 5	5	5	5
Hydrocorallia								
<i>Millepora platyphylla</i> Hemrich & Ehrenberg 1834	1 2	1	1 2		1 2		1	1 2 3
<i>M. dichotoma</i> Forskål 1775	2		2	1	1 2			1 2 3
Number of species								
In transect	62	67	54	48	58	46	58	47
In reef		90		75		89		
Number of common species								
Between transects		39		26		28	28	
Between reefs			52		58			58

used in the study were defined by Picard (1967), Battistini et al. (1975) and Bouchon (1981).

The results concerning distribution of different branching, massive and encrusting growth forms on the reef and variations in the degree of coverage are presented in Fig. 2 to 5. The proportions of massive, branching and encrusting forms in the coral coverage are shown for the cross-sections of the reefs and are clear from these figures without additional discussion.

Although species diversity (Table 1) in all transects was relatively high and varied between 46 and 67 species, the communities were dominated by the same several species. *Porites australiensis* and *P. murraensis* were generally most abundant. *Galaxea fascicularis*, *Turbinaria peltata*, *Acropora cytherea*, *A.*

millepora and *Millepora platyphylla* were the next most abundant species. The rank order of abundance of different corals in each zone measured by percentage of coral coverage is presented in Fig. 6.

'Boat channel' community

The shore zone is exposed to maximal wave action and light intensity. The coral community of this zone is usually formed by species typical of boat channel and reef flat: *Pocillopora verrucosa*, *Psammocora contigua*, *Acropora millepora*, *A. digitifera*, *Goniastrea retiformis*, *Millepora platyphylla* and encrusting colonies of *Zoanthus* sp. (from 12 to 31 species). Coral coverage is

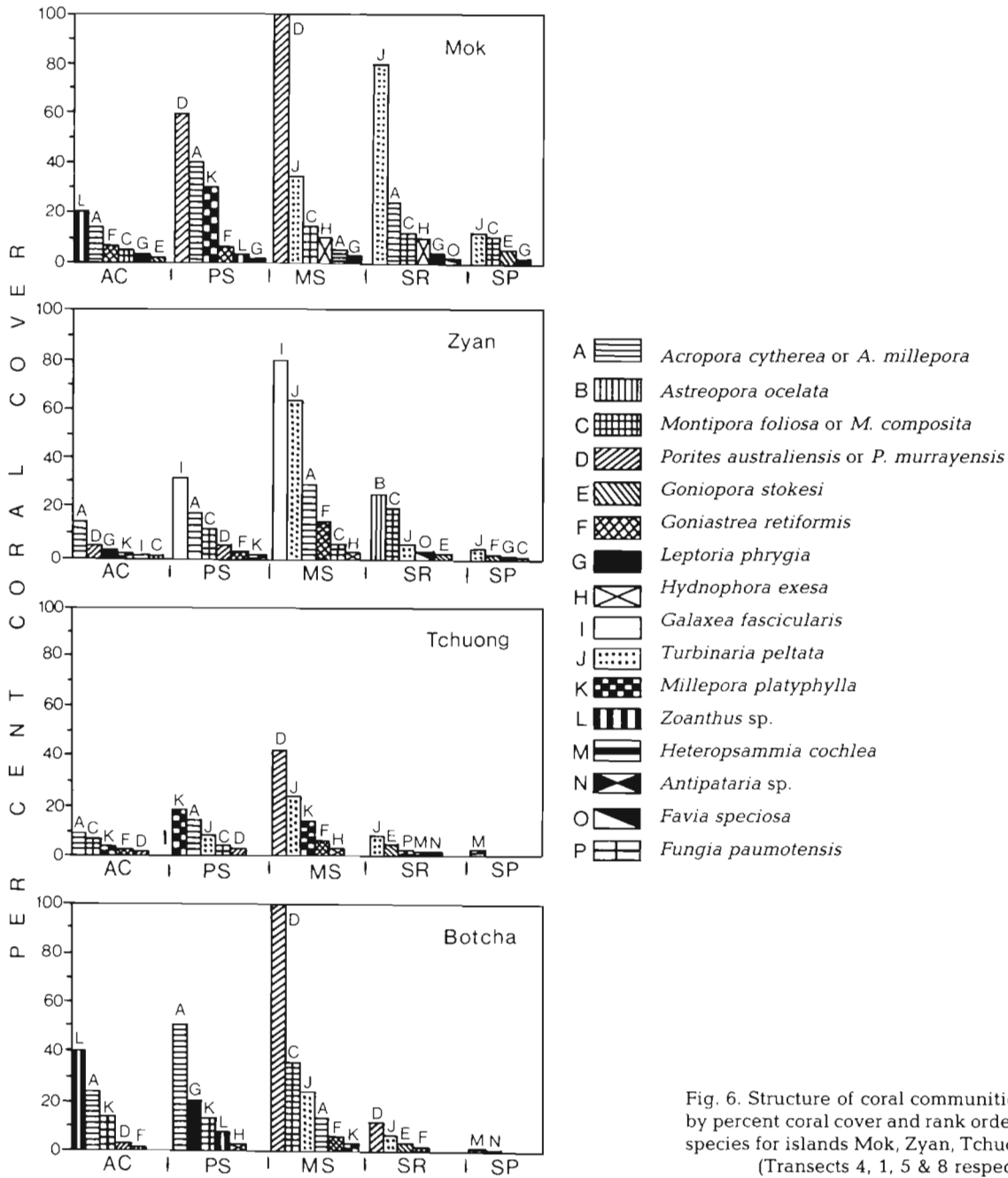


Fig. 6. Structure of coral communities as measured by percent coral cover and rank order of abundance species for islands Mok, Zyan, Tchuong and Botcha (Transects 4, 1, 5 & 8 respectively)

seldom above 40%. Maximal coverage is attained by *Zoanthus* sp. (40%), *Acropora* (34%), *Millepora platyphylla* (12%), *Leptoria* (6%), and *Porites* (4.5%).

The growths of *Turbinaria decurres* and the alga *Laurencia* sp. seldom cover more than 10% of the substratum. In general appearance and species composition of coral and algal coverage, the zone looks very similar to the boat channel defined by Bouchon (1981).

'Reef flat' community

This community is generally characterized by one or two species of dominant scleractinians. In this community an inner and an outer part can be distinguished, which differ in dominant species, some of them occupying only limited reef areas.

The inner part of this community differs from the previous 'boat channel' community by the appearance

of large branching and massive colonies and by small monospecific settlements. A mosaic pattern of coral settlements is very typical of this reef part. Coral coverage ranges from 20 to 100 %. The dominant genera are *Acropora* (12 to 52 %), *Galaxea* (18 to 32 %), *Leptoria* (12 to 20 %), *Montipora* (12 %) and the hydroid *Millepora* (8 to 14 %). A total of 13 to 32 scleractinian species occur in this subzone. A prominent feature of the inner part community is the development of small monospecific settlements of *Acropora cytherea* and *Galaxea fascicularis*.

The outer part is distinguished by the development of continuous monospecific settlements of corals typical of the reef flat and includes 20 to 47 scleractinian species. The reef flat is usually covered by *Acropora* growths but the Namsu reefs are dominated mostly by *Porites murrayensis* (48 to 100 %) and *Galaxea fascicularis* (10 to 100 %). *Turbinaria peltata*, *T. mesenterina* (24 to 64 %), *Acropora millepora* (10 to 54 %), *Montipora foliosa* (12 to 36 %), *M. hispida* (12 to 20 %), *Goniastrea retiformis* (6 to 15 %) and *Favia speciosa* (3 to 12 %) are common here. The degree of coverage by corals is usually high (60 to 100 %) and seldom below 40 %. Vast areas (several tens of square metres) covered with *Galaxea* and *Turbinaria* colonies are coalescent with large massive colonies of *Porites*. The inner and outer parts of the zone with their respective Scleractinia communities were found to be similar in several dominant species and in the community structure to the inner and outer parts of the reef flat described by Loya (1972), Pichon (1973) and Bouchon (1981).

Reef slope community

Reef slope communities have been described by many authors: Picard (1967), Pichon (1973), Faure & Montaggioni (1976) and Bouchon (1981). The reef slope community of the islands studied is remarkable for its high coral diversity and richness in growth forms. The species found here are either widespread or restricted to this zone only. Species with a wide distribution are *Acropora millepora*, *Montipora hispida*, *Pavona decussata*, *Porites lutea*, *Favia speciosa*, *Platygyra daedalea*, and *Goniastrea fascicularis*. The species *Pseudosiderastrea tayamai*, *Goniopora columna*, *Alveopora allingi*, *Oulastrea crispata*, *Leptastrea pruniosa* and *Trachyphyllia geoffroyi* seem to prefer this particular zone of weaker light and wave action. The lower levels of the reef slope are occupied by numerous colonies of *Alcyonacea*, *Gorgonacea* and *Antipatharia*. A total of 5 to 39 scleractinian species occurred in the zone. The coverage rate varied in the range 25 to 60 %, approaching 100 % in the sites occupied by monospecific settlements. The highest

percentage of coverage is contributed by dominant *Porites* (12 to 42 %), *Montipora* (6 to 20 %), *Astreopora* (26 %), *Turbinaria* (12 %) and *Fungia* (3 to 5 specimens per m²). The lower level of the reef slope supported small separate colonies of *Turbinaria peltata*, *Psammocora profundacella*, *Astreopora ocellata*, *Coscinarea columna*, *Fungia paumotensis* and *Trachyphyllia geoffroyi*.

Sloping platform community

A low rate of coverage (several percent and fractions of percent) and suppressed, small and scattered colonies of about a dozen Scleractinia species are typical of the zone. Representatives of *Leptoseris*, *Goniopora*, *Leptastrea*, *Lobophyllia*, *Symphyllia*, *Trachyphyllia* and *Turbinaria* which are common for deep sites with low light intensity inhabit this peripheral reef part.

The sloping platform of the Namsu reef is distinguished by the development of small single scleractinian corals *Heteropsammia cochlea* and *Bathyactis palifera* (up to 400 to 800 specimens per m²) with tufts of the grass *Halophila decipiens* scattered between them. Glynn (1974), Faure (1977), Bouchon (1981) and other authors have reported the scarcity of vegetation on the sloping platform.

DISCUSSION AND CONCLUSION

Qualitative diversity of Scleractinia in different reef zones and reef zone parts was expressed through the degree of similarity (number of common species). The various reef zones contained from 0 to 62 species in common. Adjoining zones supported the greatest number of common species. The greatest similarity is typically found in the 3 coastal zones: 44 to 52 % of common species in the 'algal-coral' and 'polyspecific settlement' zones, 36.31 to 62.5 % in 'polyspecific' and 'monospecific' settlements, and 25.52 to 58.62 % in the 'algal-coral' and 'monospecific' settlements. A far lower similarity (22.84 to 34.28 %) was found between the species compositions of the 'monospecific' settlement and the 'reef slope'. Very few or no common species were found in zones remote from each other. The 'algal-coral' zone and the 'sloping platform' had 0 to 13 % and the 'polyspecific settlement' zone and the 'sloping platform' supported 0 to 17 % species in common. Coastal zones were inhabited by common reef corals adapted to a wide range of ecological conditions. The reef slope zone always supports some specific and some widespread reef species. Similar and other characteristics of the slope communities have been given by Loya (1972), Pichon (1973), Maragos (1974), Faure (1977) and Bouchon (1981).

The degree of affinity expressed by the number of common species between different sides of reefs was high, 46.18 to 61.12%. The reefs of separate islands had nearly 60% species in common. This may be explained by noting that the Namsu reef zones can be only conventionally compared to lagoons (boat channel) or reef flat. On Namsu reefs there are no lagoons or boat channels separated by a reef flat and also no reef-flat platform. An exception is the southeastern side of Tchuong Island, where we observed shallow reef-parts which were morphologically similar to a lagoon or reef flat and contained combinations of taxa and growth forms of scleractinians and algae usually typical of these zones. Coastal zones of the southeastern part of Tchuong reef have 17.12 to 29.41% of common species. This is consistent with the coefficients of similarity of other reef zones with typical zonality, which possess no more than 50% species in common (Bouchon 1981). On the Jang Bo reef in the Fukhang Province of South Vietnam, all the typical zones show a high degree of similarity: 6.88 to 37.14% of species in common. Similar affinity is found for scleractinian communities of various zones of more than 20 other reefs of the province.

Qualitative diversity of Scleractinia over a reef shows different ecological requirements of coral species. For Namsu reefs we have established 3 groups of corals in terms of their adaptation to different wave action and illumination:

(1) Coral species widespread from the lower horizon of the intertidal zone down to a reef slope: *Pocillopora damicornis*, *Acropora millepora*, *Montipora hispida*, *Galaxea fascicularis*, and *Goniastrea retiformis*.

(2) Coral species inhabiting the lower part of the reef slope and adapted to weaker illumination: *Pseudosiderastrea tayamai*, *Goniopora columna*, *Alveopora allingi*, *Oulastrea crispata*, *Leptastrea pruniosa* and *Fungia paumotensis*.

(3) Coral species inhabiting the sloping platform and adapted to limited illumination: *Trachyphyllia geoffroyi*, *Montipora subtilis*, *Turbinaria peltata*, *Heteropsammia cochlea* and *Bathyactis palifera*.

Zones of intensive wave action are inhabited by *Acropora rotumana*, *A. robusta*, *Favia pallida*, *Goniastrea retiformis* and the hydrocoral *Millepora platyphylla*.

The following 5 genera show the greatest species diversity: *Acropora* (24 species), *Favia* (11 species), *Montipora* (10 species), *Turbinaria* (9 species) and *Porites* (7 species). These genera are responsible for the maximal coverage and development of mono-specific settlements occupying vast areas, but their contributions vary. The densest and largest settlements are formed by *Porites* and *Galaxea*, which often occupy 100% of the available area. *Turbinaria* and *Acropora*

are responsible for 64 and 54% of coverage, respectively, and *Montipora* cover up to 40% of the substratum. Encrusting colonies of *Millepora* and *Zoanthus* cover small areas in the coastal zone.

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