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# THE CORAL REEF ECOSYSTEM AT CHIRIATAPU IN SOUTH ANDAMANS : 1. SPECIES COMPOSITION AND ZONATION

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ABSTRACT

The coral reef at Chiriatapu is a leeward fringing reef with a tropical oceanographic setting. Surveys of reef corals at Chiriatapu were done with respect to species composition and zonation. Data from this survey records 38 species from 13 families, 12 are new records from this region. The new records now raise the total number of reported reef coral genera and subgenera from 31 to 36 (including soft corals). The distribution and zonation are largely controlled by an ecological grid, modulated by such parameters as space, light, salinity, water motion and nutrients, while the succession of major types follow the hydrodynamic gradient and the energy changes of the sea (*Porites* → *Acropora* → *Pocillopora* series). This colonization pattern seems to be regulated through growth gradients of species based on 'r' and 'k' selection. Indo-Pacific species belonging to the genera *Pocillopora, Acropora, Porites, Montipora, Favia* and *Fungia* account for much of the coral coverage, and the assemblage shows consistency in distribution with Indo-Pacific reefs. A striking feature is the abundance of octocorals which have selected the channel slopes as their niche.

## INTRODUCTION

VERY few studies have been carried out on the taxonomic and ecological aspects of the various reefs around Andamans since the pioneering work of Sewell (1922). Inspite of recent investigations (Pillai, 1972; Scheer and Pillai, 1974; Reddiah, 1977; Stoddart, 1973; Pillai 1983), large gap exists in our knowledge of the corals and coral reefs of this region. The innumerable reefs present here are yet to be systematically studied and analysed, with reference to the general topography, ecology, depositional history, floral and faunal composition. Most of the works mentioned above are concentrated on the hard corals (scleractinians), while the soft corals (octocorallia) have been left practically untouched.

Coral reefs have a set ecological tuning with respect to physical, chemical, geological and meteorological parameters and have been studied by several workers (Agassiz, 1903; Kawaguti, 1941; Vaughan and wells, 1943; Banner, 1952; von Arx 1954; Odum, 1955; Goreau, 1959; Weins, 1962; Yonge, 1963; Pillai, 1972; Scheer, 1972; Loya, 1972; Stoddart, 1973; Glynn, 1974; Dana, 1975; Orme, 1977; Smith, 1978; Muscatine, 1980; Hatcher and Frith, 1985; Mukherjee, 1988) in order to describe and quantify the reefs ecosystem and dynamics.

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Rosen (1971 b) has predicted the generic diversity of corals in the Indo-Pacific region based on water temperature and he lists about 44 genera of hermatypic corals for the Andaman region. Pillai (1972) records about 31 genera (23 hermatypic and 8 non-hermatypic) from this region.

Information regarding reef community structure is a more recent development and gives an idea about the biological interaction between species, their interaction with the environment, and the structural role they play in the formation and maintenance of reefs as persistent geological features in the marine environment. Interesting accounts in this aspect has been given by Loya (1972), Stoddart (1973), Connel (1973), Jokiel and Maragos (1978), Pichon (1978) and Scheer (1978).

Rosen (1971 a) has developed a model based on water movement in the various parts of the reef. It relates to the succession of major types of corals along hydrodynamic gradients. Water movement not only controls the type of coral species that can develop in different areas of the reef, but also induces a growth form change in the same species inhabiting different zones.

This paper describes the scleractinians and octocorals collected at the Chiriatapu fringing reef in south Andamans during November - December 1979, 1982 and 1984. Additional studies have been made to correlate the pattern of zonation and distribution with various environmental parameters such as light, temperature, salinity and water motion, etc. and the modulation of the biogeochemical cycle by corals. The community organisation has been analysed to reveal the various coral assemblages, their dominance, habit preferences and niche seggregation.

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## Topography Structure and Zonation

### *Topography*

The Andaman and Nicobar group of islands in the bay of Bengal, forms a chain, that extends for about 850 km between 06°45'N and 13°45'N and within 92°15'E and 94°00'E (Fig. 1).

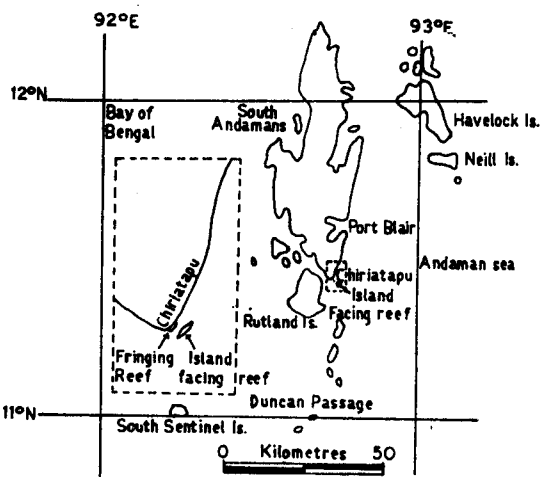


Fig. 1. The Andaman Islands. Inset : The Chiriatapu region enlarged.

The island represents the peak of a prominent oceanic rise, extending from the mountain ranges of western Burma and continuing in a south easterly direction through the islands of Sumatra and Java.

The islands are in two groups : the Andamans and the Nicobars, with the 10° channel seperating the two. The main Andaman ridge (non-volcanic) is broadly divided into the north, middle and south Andamans. Chiriatapu lies off the east coast of south Andamans, south of Port Blair.

Geologically, the Chiriatapu bedrock belongs to the serpentine group (Srinivasan, 1979) consisting of ultrabasic and basic rocks such as gabbroes, peridotites, dunites and serpentinites, suggesting an origin between late Cretaceous to Eocene (70-45 million years ago). The geological time has significance because, it was during the Eocene that in the eastern Tethys that the Indian and Malaysian coral fauna began to differentiate from that of the Central Tethys.

*Structure and zonation*

The reef at Chiriatapu is a fringing reef. The reef structure starts about 100 m from the back shore, skirting the beach and ends some distance in front of another small island (Fig. 2). The reef is leeward, being protected by the presence of islands on either side.

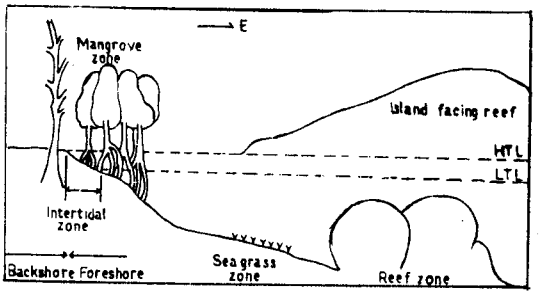


Fig. 2. Location of the reef relative to the shore and the island in front.

The beach is mainly sandy with rubbles to a certain extent and slopes gradually into the sea, forming a well defined intertidal zone (Fig. 2) which supports a rich invertebrate fauna including a variety of crabs such as the ghost crab (*Ocypode* sp.) and the land adapted hermit crab *Coenobita* sp.

On the two sides of the beach and extending laterally in the mangrove zone consisting mainly of *Rhizophora mucronata* and *Rhizophora apiculata*. These mangroves are a unique feature in the Andaman group of island and is present in sheltered bays as well in open shores. They provide a sheltered environment for the corals, protecting them from wind action and abrupt deposition of land drawn sediments. At about five metres from the mangrove zone, is the sea grass zone consisting mainly of *Thalassia hemprichi*.

The reef may be divided into five major physiographic zones.

1. *Inner flat* extends for about 15-20 m and forms a platform of rock skirting the shore. It has a rich coral fauna consisting mainly of massive corals covered with a thick algal turf. The turf is grazed by herbivorous organisms and thus provides one of the major food sources in the energy flow chain of the reefs (Fig. 3).

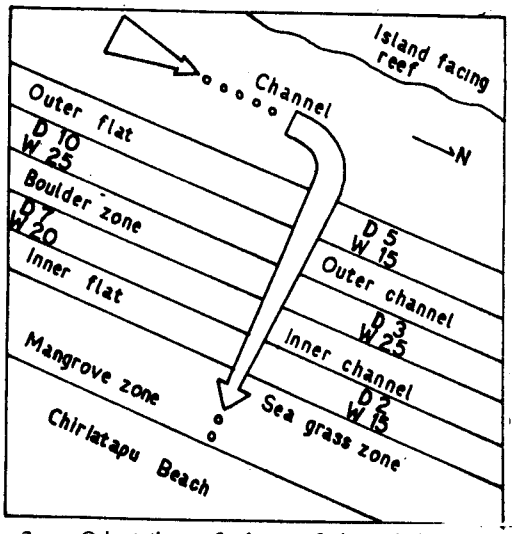


Fig. 3. Orientation of the reef in relation to the topographic features. Arrows indicate the direction of water current. D = depth in metres, W = width in metres.

2. *Inner channel* is about 20-25 m in width and about 7 m in depth. It is composed mainly of sand and dead coral debris, in which abound some of the larger molluscs and echinoderms such as *Trochus* sp. and *Holothuria atra.*

3. *Boulder zone* is a mixed coral zone and lies next to the inner channel. It is about 25 m in width and 3 m in depth and is occupied by a mixed community of encrusting, foliaceous and ramose corals.

4. *Outer channel* is about 20 m in width and 10 m in depth. It is relatively less transparent and the bottom is not visible. The slopes of the channels are inhabited by some of the more colourful forms, comprising of a large number of soft corals, along with sponges.

5. Outer flat is beyond the outer channel. The reef flattens somewhat to form the outerflat which is about 15 m in width and 5 m in depth. Here are to be found, some of the fastest growing species. The reef edge then passes steeply to the sea bottom.

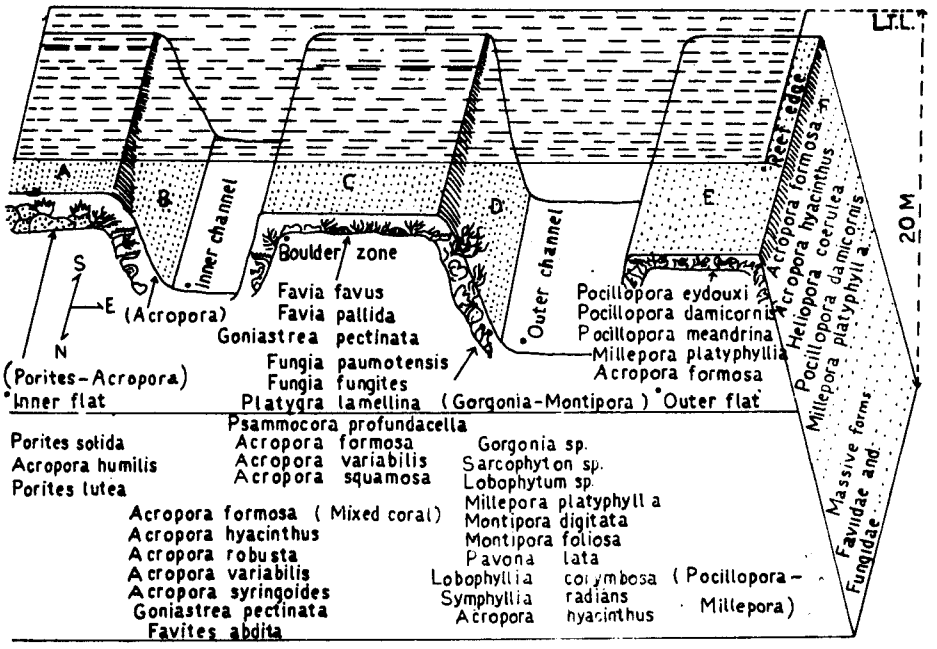


Fig. 4. Section through the fringing reef at Chiriatapu showing the zones and their general configuration. A, B, C, D, E indicate coral collection sites.

The various zones and their general configuration are represented in Fig. 4, while Table 1 summarizes the topographic parameters of the reef. All the zones lie parallel to the longitudinal axis of the reef edge, which is in line with the shore and the island in front.

## MATERIALS AND METHODS

Corals were collected from various reef zones as indicated in Fig. 2. The collected corals were washed with a 1 : 10 solution of bleaching powder and dried. Each of them were then tagged with information regarding location, depth, association and per cent coverage.

Transparency was measured with a standard secchi disc, while air and water

temperature were measured by mercury thermometer. Water quality was analysed on the spot using standard methods (Strickland and Parsons, 1963). Evaporation was calculated from pan measurements, while data on pressure, clouds, relative humidity, vapour pressure, wind speed and rainfall were taken from weather reports recorded by the Meteorological Institute of India.

*Abiotic environment*

The Chiriatapu reef being leeward, wind action is relatively low, except during tropical storms and cyclones, which are quite frequent in the Andamans. The mean wind velocity during the period of survey was 4.8 m per second while over the reef the average velocity was about 0.8 to 1.2 m per second. Water current is also relatively low. Although moderate surf prevails down south of the reef, where the island facing the reef ends and it becomes windward, but over the reef, the water is quiet. The resultant surface-water wind drift reaches diagonally to the shore (Fig. 3). Diurnal variation of tide height shows a tidal range of 0.5 to 1.5 m. Thus the region may be termed as mesotidal.

TABLE 1. *Topography of the Chiriatapu Fringing reef*

| Site | Distance from low tide mark (m) | Upper limit of corals from LTL (m) | Maximum depth from LTL (m) | Lower limit of corals from LTL (m) | Incline (°) | Percent coverage |
|---|---|---|---|---|---|---|
| A | 10-25 | 1-3 | 6 | 3-5.5 | 0 | 80 |
| B | 25 | 2 | 7 | 6.0 | 30 | 40 |
| C | 45-70 | 3 | 7 | 5.0 | 0 | 50 |
| D | 70 | 3.5 | 10 | 9.5 | 35 | 40 |
| E | 95-110 | 5 | 10 | 6.5 | 0 | 70 |
| F | 110 | 5.5 | 20 | 15 | 60 | 50 |

## RESULTS

*Oceanographic setting*

Reefs are adapted to and themselves modify their environment. The preliminary coarse tuning for the growth of the reefs is set by the general environmental parameters, but once growth starts, it seperates an ecosystem quite distinct from the general oceanic biome by introducing diverse biological components into the bio-geo-chemical cycle of the oceans.

Early morning temperatures across the reef are nearly uniform, but within a few hours the

TABLE 2. *Water quality at the Chiriatapu reef*

| Zone | Salinity (‰) | $CO_2$ Mole/$m^3$ | $O_2$ | Alkalinity equiv/$m^3$ | pH | Water Temp. (°C) | Light penetration (m) | Current |
|---|---|---|---|---|---|---|---|---|
| 1 | 35.75 | 2.005 | 5.23 | 2.358 | 8.5 | | Complete | |
| 2 | 36.64 | 2.421 | 1.34 | 2.567 | 7.8 | | Complete | |
| 3 | 35.74 | 2.000 | 5.27 | 2.360 | 8.2 | 28.72 (mean) | Complete 8.12 | Quiet, slight surf South of the reef |
| 4 | 36.64 | 2.421 | 1.37 | 2.567 | 7.8 | | | |
| 5 | 35.72 | 1.930 | 5.65 | 2.349 | 8.3 | Complete | | |
| 6 | 36.52 | 2.376 | 4.42 | 2.570 | 7.8 | 9.57 | | |

temperature near the shore is higher than at distances farther into the sea. The mean day temperature of the sea water is 28.7°C and is approximately a degree lower than the mean air temperature during the day. The temperature pattern shows a distinct relation with the depth of the zone and its distance from the shore.

The conditions of light can be considered to be favourable for both photosynthesis and calcium deposition, due to complete illumination of most of the coral zones upto a depth of 7 m (Table 2). At greater depths, such as in the outer channel and reef slope, the extinction coefficient (K) varies from 0.20 to 0.18, the lower value being attained in the reef edge.

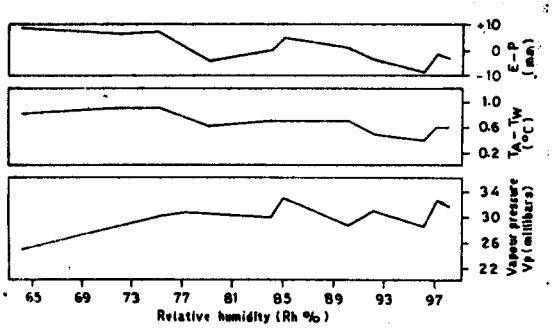


Fig. 5. General environmental conditions at Chiriatapu during the period of survey. TA = air temperature, TW = water temperature, E = evaporation, P = precipitation.

In the Chiriatapu reef, the high temperature of the day (about 32.8°C at mid-day) and a constant positive difference between the air and water temperatures ($T_A - T_W = 0.86 \pm 0.06$°C) results in a high rate of evaporation and consequently the humidity is high (mean relative humidity is 80%) (Fig. 5). Precipitation and evaporation rates indicate a net excess of evaporation of 0.75 ± 0.70 m which raises the salinity of the reef. The average salinity of the reef is 36.09 ± 0.43‰ and is less than the salinity of the surrounding ocean (Table 2).

The chemical environment at Chiriatapu shows a marked alternate gradient in relation to the distribution of the biota (Table 2). The aging process of the water occurs in the channels while the metabolic rhythm of the biota modulate the circulation and controls the biogeochemical cycle (dealt in details elsewhere).

*Coral community*

A list of the corals collected from the fringing reef is presented in Table 3. The list includes 38 species from 13 families of which 12 are new records from this region. The new records now raise the total number of reported coral genera and subgenera from 31 to 36 (including hermatypic, ahermatypic and soft corals). The number will definitely increase with detailed survey of the various reefs present in the Andaman and Nicobar group of islands.

TABLE 3. *Species list of reef corals collected from the Chiriatapu reef the new records are shown with an asterisk*

Suborder : Astrocoeniina (Vaughan and Wells, 1943)

**Family : Pocilloporidae (Gray, 1849)**

*Pocillopora damicornis* (Linnaeus, 1758)*

*P. eydouxi* Milne Edwards and Hoime, 1860

*P. verrucosa* (Ellis and Solander, 1786)*

*P. meandrina* (Dana, 1846)*

**Family : Acroporidae (Verrill, 1902)**

*Acropora formosa* (Dana, 1846)

*A. humilis* (Dana, 1846)

*A. hyacinthus* (Dana, 1846)

*A. variabilis* (Klunzinger, 1879)

*A. hebes* (Dana, 1846)

*A. syringoides* (Brook, 1892)

*A. squamosa* (Brook, 1892)

*A. echinata* (Dana, 1846)

*Montipora digitata* (Dana, 1846)

*M. foliosa* (Bernard, 1897)

*M. verucosa* (Lamarck, 1816)

Suborder : Fungiina (Verrill, 1865)

**Family : Agariciidae (Gray, 1847)**

*Pavona lata* (Dana, 1846)

**Family : Thamnasteriidae (Wells, 1956)**

*Psammocora profundacella* Gardiner, 1905

**Family : Fungiidae (Dana, 1846)**

*Fungia (Pleuractis) paumotensis* Stutchbury, 1833

*F. (Ctenactis) echinata* (Pallas, 1766)

*F. (Verillofungia) concinna* Verrill, 1864

*F. (Danafungia) danai* Milne Edwards and Haime, 1960

*F. (Fungia) fungites* (Linnaeus, 1758)

**Family : Poritidae (Gray, 1842)**

*Porites solida* (Forsskal, 1775)

*P. lutea* Milne Edwards and Haime, 1851*

Suborder : Faviina (Vaughan and Wells, 1943)

**Family : Faviidae (Gregory, 1900)**

*Favia favus* (Forskål, 1775)

*F. pallida* (Dana, 1846)

*Favites abdita* (Ellis and Solander, 1786)

*Goniastrea pectinata* (Ehrenberg, 1834)

*Platygyra lamellina* (Ehrenberg, 1834)

**Family : Mussidae**

*Lobophyllia corymbosa* (Forskål, 1775)

*Symphyllia radians* Milne Edwards and Haime, 1848

**Family : Helioporidae (Moseley, 1876)**

*Heliopora coerulea* (Pallas, 1766)*

Suborder : Stolonifera (Hickson, 1883)

**Family : Tubiporidae** (Ehrenberg, 1828)

*Tubipora musica* (Linnaeus, 1758)*

Suborder : Alcyoniina

**Family : Alcyonidae**

Sarcophyton sp.

*Lobophytum* sp.

Suborder : Holaxonia

**Family : Gorgonidae**

*Gorgonia* sp.

**Family : Milleporidae (Flemming, 1828)**

*Millepora platyphylla* (Hemprich and Ehrenberg, 1834)*

Classification and systematic sequence followed in the arrangement of the checklist is that of Wells (1956).

*Zonation and species combination*

The coral community at Chiriatapu may be classified into five combinations or assemblages corresponding to the morphological zones (A, B, C, D and E) (Fig. 4).

A. The *Porities* — *Acropora* combination is found in the origin zone. *Porites lutea* forms huge rounded colonies on which are interspersed colonies of *Acropora humilis.* The associated species are *Porites solida, Acropora formosa* and *Acropora hyacinthus.*

B. The second assemblage occupies the slopes of the inner channel and consists of *Acropora formosa, A. hyacinthus, A. robusta, A. variabilis, A. syringoides, A. hebes, Goniastrea pectinata* and *Favites abdita.*

C. The boulder zone has a mixed coral assemblage and is populated by *Favia favus, F. pallida, G. pectinata, Fungia paumotensis, F. Fungites, F. danai, Platygyra lamellina, Psammocora profoundacella, A. formosa, A. variabilis, A. syringoides* and *A. squamosa.*

D. The *Gorgonia* — *Montipora* assemblage occupies the outer channels and includes mostly the octocorals and hydrozoan forms. Prominent species in this zone are *Gorgonia* sp., *Sarcophyton* sp., *Lobophytum* sp., *Millepora platyphylla.* Associated species include *Montipora digitata, Pavona lata, Montipora foliosa, M. verucosa, Lobophyllia corymbosa, Symphyllia radians, A. formosa, A. hyacinthus, P. meandrina.* However, the conspicuous feature of the outer channel slopes is the abundance of soft corals and sponges. The gorgonians with their branched tree like structure forms a coral garden. Most of the gorgonians found here are coloured, ranging from orange to deep red.

TABLE 4. *Distribution of corals at Chiriatapu*

| Sites | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| *P. damicornis* | | | | | | |
| *P. eydouxi* | | | | | | |
| *P. verrucose* | | | | | | |
| *P. meandrina* | | | | | | |
| *A. formosa* | • | • | • | • | • | • |
| *A. humilis* | • | • | • | • | • | • |
| *A. hyacinthus* | • | • | • | • | • | • |
| *A. variabilis* | | • | • | | | |
| *A. robusta* | | • | | | | |
| *A. hebes* | | • | • | • | | |
| *A. syringoides* | | • | • | | | |
| *A. squamosa* | | | • | • | | |
| *A. procumbens* | | • | | • | | |
| *M. digitata* | | | | • | | • |
| *M. foliosa* | | | | • | | |
| *M. verrucosa* | | | | • | | |
| *P. lata* | | | | • | | |
| *F. Paumotensis* | | • | • | • | | |
| *F. echinata* | | | • | • | | |
| *F. concinna* | | | | • | | |
| *F. danai* | | | | • | | • |
| *F. fungites* | | | | • | | • |
| *P. sgillda* | • | | | | | |
| *P. lutea* | • | | | | | |
| *F. favus* | | | • | • | | |
| *F. pallida* | | | • | | | |
| *F. abdita* | | • | | | | |
| *G. pectinata* | | • | • | | | • |
| *P. lamellina* | | | • | | | |
| *L. corymbosa* | | | • | • | | |
| *S. radians* | | | | | • | • |
| *H. coerulea* | | | | | • | • |
| *T. musica* | | | | | • | |
| *Sarcophyton Sp.* | | | | | • | |
| *Lobophyum Sp.* | | | | | • | |
| *Gorgonia Sp.* | | | | | • | |
| *M. platyphylla* | | | | | • | |

E. The *Pocillopora — Millepora* assemblage is found in the outer flat (Table 4) and consists of a mixed community of fast growing species such as *Pocillopora eydouxi, P. damicornis, M. platyphylla, A. formosa, A. hyacinthus* and *A. humilis.*

F. The reef edge slope has two distinct communities, the upper 10 m consists mainly of foliaceous and ramose corals, while the lower region is occupied by various species of Faviidae and Fungiidae and includes mostly massive forms. Table 4 summarizes the occurrence of the various species along the reef.

## DISCUSSION

The general structure and topography of the reef at Chiriatapu conforms to an ideal fringing reef and has an orientation similar to other fringing reef types described earlier by Vaughan (1919), Wells (1951), Goreau (1959) and Pichon (1967). Departure arises in the presence of two deep channels, an outer and an inner, which are completely devoid of corals and consists mainly of sand and dead coral debris.

The conditions of light and temperature at Chiriatapu can be considered favourable for both photosynthesis and calcium deposition, due to complete illumination of the coral zone at all depths (k varies from 0.18 to 0.20), while the temperatures are within accepted optimal range for hermatypic corals (25 to 29° C, Vaughan and Wells, 1943).

Temperature and the depth of the euphotic zone also have a pronounced effect on the lower limit of the corals. Rosen (1971 b) has pointed out a simple relationship between coral diversity and water temperature. At Chiriatapu the reef edge slope reaches a depth of 20 m,

which is within the euphotic zone. The significance being the dependence of these organisms on photosynthetic products, since the "combustible energy-giving material" is normally supplied by the zooxanthellae (Gohar, 1940, 1948) and these can only be available when there is sufficient light for photosynthesis. Turbidity, light and temperature represents a complex interaction of factors, which have been suggested to limit reef development (Smith, 1978).

The modern reef structure in and around Andamans seems to have developed about 5000 years ago (details elsewhere) and has a pronounced tuning of the biogeochemical cycle. The metabolic rhythm of the biota (production, respiration and calcification) along with community parameters such as biotic interaction produces a fine tuning, which is evident in the marked environmental gradient within the reef. This gradient controls the hydrodynamics and nutrient inputs within the system. The average salinity of the reef is 36.09‰, close to the 34-36‰ range, considered by Vaughan and Wells (1943) to be optimal for coral growth.

Rosen (1971 b) has classified the Indo-Pacific reef coral genera on the basis of the frequency with which they have been reported on islands in the Indian Ocean. Class I genera are those occurring in more than 50% of the observed localities, Class II genera are found in 25-50% of the localities, while Class III genera occur in 25% of the localities.

Of the 12 Class I genera, nine (75%) are found in the Chiriatapu reef. Two genera namely *Galaxea* and *Cycloseris*, though not found in this reef, have been reported (Pillai, 1972) from other reefs in the Andaman and Nicobar Islands. So 92% of the Class I genera are represented here.

Of the 25 Class II genera, about 11 (44%) occur in this reef, while at least 15 (60%) have been reported from Andamans. Among the 44 Class III genera, only 1 (*Fungia ctenactis*) has been collected from the Chiriatapu reef, while, at least 5 (11%) have been reported from this region. However, the conspicuous feature of this reef, is the abundance of soft corals (octocorallia) and large gaps exist in our knowledge about the occurrence, diversity and taxonomy of the octocorals of this region. Thus with regard to the scleractinians, the reefs of the Andaman region appear to be quite representative of the Indo-Pacific reefs. However, detailed systematic studies will surely increase the number of scleractinian genera and explain the distributional discontinuties of some of them.

The pattern of arrangement follows hydrodynamic gradients with a *Porites* → *Acropora* → *Favia* → *Pocillopora* series growing sequentially. The inner flat with insignificant wave action has formed an ideal region for the development of *Porites*, which is the dominant species and forms massive colonies. The encrusting, thick algal mat serves as a suitable foraging ground for reef fishes such as *Scolopsis bilineatus*, which move in the schools to their feeding ground.

*Acropora* attains dominance in the slopes of the outer channel and the outer flat. The predominant species being *Acropora formosa* which, along with *Acropora humilis* and *Acropora hyacinthus* attains a constancy Class I, being present in all the zones.

The inner channel is dominated by the soft corals and sponges, while the reef edge is occupied by various species of *Pocillopora*. These fast growing species are adapted to the wave surf experienced at the edge.

The generic diversity and the pattern of zonation conforms of the model developed by Rosen (1971 a). He has predicted about 44 genera of corals for this region and the number of genera reported is 31. The discrepancy lies in undercollection and in the fact that most of the reefs are yet to be studied in details.

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