The Distribution and Community Structure of Octocorals in Northeastern to Southeastern Waters of Hong Kong SAR

LEE, Mei Wah

A Thesis Submitted in Partial Fulfillment of the Requirement

for the Degree of Master of Philosophy

in

Biology

August 2007

Thesis Committee

Supervisor:	**Professor Put O. ANG, Jr.**
Internal examiners:	**Professor Ka Hou CHU**
	Professor Lee Man CHU
External examiner:	**Professor Jun-Im SONG**
	(Department of Life Science
	Ewha Womans University, Korea)

Acknowledgements

It is so thankful that this project has finally come to an end. Throughout these three years of my postgraduate study, I have encountered many problems, followed by worries and doubts. Fortunately, with the help from lots of people, all difficulties were successfully addressed. This will be one of the most important and unforgettable experiences in my life. In here, I would like to take the opportunities to express my sincere thanks to all those people who supported and cared about me all these times.

First of all, I would like to thank Prof. P.O. Ang for introducing me to this amazing underwater world. His patience in supervision, countless encouragement and endless support to my research are important reasons for this study to be completed. I would also like to thank Prof. K.H. Chu and Prof. L.M. Chu for giving valuable comments and suggestions on my research and their evaluations of this thesis.

I am much obliged to my beloved grandparents, parents and elder sister for their concern and understanding. They let me grow up in a comfortable environment that is full of love and care.

I am so grateful to Mr Y.H. Yung for his generous help with each journey to and from the field sites and for his strict concern about dive safety. He did teach me a lot in these few years. Special thanks to Mr Ben H.B. Yeung for the technical supports and all the help in my experimental set-ups.

Special thanks are made to my buddies, Mr Chris H. L. Fung, Ms Winnie S.Y. Wong, Mr Jovy M.C. Tam, Mr Atwood Y.M. Chiu, Mr Sven T.P. Lin, Mr F.F. Yeung and Mr Anton Y.T. Tsang and all other labmates for their assistance in the field. They were always ready to help, and I am so glad to have become a good friend with them. Special thanks to Chris H. L. Fung, he is my trustful buddy and the one who took most of the underwater photos for the octocorals. I am also thankful to Ms Choyce L.S. Choi and Mr Frank C.C. Cheang for their comments on the project, and all the people in Ping Chau Store for their friendship and kind help as well.

Heartfelt thanks to Dr. P. Alderslade, Dr. L. van Ofwegen and Dr. Y. Benayahu for their kindness in helping with the species identifications and for their valuable comments on my project. I would also like to thank all the people I met during the International Octocoral Workshop in India, 2005, for all their countless concern, opinions and support on my research.

My gratitude to my friends Ms Maggie H.L. Leung, Ms Darren K.L. Hon, Ms Ming L.M. Lee, Ms Lolita W.Y. Ip, Ms Yan H.Y. Yeung and Ms Eva Y.W. Yau for sharing my worries and happiness. Last but not least, I would like to send my greatest love to my dearest friend, Mr Kinson K.S. Lui for his care and love in the past six years.

Abstract

Octocorals (Cnidaria: Octocorallia), which include soft corals and gorgonians, are widely distributed in coral reefs of the Indo-West Pacific. However, information and studies about these corals in Hong Kong waters are very limited. Only very few published reports about Hong Kong octocorals are available in the literature to date. Although the northeastern to southeastern waters of Hong Kong are renowned for their pretty octocoral communities, their ecological information about them, such as taxonomic composition and community structures, remain not well studied. Thus, in order to better protect and conserve the octocorals of Hong Kong in the future, a more systematic and comprehensive study is needed.

This study aimed at investigating and comparing the diversity and community structures of soft coral and gorgonians in northeastern waters of Hong Kong and at exploring Hong Kong northeastern to southeastern waters for the existence of other possible undiscovered octocoral communities. An up-to-date taxonomic description and checklist of Hong Kong octocoral species was compiled. Assessment of octocoral community structures was mainly focused in Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Long Lok Shui (LLS) within Tung Ping Chau Marine Park (TPCMP). Two depth zones (<- 8 m and >- 8 m CD) in each site were intensively surveyed using belt

transect quadrat random point method. Investigations on how food concentration, as indicated by the amount of suspended particulate in the water, and water motion, as indicated by clod card weight loss, could exert certain level of effects in influencing the distribution of octocorals, their community structure and morphological assemblages were also carried out.

A total of 27 genera of octocorals (12 soft coral and 15 gorgonian) were recorded from the northeastern to southeastern waters of Hong Kong, of which, two genera of soft corals (*Carijoa* and *Elbeenus*) and two genera of gorgonians (*Leptogorgia* and *Viminella*) are new records for Hong Kong. Alcyoniidae and Plexauridae were the two most common families found, with soft coral genus *Dendronephthya* being the most common, recorded in 29 out of the 30 sites spot-checked.

The coral communities of TPCMP support a rich octocoral fauna. Out of 27 genera recorded in Hong Kong waters, a total of 23 genera (10 soft corals and 13 gorgonians) belonging to nine families were found there. Highest octocoral cover was recorded in the deeper water regions of KLS (22.30±7.32%), followed by that in LLS (13.13±6.36%) and LGS (8.83±6.75%). All of the octocoral communities examined showed great dominance by particular species, such as *Lobophytum* sp., *Sinularia* sp.

and *Echinomuricea* sp., and their abundance varied among different sites and depths. Significant difference in the coral cover was revealed with the octocoral cover in KLS being statistically different from those in LLS and LGS. Differences in topographic relief and availability of hard substratum are likely the main factors contributing to the spatial difference in octocoral distribution and abundance in TPCMP.

Distinct vertical zonation pattern of octocorals was observed in the marine park, with zooxanthellate soft corals dominating the shallow water region and zooxanthellate-free gorgonians occupying most of the available space in deep water region. Zooxanthellate soft coral genera like *Lobophytum*, *Sinularia brassica* and *Sansibia* predominantly occupied the space of the coral communities at the depth of -5 – -6 m Chart Datum (CD). Azooxanthellate gorgonian genera like *Echinomuricea*, *Echinogorgia*, and *Menella* had a strong preference for deeper water regions (-8 – -13 m CD). Sizes of octocorals in both shallow and deep water regions were similar.

Differences in environmental parameters other than depth could exert certain level of effects in influencing the distribution of octocorals, their community structures and morphological assemblages. Optimal amount of food concentration and strength of water motion are critical in structuring the octocoral distribution. The results of this study suggested higher suspended particulate amount and weaker water motion appear to favor the growth of octocorals in deep water regions. However, octocoral morphological assemblages were found not to be significantly correlated with the amount of suspended particulate and the level of water motion, suggesting that other physical variables like irradiance and seawater temperature could be more important in influencing the structure of octocoral morphological assemblages in the three study sites examined.

In this study, Breaker's Reef and Ninepins were found to support a very diverse and extensive octocoral community. However, these sites received very little attention from the government or the public. Some rare and uncommon species were spotted in these sites. These sites are therefore worthy of further studies and assessment. This present research generated important baseline information that should prove to be critical and useful for further establishment of more marine protected areas in Hong Kong.

論文摘要

八放珊瑚 (腔腸動物門：八放珊瑚科) 當中包括軟珊瑚和柳珊瑚，是廣泛分佈於西印度太平洋珊瑚礁之中的海洋生物。香港過往關於這些動物的資料及研究卻是少之又少，只有三份文獻曾略爲提及。香港東北及東南面的水域一直被共認爲八珊瑚品種繁多及覆蓋率高的地方，可是從來都沒有任何長時間和全面的研究在此進行過。因此，爲了能於將來更有效地去保育及存護此類珊瑚，一個有系統而又深入的研究是必要的。

是次的研究主要有兩個目的，就是調查及比較香港東北及東南面水域的軟珊瑚及柳珊瑚的物種多樣性及其群落結構，以及進一步探索於這個水域內還未被發現而又值得去保護的八放珊瑚群落。本研究也於香港特別行政區的東平洲海岸公園內的三個地點，包括更樓石、難過水及龍落水進行比較仔細的調查。我們採用隨機樣點樣帶法，分別於各個地點的淺水 (少於八米) 及深水 (多於八米) 區域內進行八放珊瑚的分佈及群落結構的監測。此外，從研究水中懸浮顆粒的數量 (代表食物濃度) 及石膏塊的重量流失 (代表水的流動度)，我們更可推斷出這些環境因素如何影響著八放珊瑚的分佈、其群落及形態的結構。

在東北及東南面的水域內，我們一共錄得 27 個屬 (12 種軟珊瑚及 15 種柳珊瑚)

的八放珊瑚，而其中兩個軟珊瑚屬 (*Carijoa* 及 *Elbeenus*) 及兩個柳珊瑚屬 (*Leptogorgia* 及 *Viminella*) 更是在香港首次被發現。在香港的珊瑚群落中，大部份的八放珊瑚都屬於軟珊瑚科 (Alcyoniidae) 及叢柳珊瑚科 (Plexauridae)。在抽樣調查的30個地點中, 我們於其中的29地方發現木軟珊瑚 (*Dendronephthya*) 的蹤跡，因此牠是香港最常見及普遍的八放珊瑚品種。

東平洲海岸公園位於香港最東北面的水域，擁有一個豐富而多樣化的八放珊瑚群落。在香港錄得的 27 個八放珊瑚屬中，有 23 個 (10 種軟珊瑚及 13 種柳珊瑚) 可於這個海岸公園內找到。調查發現更樓石深水區域內的八放珊瑚覆蓋率是最高的 (22.30±7.32%)，其次是龍落水 (13.13±6.36%) 及難過水 (8.83±6.75%)。在這三個地方內，豆莢軟珊瑚 (*Lobophytum* sp.) 、短指軟珊瑚 (*Sinularia* sp.) 及刺尖柳珊瑚 (*Echinomuricea* sp.) 的數量爲最多，牠們的覆蓋率會隨著不同的環境及水深而有所不同。根據統計分析所得，更樓石的八放珊瑚覆蓋率明顯地跟龍落水及難過水的有所不同，因此，不同的地勢起伏及堅硬基層的可用性會是其中兩個導致軟珊瑚及柳珊瑚於東平洲海岸公園不同地方的分佈上有所差別的主要因素。

在這個海岸公園內，八放珊瑚的垂直分佈亦頗爲明顯。不同種類的八放珊瑚的生態位會根據牠們對生長需求的不同而有所差異：有蟲黃藻的軟珊瑚，主要集中在淺水區域，當中的豆莢軟珊瑚 (*Lobophytum*)、短指軟珊瑚 (*Sinularia*) 和異軟珊

瑚 (*Sansibia*) 大量分佈在位於 5 – 6 米水深的大石上。而沒有蟲黃藻的柳珊瑚，例如刺尖柳珊瑚 (*Echinomuricea*)、刺柳珊瑚 (*Echinogorgia*)及小月柳珊瑚 (*Menella*)，則比較喜歡生長在 8 – 13 米水深的地方。不論在淺水或深水區域內，所有錄得的八放珊瑚的體積大小都是相近的。

除了水深之外，其他不同的環境因素都可能對八放珊瑚的分佈，其群落及形態結構有著一定程度的影響。這些珊瑚通常都分佈於擁有最適量的食物濃度及海水流動強弱的地方中。研究結果顯示，八放珊瑚比較喜歡在深水、有高量的懸浮顆粒數量及海水流動較弱的地方中生長。可是，這兩種環境因素對八放珊瑚的形態結構卻沒有明顯的關係，因而可能有其他更重要的因素，例如日光照射及水溫，更能直接地影響著在這三個研究地方八放珊瑚的形態結構。

在這次研究中發現，東北面的打浪排和東南面的果洲群島擁有一個非常廣泛，物種數量及覆蓋率極高的八放珊瑚群落，而更重要的是，有一些非普遍甚至罕有的軟珊瑚品種更可在這裡找到。可是，這兩個地方之前一直未受到政府部門或公眾所重視，因此這一類極具生態價值的地方是值得去繼續研究及調查的。是次研究對八放珊瑚於香港水域的分佈提供了重要及寶貴的基線資料，而這些資料望能有助於政府部門日後在成立海洋保護區時起了一定的參考作用。

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Chapter 1 Introduction

1.1 Ecology of Octocorals

Coral reef is one of the most diverse and productive ecosystems that makes up an area of about 250,000 km^2 of the earth's surface. It covers about 0.2% of the ocean floor (Veron 2000). The reefs are mainly located in the warm and shallow water of tropical oceans worldwide. It is a very dynamic ecosystem and plays a very important role in providing food and habitats for many marine flora and fauna. Reefs have high ecological value. Many studies on the distribution, growth, competition, reproduction and other different aspects of the biology of reef organisms have been conducted. The most common targets under studied are the scleractinian corals (Wallace 1985, Dai 1990, Veron 2000), seaweeds (Robertson 1987, Kilar & Hanisak 1988, Murray & Dixon 1992) and reef fishes (Randall 1974, Sale 1996, Jones *et al.* 1998, Roberts *et al.* 2001).

Whenever the term "coral reefs" is mentioned, the most common picture people may come up with is a picture of the scleractinian (hard) corals. This group of corals possesses a solid and massive calcium carbonate skeleton. Many of them are also called the hermatypic corals, or the major reef-builder of the coral reefs. Technically, however, corals are made up of several groups of marine organisms under the class Anthozoa, which can further be divided into three subclasses: Hexacorallia (hard corals, black corals, anemones and zoanthids), Octocorallia (soft corals, gorgonians and sea pens) and Ceriantipatheria (tube anenomes). When compared with the Hexacorallia, the latter two groups have received relatively little attention by the public as well as by the scientific community as a whole.

The taxonomy, ecology and biology of octocorals are very much understudied. Compared with that of the hexacorals, especially the scleractianian or hard corals, their ecological importance is usually being neglected. They may just be mentioned as accessory information in general description of coral reef surveys (Nishihira & Yamazato 1974). Most aspects of their physiology and biology are still unknown. Octocorals are important members of the marine ecosystem and reef communities. They can increase the spatial and ecological heterogeneity of the reef by acting as temporary or permanent hosts and shelters of a wide variety of associated organisms, such as algae, bivalves, crustaceans, fish, brittle stars and gastropods (Gerhart 1990, Morton 1995, Fabricius & Alderslade 2001, Chiappone *et al.* 2003, Buhl-Mortensen 2004). Suspension feeders like barnacles and mussels are often found to grow on the branches of gorgonians for better exposure to currents. The egg cowry *Ovula ovum* obtains food by grazing on the tissue of soft corals. Even some epiphytic algae can be found growing on the dead areas or branches of octocorals occasionally (Fabricius & Alderslade 2001). Moreover, the bioactive chemicals produced by octocorals are important natural resources for medical use. Compounds with high pharmacological values like antimicrobial (Kelman *et al.* 1998), neuro-protective (Badria *et al.* 1998), anti-inflammatory (Mayer *et al.* 1998) and antifouling (Slattery *et al.* 1995, Wilsanand *et al.* 2001) activities are being extracted and applied commonly in medical science.

1.2 General Biology of Octocorals

Octocorals belong to phylum Cnidaria and class Anthozoa. As each of their polyps bears eight tentacles that are fringed with pinnules, they are grouped under the subclass Octocorallia (hence the common name octocorals). Octocorals are further divided into several orders, including the soft corals (order Alcyonacea) and gorgonians (also known as sea fans and sea whips, order Gorgonacea).

Unlike the massive and solid skeleton of scleractinian corals, only discrete calcium carbonate spicules, called the sclerites, are formed in octocorals. These are dispersed throughout the fleshy coenenchyme of the corals, providing support and protection for the whole colony as well as allowing a certain degree of flexibility for the colony. In some octocorals, the sclerites may be densely accumulated in the basal part of the stem. The shape, size and colour of sclerites vary widely among species. Hence, they are used as a special and important taxonomic feature for identification uses. As this group of corals possesses only tiny sclerites as their skeleton, thus, in contrast to hard corals, they are non-reef building or are ahermaptypic corals that do not contribute much to the formation of the reef framework. Nevertheless, their sclerites can form an important component of the sandy patches within the reef system. Soft corals and gorgonians can be easily distinguished by the different mode of support. Soft corals do not process with rigid internal skeleton of support, instead water is pumped through the mouths of the polyps into the canal system, the hydrostatic pressure inside the soft coral body will provide great support to the whole colony, and this is known as "hydroskeleton". For gorgonians, they have a relatively solid internal central axis covered with a thin layer of coenenchyme and polyps. Both the soft corals and gorgonians process with tiny sclerites and they disperse throughout the whole colonies.

Octocorals can be classified into two types: zooxanthellate or azooxanthellate corals depending on the presence or absence respectively of symbiotic zooxanthellae in their body. These dinoflagellates make use of the organic wastes from their host as their source of nutrients and carry out photosynthesis to produce photosynthates that contribute to the energy need of their host. Azooxanthellate corals do not contain zooxanthellae. They require food intake as their only source of nutrients. As zooxanthellate corals need light for their symbionts to carry out photosynthesis, their distribution ranges will be limited by the availability of light and water clarity (Fabricius & McCorry 2006). Hence, zooxanthellate corals are more restricted to the shallow water region where there is sufficient sunlight, while theoretically there is no depth limit for the azooxanthellate corals. The latter could be found even down to a depth of 300 m.

All octocorals are heterotrophic suspension feeders, even though the zooxanthellate members of the group can also depend partially on their symbionts for other sources of nutrition. They usually feed on small food particles such as phytoplankton and zooplankton (Fabricius & Klumpp 1995, Fabricius *et al.* 1995b). However, since their nematocysts are small and weak, they cannot actively capture their prey but would depend on water current to bring in their food. Food particles transported to the coral colonies will then be trapped and captured by the tentacles and pinnules of the individual polyp. The intensity of water current may thus affect their feeding rate. The food concentration and water movement are the main factors directly affecting the growth and distribution of octocorals (Sebens 1984, Fabricius & Klumpp 1995, Fabricius *et al.* 1995b). The highest abundance of octocorals is usually found in places with intermediate water flow rate.

1.3 Diversity and Worldwide Distribution of Octocorals

Octocorals have a worldwide distribution and are present in every ocean. They are found from tropical to polar seas, from shallow subtidal to abyssal depths in water temperature of -1°C to 30°C (Alderslade 1984). They are dominant in the waters of Indo-West Pacific. Many studies have documented that, besides scleractinian corals, they are also important members of the coral reef that compete for space in the benthic communities (Benayahu & Loya 1977, Tursch & Tursch 1982, Dinesen 1983, Benayahu 1985).

1.3.1 Distribution in Indo-West Pacific Waters

The soft-coral fauna in Red Sea has been studied for nearly two hundred years. In order to know more about the faunistic composition and distribution of the soft corals, hundreds of diving surveys were conducted around Sinai Peninsula (Northern Red Sea) (Benayahu 1985) and Dahlak Archipelago (southern Red Sea) (Benayahu *et al.* 2002). The twelve-year study in the Northern Red Sea (Benayahu 1985) came up with a record of 183 octocoral species in 21 genera, with more than 50% being represented by the family Alcyoniidae and 31%, Nephtheidae. *Sinularia* was the most diverse genus (42 species), followed by *Cladiella* (30 species), *Dendronephthya* (29 species), *Xenia* (20 species) and *Sarcophyton* (14 species). The diverse assemblage of the alcyoniids reported in this study was characterized by their patchy distribution and high coverage of mono-specific carpets. The shallow water areas were highly dominated by only several alcyoniids while in the deeper zone, there was a remarkable increase in the species diversity. Benayahu (1985) concluded that the distribution pattern revealed was mainly related to the availability of hard substrata for settlement in different water depths. In the subsequent study in the southern Red Sea (Benayahu *et al.* 2002) and combining information based on previous collected materials and literature, a total of 28 species in 14 genera was recorded in Dahlak Archipelago, with family Alcyoniidae again being well-presented. When comparing the species diversity of soft corals between Northern and Southern Red Sea, distinct latitudinal species attenuation could be observed. For example, *Sinularia* and

Dendronphthya were the most diverse and highly dominant genera in the northern part, but they were uncommon and less diverse in the south. Moreover, the alcyoniids seldom formed mono-specific carpets in the south. This latitudinal attenuation might be attributed to differences in the water temperature and turbidity. Nonetheless, all these results showed that soft corals were the second most important and diverse benthic components in the Red Sea after the hard corals.

Except for a few taxonomic papers, there were no studies on the species composition and distribution of octocorals in Singapore until the 1990s. A preliminary survey of the gorgonian fauna was conducted on the crest, slope, and at the bottom of 15 study sites in the territory of Singapore (Goh & Chou 1994). At least 21 species in 11 genera were recorded, which were mainly composed of *Verrucella* spp. and *Subergorgia* spp.. Highest abundance of gorgonian colonies was found at the bottom of the reefs (86%), and the species richness was the highest there as well with about 95% of all of the species recorded. This distribution pattern was attributed to the availability of suitable substrata for gorgonian settlement at this depth. The authors later published a more comprehensive checklist listing all known gorgonian species found in Singapore (Goh & Chou 1996), including those from the previous records (Shann 1912). A total of 31 species from 12 genera and 6 families were listed, of which 14 species were new geographical records for Singapore.

In the Central Great Barrier Reef, Dinesen (1983) reported that soft corals are the major component of sessile reef benthos. Their abundance and living coverage were the highest on the slopes of the outer shelf reefs of Coral Sea. In water beyond 10 m depth, soft coral cover (~40%) was nearly equal to that of hard corals. Beyond 15 m depth in Myrmidon Reef, the coverage of soft corals (~45%) exceeded that of the scleractinians. These soft corals were mainly dominated by members of the families Xeniidae and Alcyoniidae. This same study also found that soft coral cover peaked at depths below the maximum hard coral cover.

The Siboga Expendition carried out from 1899 to 1900 was one of the most extensive collection trips that covered more than 100 sites in Indonesia and part of the Sulu Archipelago. As a result of this Expendition, a total of 639 soft coral and gorgonian species, which belonged to 143 genera and 26 families were identified (Nutting 1910a-1910e, 1911, Stiasny 1935, 1937). This undoubtedly points to the extremely rich and high diversity of octocoral fauna within this part of the world.

Soft corals were also found to be very dominant in Laing Island, Papua New Guinea

(Tursch & Tursch 1982). The live covers of soft and hard corals were nearly the same (18%). The study areas were mainly dominated by *Litophyton viridis*, accounting for 55.48% of the soft coral cover. Coverage of the soft corals fluctuated among the study depths: The abundance of corals was very low at 1 m depth (~2%), increased up to over 40% at 2-2.5 m, and decreased back to 3% at 5 m depth. These authors pointed out that the low coverage of corals at 1 m depth could be attributed to the strong wave action, while the availability of sunlight would be the possible factor in limiting the distribution of soft corals at 5 m depth. They also concluded that soft corals were the major contributors to the reef biomass in Laing Island.

Several studies on the species composition of octocorals were carried out in Sesoko Island, Ryukyu Archipelago, Japan in the 1970s. (Utinomi 1976a, b, 1977a, b). Subsequent visual survey around the island in shallow and deep reef zones of 30 m targeted Clavulariidae, Alcyoniidae and Xeniidae as the study families (Benayahu 1995). In this survey, a total of 39 species of soft corals were recorded, with 20 new zoogeographical records identified. A total of 87% of the species belonged to the family Alcyoniidae, and the most dominant genera were *Lobophytum*, *Sarcophytum* and *Sinularia*.

A recently completed study in Nanwan Bay and Green Island of Southern Taiwan reported a total of 69 species in 22 genera (Benayahu *et al.* 2004), including one new species and 43 new records for Taiwan. In these study sites, Alcyoniidae was well-presented. The faunistic composition and diversity were very different between these two study sites: The species of the family Alcyoniidae were the most dominant components in Nanwan Bay, comprising 88% of the total number of species recorded. *Sinularia* was the representative genus, with 30 species densely inhabited the space in the shallow water regions. In Green Island, Alcyoniids were fairly rare, and none of the *Sinularia* colonies found. Instead, Xeniidae was the major and most diverse soft coral group occupying the benthic community. This difference in the interesting distribution pattern between the two study sites may be explained by the ability of some soft corals to withstand harsh environmental conditions. The body of Alcyoniid was more rigid. It could thus better survive the bad weathers, such as the typhoons in Nanwan Bay. In contrast, Green Island was more sheltered and protected, thus corals like Xeniid would be favored as they had a much softer and more delicate body. When compared with other study sites in the Asia Pacific region, Taiwan hosts the most diverse soft coral community. This, however, may be a result of more sampling efforts in Taiwan than in other sites around the Asia Pacific.

Although gorgonians have a cosmopolitan distribution, there are very few taxonomic papers about them in mainland China. CP Li was the only scientist who worked on the taxonomic studies of soft corals in the South China Sea in the 1980s. In her studies, 55 species in 19 genera were recorded from Yalong Bay (Li 1982), Xisha Island (Li 1984) and Nansha Island (Li 1991). Of which, 14 species were new to science and nine species were new geographical record in Chinese waters. For gorgonians, Zou (1989) had recorded 43 species in 19 genera from the waters of the South China Sea.

1.3.2 Octocoral Studies in Hong Kong

Information and studies on ahermatypic corals in Hong Kong waters are very limited. Only very few published reports about Hong Kong octocorals are available in the literature to date. The first two reports on gorgonians in Hong Kong were given by Stimpson (1855) and Verrill (1865), with a total of nine species belonging to Gorgonoidea found. Octocorals represented simply a minor part of their coral reef studies. Later, a more comprehensive taxonomic study on gorgonians in Hong Kong was presented in 1980, with a total of 26 species belonging to 15 genera being recorded (Zou & Scott 1982, see Table 1.1). For soft corals, some specimens were collected during the First International Marine Biological Workshop in Hong Kong. A total of 10 species in 4 genera were recorded (Li 1986, see Table 1.2). With the recent update and revisions on the genera of gorgonians and soft corals, the identifications made in these two studies described above need to be reviewed and revised.

The first study on the distribution and abundance of octocorals in Hong Kong, primarily gorgonians, was restricted only to a small embayment, the Cape d'Aguilar Marine Reserve in southern Hong Kong (Clark 1997). A total of 15 species of gorgonians belonging to four families, i.e. Paramuriceidae, Telestiidae, Plexauridae, and Ellisellidae were identified (Table 1.3). The octocoral community was mainly dominated by four species, *Euplexaura curvata*, *Ellisella gracilis*, *Dendronephthya gigantean* and *Echinogorgia lami*, making up 95% of the total number of colonies recorded among 55 transects. *Euplexaura curvata* was the most dominant species, with a total of 620 individuals recorded. The results suggested that the abundance and diversity of gorgonians increased with depth, further confirming that there was a need of hard and firm substratum for better settlement and survival of gorgonians.

The most recent and more detailed study on octocorals in Hong Kong, using Rapid Ecological Assessment technique (REA), was done to investigate the distribution and taxonomic richness of octocorals in the northeastern to southern waters of Hong Kong

(Fabricius & McCorry 2006). Up to 41 benthic surveys were conducted on 19 reefs, and the data showed that the octocoral communities in Hong Kong were characterized by a high proportion of zooxanthellae-free taxa (average 79% to the total number of octocoral genera recorded per survey), whereas zooxanthellate species were sparsely represented. A total of 42 species in 23 genera were recorded, with Plexauridae, the most abundant and species rich family, dominated the communities (Table 1.4). Coverage of octocorals was low (<1%) in most of the surveys. For the zooxanthellate taxa, the abundance and the richness increased with increasing water clarity, with their distribution becoming restricted below 12 m depth. For the zooxanthellate-free taxa, as their growth was not limited by the availability of light, their diversity increased with depth, and became the dominant octocorals in deeper water.

Northeast to southeastern waters of Hong Kong are renowned for their pretty octocoral communities by divers. However, as no long-term and comprehensive underwater surveys have been carried out in these areas before, the ecological information on octocorals, such as their taxonomic composition and community structures, remain not well-studied. Moreover, the identity of the octocoral species in Hong Kong waters has not been systematically verified and updated in recent years, in view of the major taxonomic revisions being undertaken on many members of this group in the last 20 years. Thus, in order to have a better knowledge, protection and conservation of the octocorals in Hong Kong, a more comprehensive study is needed. The current study is a two-year underwater survey to provide up-to-date baseline information about octocorals of Hong Kong.

1.4 The Marine Environment of Hong Kong

Hong Kong (latitude 22°N) lies within the sub-tropical region of the northern South China Sea and is made up of Hong Kong Island, Kowloon Peninsula and the New Territories with 230 islands. It is surrounded by sea on three sides (Fig. 1.1), with a coastline of about 1,200 kilometers long. Hong Kong is located in the eastern side of the Pearl River delta. Its western region is highly influenced by freshwater and sediments brought by the Pearl River so that it is relatively turbid. Its salinity ranged from 2 ppt to 10 ppt. The eastern waters, on the other hand, are little influenced by the Pearl River outflow and have predominantly oceanic characteristics. The salinity of the eastern water is thus less variable, ranging from 29 ppt to 33 ppt. Apart from the influence of Pearl River, the marine habitat is also affected by oceanic currents. In summer, the Hainan Current with warm water flows from the southwest, while the Taiwan Current brings cool water from the Taiwan Strait in winter (Watts 1973). Thus, larvae of marine organisms from other places can be brought to Hong Kong by these currents. The northeastern shore of Hong Kong is characterized by the presence of more extensive rocky substratum, and is therefore a more suitable habitat for the growth and settlement of organisms such as corals and fish. Tung Ping Chau Marine Park (TPCMP), which is located in the northeastern most region of Hong Kong, is famous for supporting a rich marine biodiversity (also refer to Chapter 3 Section 3.2 and Figs. 3.1-3.2 for a more detailed description). It is designated as the fourth marine park in Hong Kong in 2001. The northeastern side of island is found to support very diverse scleractinian coral communities, with 65 species of hard corals recorded that contribute to more that 60% of total benthic cover in some areas (Ang *et. al.* 2000). The south to southwestern side of the island is more exposed to waves and the water current stronger. A rich soft coral and gorgonian community is found in the deeper water region (-8- -13 m Chart Datum (CD)) of this area.

1.5 Objectives

This thesis research has the following objectives:

1. To investigate and compare the diversity and community structures of soft coral and gorgonians in northeastern waters of Hong Kong and to explore other possible

undiscovered octocoral communities in northeast to southeastern waters of Hong Kong.

2. To compile an up-to-date octocoral species checklist of Hong Kong with baseline information on their abundance and distribution in Hong Kong waters.
3. To study the ecological relationship between the octocoral assemblages and the environmental variables in selected sites, in order to find out how the coral distribution patterns are affected by the physical conditions.

1.6 Thesis Outline

This thesis is divided into five chapters. Each chapter is briefly described as follows:

Chapter 1 - Introduction

This chapter first introduces the general background information like basic ecology and biology of octocorals, their ecological importance in the coral reef ecosystem. It then provides a literature review on the distribution, diversity and abundance of octocorals in Indo West Pacific. Related studies conducted in Hong Kong are also examined. Finally, the objectives of the current research are given as well.

Chapter 2 – Taxonomic Descriptions of Octocoral Genera in Northeastern to Southeastern Waters of Hong Kong

This chapter describes the soft coral and gorgonian species found in northeastern to southeastern waters of Hong Kong. An annotated, updated checklist of 12 genera of soft corals and 15 genera of gorgonian is presented. Underwater photographs of live colonies, photographs of preserved specimen and their sclerites are shown. This chapter also provides information on the distribution of these octocorals based on results of spot checks in 30 sites along the northeastern to southeastern waters of Hong Kong.

Chapter 3 – Spatial Comparison of Octocoral Assemblages in Tung Ping Chau Marine Park (TPCMP)

This chapter provides information on the community structures of octocorals in three study sites in TPCMP. It includes the abundance, species composition and coverage of soft corals and gorgonians found in shallow and deep water regions. The horizontal and vertical distribution patterns of octocorals were revealed. The species composition and size structure of octocorals were further analyzed by multivariate analyses.

Chapter 4 - Ecological Relationship of Amount of Suspended Particulates and Water Motion with Octocoral Assemblages

This chapter examines how the environmental variables such as suspended particulate concentration and water motion could influence the distribution of octocorals in TPCMP. The methodologies of measuring these physical factors are described in detail. The physical factor that most affects the distribution pattern of octocoral was examined.

Chapter 5 – Summary and Perspectives

This chapter integrates all the findings of this current research. The significance and implications of these findings are discussed with respect to the octocoral community in TPCMP and that of Hong Kong in general.

Table 1.1 Octocorals from Hong Kong as reported by Zou & Scott (1982).

Family	Genus	Species
Acanthogorgiidae	*Acalycigorgia*	*inermis*
	Acanthogorgia	*vegae*
	Anthogorgia	*bocki*
Anthothelidae	*Semperina*	*brunnea*
Ellisellidae	*Ellisella*	*laevis*
	Scirpearia	*erythraea*
	Scirpearia	*gracilis*
Paramuriceidae	*Echinogorgia*	*coccinea*
	Echinogorgia	*flora*
	Echinogorgia	*lami*
	Echinogorgia	*pseudosassapo*
	Echinogorgia	*sassapo reticulata*
	Echinomuricea	*indomalaccensis*
	Menella	*rubescens*
	Muricella	*abnormalis*
	Muricella	*flexuosa*
	Muricella	*sibogae*
	Muricella	*sinensis*
	Villogorgia	*compressa*
Plexauridae	*Euplexaura*	*curvata*
	Euplexaura	*erecta*
	Euplexaura	*robusta*
	Hicksonella	*princeps*
	Plexauroides	*praelonga*
Suberogorgiidae [Subergorgiidae]	*Suberogorgia* [*Subergorgia*]	*köllikeri*
	Suberogorgia [*Subergorgia*]	*reticulata*
Total 6	**15**	**26**

Table 1.2 Soft corals from Hong Kong as reported by Li (1986).

Family	Genus	Species
Alcyoniidae	*Cladiella*	*humesi*
	Cladiella	*madagascarensis*
	Cladiella	*subtilis*
	Lobophytum	*depressum*
	Lobophytum	*denticulatum*
	Lobophytum	*venustum*
Nephtheidae	*Scleronephthya*	*corymbosa*
	Scleronephthya	*pustulosa*
Spongodes	*Spongodes*	*spinifera*
	Spongodes	*studeri*
Total 3	**4**	**10**

Table 1.3 Octocorals from Hong Kong, mainly from Cape D'Aguilar Marine Reserve, as reported by Clark (1997).

Family	Genus	Species
Alcyoniidae	*Eleutherobia*	*indica*
	Dendronephthya	*gigantea*
Ellisellidae	*Ellisella*	*gracilis*
	Junceella	*juncea*
Paramuriceidae	*Echinogorgia*	*complexa*
	Echinogorgia	*flora*
	Echinogorgia	*lami*
	Echinogorgia	*pseudosassapo*
	Echinogorgia	*sassapo reticulata*
	Echinomuricea	*indomalaccensis*
	Muricella	*abnormalis*
	Muricella	*flexuosa*
	Muricella	*sibogae*
Plexauridae	*Euplexaura*	*curvata*
	Euplexaura	*robusta*
	Hicksonella	*princeps*
Telestidae	*Telesto*	*arborea*
Total 5	**10**	**17**

Table 1.4. Octocorals from Hong Kong, as reported by Fabricius (2000), Fabricius & McCorry (2006).

Family	Genus	Species
Acanthogorgiidae	*Acanthogorgia*	spp.
	Anthogorgia	sp.
	Muricella	sp.
Alcyoniidae	*Cladiella*	*digitulata*
	Cladiella	*pachycaldos*
	Lobophytum	*depressum*
	Paraminabea	sp.
	Sarcophyton	*teniospiculatum* [*tenuispiculatum*]
	Sinularia	*brassica*
Ellisellidae	*Dichotella*	*gemmacea*
	Junceella	sp.
	Verrucella	sp.
Nephtheidae	*Dendronephthya*	spp.
	Scleronephthya	*gracillimum*
Nidaliidae	*Chironephthya*	sp.
	Nephthyigorgia	sp.
Plexauridae	*Astrogorgia*	sp.
	Bebryce	sp.
	Echinogorgia	spp.
	Echinomuricea	spp.
	Euplexaura	spp.
	Menella	spp.
	Paraplexaura	spp.
Xeniidae	*Sansibia*	sp.
Total 7	**23**	**42**

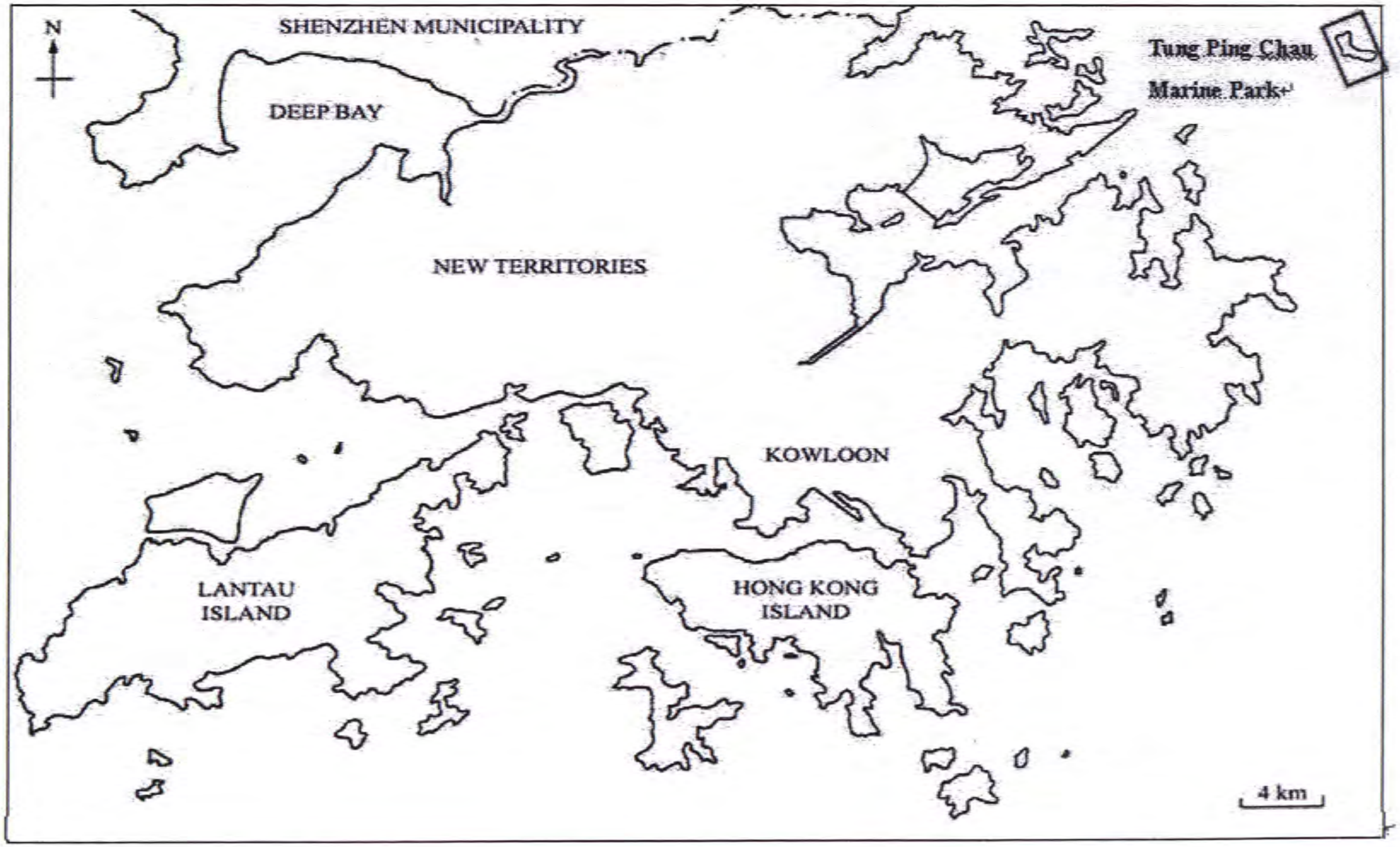


Figure 1.1 Map of the Hong Kong Special Administrative Region showing the location of Tung Ping Chau Marine Park in the northeastern corner of Hong Kong.

Chapter 2 Taxonomic Descriptions of Octocoral Genera in Northeastern to Southeastern Waters of Hong Kong

2.1 Introduction

Octocorals, as used in this thesis research, refer collectively to soft corals (order Alcyonacea) and gorgonians (Order Gorgonacea) as a group. Their polyps bear eight tentacles which are fringed by one or more rows of pinnules along both edges. This group of animals possesses only tiny sclerites as their skeletons. These sclerites vary widely in their shapes, sizes and colors and are the special and important taxonomic feature used in species identification.

Octocorals have a cosmopolitan distribution, from tropical to polar areas (Alderslade 1984). Around 90 genera belonging to 23 families in this group of organisms have been recorded and described from the tropical Indo-Pacific at diving depth (Fabricius & Alderslade 2001). Their diversity and abundance have been documented in places like the Great Barrier Reef (Dinesen 1983), Papua New Guinea (Tursch & Tursch 1982), Red Sea (Benayahu 1985, Benayahu *et al.* 2002), Japan (Benayahu 1995), Singapore (Goh & Chou 1994, 1996), Taiwan (Chen & Chang 1991, Benayahu *et al.*

2004) and southern China (Li 1982, 1984, 1986, 1991; Zou & Scott 1982). In Hong Kong, although several studies have been carried out before (see review in Chapter 1, Section 1.3.3), the records are not complete. This chapter provides an up-to-date systematic listing and description of octocorals found in northeastern to southeastern waters of Hong Kong. A total of 12 genera of soft corals and 15 genera of gorgonians are included.

2.2 Materials and Methods

Field works and specimens collection were undertaken covering the northeastern to southeastern waters of Hong Kong from September 2004 to May 2006. SCUBA spot checks were conducted in 30 sites (Fig 2.1). In each site, a timed swim method was used (Hill & Wilkinson 2004). This method can be used to survey a large area; it also guarantees that rare species can be well represented (Fabricius & Alderslade 2001). It is an efficient method for the exploration of possible undiscovered octocoral communities.

In this method, the habitats were examined down to a depth between 3 m to 20 m. Each time, the diver-observers swam from deep (max. 20 m) to shallow water regions at a constant speed for 20-30 min. Octocorals encountered were identified *in situ*. GPS readings of the survey sites were recorded on underwater survey sheets before each dive. Approximately 100 specimens were collected, and underwater photographs of each of them were taken using a digital camera (Sony Cyber-shot DSC-P150) in order to record the morphology and color of the live colonies prior to collection.

The collected specimens were preserved in 75% ethanol (ethyl alcohol) (Fabricius & Alderslade 2001) and kept in Simon F.S. Li Marine Science Laboratory (MSL), Department of Biology, The Chinese University of Hong Kong. They were subsequently examined for the morphological characteristics of the colonies and the sclerites. For sclerite examination, a sample less than 2 mm square in size was cut from the relevant part of the colony (e.g. polyp, calyx, surface and interior of coenenchyme, polypary and basal area) and placed on a microscope slide. Few drops of 10% sodium hypochlorite (bleach) were added on the samples in order to dissolve the organic coral tissue. The remaining sclerites were then rinsed carefully with distilled water and examined under a compound microscope. Description of the types and characteristics of the sclerites follows those given in the work of Brill & Backhuys (1983).

2.3 Results

Most of the coastline and potential areas with exposed and rocky substratum in northeastern to southeastern waters of Hong Kong were explored in the present study. Any potential species of octocorals encountered were noted. A total of 27 genera of octocorals are recorded, with 12 genera of soft corals in five families (Clavulariidae, Alcyoniidae, Nephtheidae, Nidaliidae and Xeniidae) (Table 2.1) and 15 genera of gorgonians in five families (Acanthogorgiidae, Plexauridae, Gorgoniidae, Subergorgiidae, Ellisellidae) (Table 2.2). Of these, two genera of soft corals (*Carijoa* and *Elbeenus*) and two genera of gorgonians (*Leptogorgia* and *Viminella*) are new zoogeographical records for Hong Kong.

Each genus is described in detailed in the following sections based mainly on the works of Verseveldt (1980, 1982 & 1983), Fabricius & Alderslade (2001) and Erhardt & Knop (2005). The specimens cannot be identified up to the species level in this current study as the taxonomic status of many groups of these octocorals still awaits thorough revision. Nevertheless, suspected species are still recognized and given a tentative designation as sp. A, B, etc.

Details of the sites surveyed, including the locations and the GPS readings of each surveyed area are given in Table 2.3 and Figures 2.1-2.12. The distribution and local rarity of the octocoral genera in Hong Kong waters are categorized as follows based on the number of locations where they are recorded:

1 – 3 sites: Rare
4 – 9 sites: Uncommon
10 – 14 sites: Common
15 – 20 sites: Dominant
> 20 sites: Abundant

2.3.1 Description of Genera – Soft Corals

Family Alcyoniidae Lamouroux, 1812

Genus *Cladiella* Gray, 1869 (Figs. 2.13-2.15)

Colony shape and color: Encrusting and lobate colony with soft, smooth, fleshy and slimy tissue. Colonies are relatively small, about 10-15 cm in diameter, and usually form patches on the substratum. Polyps are brown or greenish due to the presence of high concentration of zooxanthellae. After contraction, a sharp contrast of color between pit (dark brown) and colony surface (grey to white) can be observed. Polyps are monomorphic, retractile with short bodies.

Sclerites: Very tiny (~30-80 μm) and colorless. Those of the polyps are minute disks, and in the rest of the colony, they are dumbbell shape. Only this genus possesses dumbbell sclerites among all the soft coral taxa examined.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Shek Ngau Chau (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Tai Chau (Site 15).

Local rarity and remarks: Uncommon. Usually found in shallow waters.

Genus *Elbeenus* Alderslade, 2002 (Figs. 2.16-2.19)

Colony shape and color: Contractile colony, lobed and arborescent when expanded. Polyps are large and armed with collaret. They are spiky after contraction due to the presence of needle-liked sclerites around the polyps, which are most abundant in the basal part. The sclerites on the surface of the stalk and in interior of the base are large, can be observed with naked eyes. This genus is azooxanthellate and has only been recorded from deep (159 m) water off Palau before. The present colony was found at 13m deep, and was beige in color.

Sclerites: Sclerites in the polyps are bent, pointed and spindle-liked (100-300 μm), only associated with few warts. Those of the tentacles are smaller and flattened. The sclerites in the basal part are much larger (~600-900 μm) and warty.

Local occurrence: Kang Lau Shek (Site 1).

Local rarity and remarks: Rare, only two colonies have been found in Hong Kong waters.

Genus *Lobophytum* Marenzeller, 1886 (Figs. 2.20-2.22)

Colony shape and color: Thick, flattened and encrusting colony with polyps present on the upper surface. The upper surface is about the same diameter as that of the colony base, the lobes or ridges are oriented in radial arrangement. Sometimes, lobes will fuse together and form small crests. Those found in Hong Kong waters are usually smooth with few ridges. Colonies are brown in color, indicating the presence of high amount of zooxanthellae. Polyps dimorphic, with autozooids and siphonozooids. Autozooids are completely retractile, giving the colony a smooth and leathery appearance. For siphonozooids, they are small and densely arranged between the autozooids. Colonies of this genus are sometimes called the "leather corals", and form extensive monospecific carpets on the substratum.

Sclerites: Poorly-formed clubs could be found on the surface of the polyp region and stalk. The interior of the lobes contains spindles (~150-200 μm). The sclerites in the base interior are thicker and more robust, with larger warts. Spindles with warts are usually arranged in belt. They are colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Shek Ngao Chau (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Lan Tau Pai (Site 13), Tsim Chau (Site 14), Tai Chau (Site 15) , Kong Tau Pai (Site 19).

Local rarity and remarks: Common

Genus *Paraminabea* Williams & Alderslade, 1999 (Figs. 2.23-2.25)

Colony shape and color: Colonies are small (<15 cm), highly contractile, usually finger-liked or sparsely branched. Colonies are orange or red color. Polyps are dimorphic. The autozooids are long and retractile, the siphonozooids are very small, hard to observe after preservation. This is an azooxanthellate genus.

Sclerites: The sclerites are 6- or 8- radiates, in spherical shape (~30-50 µm). Some of them have waists. They are colored.

Field occurrence: Breaker Reef (Site 9), Lung Shuen Pai (Site 30)

Local rarity and remarks: Rare, only two colonies have been collected representing probably two species: *Paraminabea* sp. A (red) and *Paraminabea* sp. B (orange).

Genus *Sarcophyton* Lesson, 1834 (Figs. 2.26-2.28)

Colony shape and color: Colonies are soft and fleshy, with mushroom appearance. They have a convoluted or curvy polypary with folding edges, but no lobes can be found in this region. The stalk is bare and remarkably high. Juvenile colonies have typical flat, non-folded polypary; but for the adults, the disc of the polypary is funnel shape. Colonies are brown or beige in color and zooxanthellate. Polyps are dimorphic, the autozooids are the longest among all of the soft coral taxa. The polyps are completely retractile, leaving the colony surface appearing smooth and leathery.

Sclerites: They are colorless. Well-formed clubs (~100-150 μm) are present on the surface of the polypary. Elongated spindles (~150-200 μm) can be found in the interior of the disc, stalk and base. Sclerites in the polypary part are needle-liked, and those in the stalk are shorter and flatter (~100-150 μm), with a more robust appearance.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Wong Mau Chau (Site 10)

Local rarity and remarks: Uncommon

Genus *Sinularia* May, 1898 (Figs. 2.29-2.31)

Colony shape and color: The species found in Hong Kong is *Sinularia brassica*. Colonies of this species are low and encrusting, with some ridges on the margin of the upper surface. They are tough and hard after contraction due to the presence of high abundance of large spindle-liked sclerites in the colony interior, very dense especially in the basal part. Colony surface rough to touch, like sandpaper. Colonies are brown with zooxanthellae and usually form monospecific mats on the hard substratum. Only retractile autozooids present.

Sclerites: They are colorless. Small, distinct and well-formed clubs (~50-180 μm) are distributed on the surface part; while very large, plump, complexly warted spindles (~2-3 mm) are found in the interior and basal part of the colony. They are so large that they can easily be observed by naked eyes. The sclerite morphology of *S. brassica* is very unique, with a distinct V-shape that can be observed in the head of the clubs.

Field occurrence: Tung Ping Chau Marine Park (Sites 1-3), Port Island (Site 5), Shek Ngau Chau (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Lan Tau Pai (Site 13), Tai Chau (Site 15), Pak Lap Tsai (Site 17), Bluff Island (Site 23).

Local rarity and remarks: Common. This is the most diverse zooxanthellate soft coral genus, with 128 species recorded world-wide (Van Ofwegen 2000). The morphological variation is highest among the soft coral genera.

Family Clavulariidae Hickson, 1894

Genus *Carijoa* F. Müller, 1867 (Figs. 2.32-2.34)

Colony shape and color: Bush-like colony. Tall and thin axial stems, united basally and connected by root-like stolons. Colonies are brown to greenish brown, with white or cream polyps. Polyps are monomorphic, retractile with short bodies.

Sclerites: Slender and rod-like, ornamented with thorns (~200 μm). They are colorless.

Local occurrence: Shek Ngao Chau (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Lung Shuen Pai (Site 30)

Local rarity and remarks: Uncommon. They are more commonly found in deep water area (>12 m).

Family Nephtheidae Gray, 1862

Genus *Dendronephthya* Kükenthal, 1905 (Figs. 2.35-2.39)

Colony shape and color: Colonies are highly branched, bushy or tree-liked. This genus is divided into three groups: Divaricate (branched), Glomerate (grouping of numerous bundles of polyps) and Umberllate (umbrella-shaped). Polyps usually grow in small bundles on the terminal twigs, with supporting bundles generally projected far out of the head. Polyps are monomorphic, not retractile. Large variety of color morph for this genus, colonies are in bright color, like pink, purple, orange, and white. This is mainly due to the presence of colored sclerites in the polyp part (upper branches). The stalks are usually pale or white in color as the sclerites are colorless. Sometimes, the sclerites are clearly visible on the translucent body wall. Colonies are azooxanthellate.

Sclerites: Each polyp is equipped and supported with a cluster of large, long and spiny spindles that are called supporting bundles. Complex set of sclerite arrangements in the polyp is given a special terminology: non-symmetrical in eight points. This feature is important for species identification. Size, shape and color of the sclerites vary in different parts of the colony. Sclerites in polyp head are tiny (~50-200 μm) and in rod shape. Those in the interior part are very tiny with irregular shape (100 μm). For the surface part, warty and thick spindles (~0.3-3 mm) could be observed.

Field occurrence: Tung Ping Chau Marine Park (Sites 1-3), Round Island (Site 4), Port Island (Site 5), Grass Island (Site 6), Kung Chau (Site 7), Shek Ngau Chau (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Mai Fan Tsui (Site 11), Tuen Tsui (Site 12), Lan Tau Pai (Site 13), Tsim Chau (Site 14), Conic Island (Site 16) Wong Nai Chau (Site 18), Kong Tau Pai (Site 19), Town Island (Site 20), Wang Chau (Site 21), Basalt Island (Site 22), Bluff Island (Site 23), Ma Tsai Pai (Site 24), Unnamed Island (Site 25), Trio Island (Site 26), Pak Pai (Site 27), Ma Wan (Site 28a), Sai Chau Mei (Site 28b), Hoi Tam Hau (Site 28c), Stone Wall (Site 29c), Lung Shuen Pai (Site 30).

Local rarity and remarks: Abundant. There are possibly more than five species of this genus found in Hong Kong waters. *Dendronephthya* sp. A (purple) and

Dendronephthya sp. B (pink) are the two most common suspected species recorded, which can be found in most of the sites visited in this study.

Genus *Scleronephthya* Studer, 1887 (Figs. 2.40-2.43)

Colony shape and color: Colonies are small (<10 cm) and highly contractile. They appear as lumpy crusts when contracted. When expanded, however, they are arborescent with subdivided branches. They are azooxanthellate and are usually orange, pink and purple in color. Colonies tend to grow on the vertical surfaces of bare rocks, sometimes they even grow upside down. Polyps are monomorphic, highly contractile, and occur as isolated individuals

Sclerites: Conspicuous point arrangement of sclerites is present in the polyp heads. Long spindles (~200-300 μm) can be found in the polyp body. Sclerites in surface and interior parts of the colony are much larger (~300-400 μm) and with distinct warts. They are always colorless.

Local occurrence: Shek Ngau Chau (Site 8), Breaker Reef (Site 9), Ma Wan (Site 28a), Sai Chau Mei (Site 28b), Hoi Tam Hou (Site 28c), Kwo Chau Wan (Site 29a), Lung Shuen Pai (Site 30).

Local rarity and remarks: Uncommon

Family Nidaliidae Gray, 1869

Genus *Chironephthya* Wright & Studer, 1889 (Figs. 2.44-2.46)

Colony shape and color: Colonies resemble some of the features of gorgonians, but without horny and rigid central axis along branches. They are small and a bit tough, usually profusely branched. The stem and main branches are almost hollow. Branches are flexible. Polyps can be found on the main branches, branchlets and their terminals. Colonies are pink with yellow polyps, and do not contain zooxanthellae. Only one type of polyp can be found. These autozooids are able to completely retract within the prominent calyces.

Sclerites: Calyces grow on three sides of the polyp only. Polyp head is made up with spindles in a strong crown and points arrangement. The surface layer of the colony is arranged with large, long and complexly warted spindles (~0.1-1 mm). Sclerites are usually highly colored.

Local occurrence: Kang Lau Shek (Site 1), Lung Lok Shui (Site 3)

Local rarity and remarks: Rare

Genus *Nephthyigorgia* Kükenthal, 1910 (Figs. 2.47-2.49)

Colony shape and color: Colonies are firm, lobate or branched; strongly contractile and rough to touch. The calyces are large and conspicuous, shaped like volcanoes.

They are azooxanthellate and red in color. The polyps are monomorphic and retractile.

Sclerites: Large (~200-300 μm) and slightly curved spindles conspicuously arranged in the polyp in collaret and points. The surface and interior of the colony are composed of large (~300-700 μm) and complexly warted spindles. Some of the sclerites are colorless.

Field occurrence: Lung Lok Shui (Site 3), Shek Ngau Chau (Site 8), Lung Shuen Pai (Site 30).

Local rarity and remarks: Uncommon. Two suspected species recorded: *Nephthyigorgia* sp. A: branched form; *Nephthyigorgia* sp. B: digitated form.

Family Xeniidae Ehrenberg, 1828

Genus *Sansibia* Alderslade, 2000 (Figs. 2.50-2.52)

Colony shape and color: Polyps are small and soft, each tentacle fringes with a conspicuous row of pinnules on both edges. The polyps are united and connected by a soft and thin membrane or stolon creeping on the substrata. They are usually brown in color, with some areas having iridescent greenish blue color. This genus contains a high density of zooxanthellae. Polyps are monomorphic, slightly contractile.

Sclerites: Minute platelets or spheroids (~13-18 μm) that are slightly opalescent.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3).

Local rarity and remarks: Rare.

2.3.2 Description of Genera – Gorgonians

Family Acanthogorgiidae Gray, 1859

Genus *Acanthogorgia* Gray, 1857 (Figs. 2.53-2.55)

Colony shape and color: Colonies are planar and two-dimensional. They are sparsely branched. Polyps are tall and prominent without calyces, but with the margin surrounded by a spiny crown of thorns which are the protrusion of pointed end of sclerites. Polyps are contractile, but not retractile. Colonies in Hong Kong are usually in bright yellow, and are azooxanthellate. The coenenchyme layer on the stem and branches is very thin, thus the black central axis can easily be seen through the layer.

Sclerites: Warty spindles present in the polyp part. They are bent and in boomerang-shaped and are arranged along the body wall in eight double rows. These spindles are long (~300 μm), projected through the top of the polyp, forming a spiny crown. The sclerites in the coenenchyme layer are more warty. All sclerites are colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Grass Island (Site 6), Mai Fan Tsui (Site 11), Stone Wall (Site 29c), Lung Shuen Pai (Site 30).

Local rarity and remarks: Uncommon

Genus *Anthogorgia* Verrill, 1868 (Figs. 2.56-2.58)

Colony shape and color: Fan-liked colony with free branches and few net-like branch fusions. Polyps are thicker than those of *Acanthogorgia*, also without calyces, but with similar sclerite arrangement on the surface of the colony. Sclerites in points arrangement can be seen at the tips of the polyps. Polyps are cylindrical and non-retractile. The coenenchyme layer around the stem and branches is very thin, thus the central black axis can easily be seen through. Colonies are blue, white and purple in color without zooxanthellae.

Sclerites: Spindles on the polyps are blunt with large warts. Morphology of the sclerites along the body wall is similar to those of the polyps. Sclerites are arranged in angled double rows and may be colored.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Port Island (Site 5), Breaker Reef (Site 9), Stone Wall (Site 29c), Lung Shuen Pai (Site 30).

Local rarity and remarks: Uncommon. Two suspected species recorded:

Anthogorgia sp. A (blue) and *Anthogorgia* sp. B (yellow).

Family Ellisellidae Gray 1859

Genus *Dichotella* Gray, 1870 (Figs. 2.59-2.61)

Colony shape and color: Colonies are richly branched, bushy; with repeated dichotomous upright branching. Polyps are very contractile but not retractile. Contracted polyps appear as small scales pressed against the surface of the branches. Colonies are orange and are azooxanthellate.

Sclerites: Colony surface contains "pineapple-liked" clubs. The club heads are formed from a cluster of distally pointed tubercles (~100 μm). The sclerites in the subsurface layer are symmetrical capstans (~100 μm). Both sclerites are colored.

Local occurrence: Kang Lau Shek (Site 1), Wong Mau Chau (Site 10).

Local rarity and remarks: Rare, but common in Wong Mau Chau (Site 10).

Genus *Ellisella* Gray, 1858 (Figs. 2.62-2.64)

Colony shape and color: Colony sparsely branched with repeated dichotomous branching. The branches are long and thin. Polyps are monomorphic and contractile. They usually contract and form pronounced and lobe-like mounds on the branches. Colonies are yellow in color with orange polyps and are azooxanthellate.

Sclerites: The sclerites are double heads and waisted spindles. The sizes of spindles (~75 μm) are longer than those of double heads (~50 μm). Surface sclerites are colored, while those in the subsurface layer are usually colorless.

Local occurrence: Port Island (Site 5).

Local rarity and remarks: Rare, only one colony was found.

Genus *Junceella* Valenciennes, 1855 (Figs. 2.65-2.67)

Colony shape and color: Colonies unbranched and whip-liked. Polyps are very contractile but not retractile. Contracted polyps appear as small scales pressed against the surface of the branches. Colonies are red and are azooxanthellate.

Sclerites: Colony surface contains "pineapple-liked" clubs (~100 μm). The club heads are formed from a cluster of distally pointed tubercles. The sclerites in the subsurface layer are symmetrical capstans (~50 μm). Both sclerites are colored.

Local Occurrence: Lan Guo Shui (Site 2), Breaker Reef (Site 9)

Local rarity and remarks: Rare.

Genus *Verrucella* Milne Edwards & Haime, 1857 (Figs. 2.68-2.70)

Colony shape and color: Colonies are quiet large, they are richly branched and grow in one plane. Short branches are connected and give the colonies a net-like and fan shape appearance. Polyps are very contractile but not retractile and form small mounds on the surfaces when contracted. Colonies are red in color and do not contain zooxanthellae.

Sclerites: Spindles are plump and short with double heads (~50 μm), some of them have waists. All of the sclerites are colored.

Local occurrence: Lung Lok Shui (Site 3), Port Island (Site 5).

Local rarity and remarks: Rare

Genus *Viminella* Gray, 1870 (Figs. 2.71-2.73)

Colony shape and color: Colonies are tall and whip-liked, with one or a few side branches. Polyps are highly contractile, they commonly contract and bend over to form small and lobe-like mounds on the surface of the branches. Colonies do not contain zooxanthellae and are usually orange in color.

Sclerites: The surface sclerites are double heads and waisted spindles. They are colored .Sclerites in the polyps are smaller (~50 μm) and are usually flattened-rod or spindle shaped. They are colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Port Island (Site 5).

Local rarity and remarks: Uncommon, but is quite common in the deeper water regions (> -13 m Chart Datum (CD)) of Kang Lau Shek (Site 1).

Family Gorgoniidae Lamouroux, 1812

Genus *Leptogorgia* Grasshoff, 1988 (Figs. 2.74-2.76)

Colony shape and color: Colonies are composed of one or more pinnately branched plumes. The ends of the branches are pointed and tip-liked. Polyps are retractile and are arranged along the two sides of the branches. A small mound surrounds each polyp aperture when polyps are retracted. The colonies are dark red with white polyps. They are azooxanthellate.

Sclerites: In the polyp head, the sclerites are small (~100 μm), flattened rod-shaped and are red in color.

Local occurrence: Lan Guo Shui (Site 2), Lung Lok Shui (Site 3), Lan Tau Pai (Site 13).

Local rarity and remarks: Rare

Family Plexauridae Gray, 1859

Genus *Astrogorgia* Verrill, 1868 (Figs. 2.77-2.79)

Colony shape and color: Colonies grow in one plane and are sparsely branched, their branches are not linked. They have long polyps that can retract into tall calyces.

The colonies in Hong Kong are red or brown in color and do not contain zooxanthellae.

Sclerites: Spindles present throughout the colony. They can be short, long, thin, plump, bent, smooth or warty. The wall of calyces is formed from spindles (~150-200 μm) that are arranged in eight double rows. The polyp head is covered with short spindles or rods arranged in eight longitudinal groups. Sclerites can be red or colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Wong Mau Chau (Site 10), Stone Wall (Site 29c), Lung Shuen Pai (Site 30).

Local rarity and remarks: Uncommon

Genus *Echinogorgia* Kükenthal, 1865 (Figs. 2.80-2.82)

Colony shape and color: Colonies grow in one plane, thus assume a fan-shaped growth form. Short, side branches arise from the main branches, some of which are fused together, giving the colony an anastomose appearance. Calyces are prominent, with polyps completely retractable into them. Colonies are azooxanthellate; brown, red or purple in color.

Sclerites: Large variation of thick and well-formed thornscales (~100-200 μm) are arranged around the calyces. They are thorn-like or blade-like projections bearing a complex tuberculate root structure. Spindles are formed in the polyp heads, and are hockey stick-shaped or bow-shaped. The sclerites are usually red or colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Round Island (Site 4), Shek Ngau Chau (Site 8), Wong Mau Chau (Site 10).

Local rarity and remarks: Uncommon. Two suspected species recorded: *Echinogorgia* sp. A (reddish brown) and *Echinogorgia* sp. B (Purple).

Genus *Echinomuricea* Verrill, 1869 (Figs. 2.83-2.85)

Colony shape and color: Colonies with whip-like branches, or with few long and slender branches giving a loose bushy-like appearance. Branches often arise at nearly right angles from subtending base and then bent upward. The coenenchyme of those whip-like colonies are thick, while this surface layer is thin in those loose bushy-like forms. For the latter, the central black axis can be seen easily through the conenenchyme layer. Colonies feel spiky when touched. This is due to the protrusion of long pointed ends of the thornscales of the calyces above the surface layer. Polyps are retractile and long. Colonies are azooxanthellate, yellowish brown or white in color.

Sclerites: The most characteristic type of sclerites found in this genus is the thornscales present around the calyces. These have a long and smooth spine with a spreading and warty base. The polyp head contains large spindles (~300-500 μm). Sclerites in the surface of branches are irregular and complexly warted. For the white colored colonies, the thornscales are not complex, but possess only a smooth spine and base with small prickles which are red or colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Round Island (Site 4), Port Island (Site 5), Grass Island (Site 6), Breaker Reef (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Lan Tau Pa (Site 13), Tsim Chau (Site 14), Conic Island (Site 16), Trio Island (Site 26), Stone Wall (Site 29c), Lung Shuen Pai (Site 30)

Local rarity and remarks: Abundant. Two suspected species recorded: *Echinomuricea* sp. A (white) and *Echinomuricea* sp. B (yellowish brown). *Echinomuricea* sp. A is very common in Tung Ping Chau Marine Park beyond 10 m depth, especially in Kang Lau Shek (Site 1).

Genus *Euplexaura* Verrill, 1869 (Figs. 2.86-2.88)

Colony shape and color: Colonies usually grow as fan-shaped in one plane. They can be sparsely or richly branched. The branch ends are not connected. The coenenchymes around the stem and branches are thick, so are usually of similar diameter. Branchlets are short and rise up at right angles to the branch axis. The polyps are retractile, leaving obvious pits on the colony surface when retracted. Colonies are purple or brick red, without zooxanthellae.

Sclerites: Pointed spindles present in the polyp heads, sometimes bent (~100-200 μm). Large, robust and spheroidal sclerites (~100-150 μm) are found in the coenenchyme, associated with large complex warts. Sclerites are colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Round Island (Site 4), Port Island (Site 5), Wong Mau Chau (Site 10), Lan Tau Pa (Site 13), Tsim Chau (Site 14), Tai Chau (Site 15), Conic Island (Site 16), Pak Lap Tsai (Site 17), Wong Nai Chau (Site 18), Wang Chau (Site 21), Trio Island (Site 26), Stone Wall (Site 29c), Lung Shuen Pai (Site 30).

Local rarity and remarks: Dominant. Two suspected species recorded: *Euplexaura* sp. A (purple) and *Euplexaura* sp. B (white colony with purple polyps).

Genus *Menella* Gray, 1870 (Figs. 2.89-2.91)

Colony shape and color: Colonies grow on a plane and are richly branched. Side branches often arise at nearly right angle from the main branches and then bent upward. The branch ends are not anastomosed. Polyps are retractile, some darker pits on the stem surface can easily be observed after the polyps are completely retracted into the hemispherical calyces. Colonies do not contain zooxanthellae, and are with red or yellow polyps on white stalk.

Sclerites: The entire surface of the colony is covered with leaf-scale sclerites, which are associated with a tuberculate and bifurcate "root" structure. Some of these leaf-scales are small (~100-200 μm) and the blade portion of the scale is broad with irregular ribs. In the polyp part, spindles, rods or tripod-shaped sclerites may appear. Sclerites are colorless.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Stone Wall (Site 29c).

Local rarity and remarks: Uncommon. Two suspected species were recorded: *Menella* sp. A (white stalk with red polyps) and *Menella* sp. B (white stalk with yellow polyps).

Genus *Paraplexaura* Kükenthal, 1909 (Figs. 2.92-2.94)

Colony shape and color: Colonies usually grow in one plane, sparingly branched. Branches erect and separate. Side branches often arise at nearly right angle and curving upwards. The ends of branches do not fuse together. The coenenchyme is thicker than the other genera in the same family. Polyps are totally retractile. Colonies in Hong Kong are orange in color with white polyps.

Sclerites: The surface of the branches contains sclerites with a complex tuberculate basal portion, with the upper surface covered in projections of various morphologies. Sclerites of the least complex forms are flat and covered with round mounds. Those of the most complex forms are larger in size (~200-300 μm), with huge thorns at the top and complex tubercles at the base. Sclerites can also be cock's-comb-like. Numerous intermediate states of sclerites can also be found. No well-developed scales are present. The sclerites in the polyp head are small (~100 μm), rod-liked and flat. Sclerites are orange in color.

Local occurrence: Tung Ping Chau Marine Park (Sites 1-3), Round Island (Site 4), Port Island (Site 5), Grass Island (Site 6), Shek Ngau Chau (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Mai Fan Tsui (Site 11), Lan Tau Pai (Site 13), Tai Chau (Site 15), Ma Wan (Site 28a), Sai Chau Mei (Site 28b), Stone Wall (Site 29c), Lung Shuen Pai (Site 30).

Local rarity and remarks: Dominant.

Family Subergorgiidae Gray, 1859

Genus *Subergorgia* Gray, 1857 (Figs. 2.95-2.97)

Colony shape and color: Colonies are quite large (>40 cm tall), usually grow in one plane with dichotomous branches that do not form nets. Under the coenenchyme is the horny axial medulla that is made up of gorgonin that contains a massive amount of collagen. The branches are thus strong and cannot be broken easily. All branches have a narrow groove running along their entire length. Polyps are retractile and are arranged along the two sides of the branches. Colonies are red in color with white polyps.

Sclerites: The sclerites in the polyp head are flattened spindles (~50-100 μm). Cortex sclerites are warty ovals, sometimes with girdles of warts (~50 μm). Those in the medulla are narrow, elongate and are fused together. They are colorless or brown in color.

Local occurrence: Tung Ping Chau Marine Park (Site 3), Lan Tau Pai (Site 13).

Local rarity and remarks: Rare

2.3.3 Species Profile in Dominant Octocoral Communities

The top five sites found to support a high abundance and diversity of soft corals and gorgonians in this study were Lung Lok Shui (Site 3, 19 genera), Lan Guo Shui (Site 2, 18 genera), Kang Lau Shek (Site 1, 17 genera), Breaker Reef (Site 9, 16 genera), Port Island (Site 5, 14 genera) (Table 2.4). All these sites are located in the northeastern region of Hong Kong and are presumably exposed to the same general environmental conditions like salinity, temperature and tidal amplitude. However, the microenvironment in each site may differ.

Lung Lok Shui, Lan Guo Shui and Kang Lau Shek, the top three sites which supported the highest species richness and abundance of octocorals, are all located in the southern and southwestern side of Tung Ping Chau Marine Park (TPCMP) where layers of sedimentation rocks form a fairly steep and rocky slope up to 15 m deep (below Chart Datum (CD)). However, the seabed profile in these sites and their level of exposure to wind vary because of differences in their specific location and orientation. The species composition and the dominant species among these sites may also be different. In Lung Lok Shui (Fig. 2.2), six soft coral genera and 13 gorgonian genera were recorded. Of these, *Lobophytum*, *Sinularia* and *Paraplexaura* were the dominant genera. Zooxanthellate *Lobophytum* and *Sinularia* usually formed a monospecific carpet of up to 2-4 m^2 in area at the depth of 6-10 m. *Paraplexaura* was well represented in this site. Large number of them could be found in deeper water region (-10- -13 m CD) and always with a larger colony size (>30 cm height). On top of that, rare gorgonian genera such as *Subergorgia, Anthogorgia* and *Verrucella* could also be found. Octocoral diversity was also rich in Lan Guo Shui (Fig. 2.2), comprising six soft coral and 12 gorgonian genera. In the deeper water region, at -12 to -15 m CD, it was dominated particularly by the gorgonian genera *Juncella*, *Viminella* and *Ellisella*. These Ellisellid species had a large size (30-50 cm height) and were found to grow on the bare surface of big boulders. In Kang Lau Shek (Fig. 2.2), eight soft coral genera and nine gorgonian genera were found. *Sinularia, Echinomuricea* and *Menella* were the dominant genera showing the highest abundance at -10- -12 m CD. The abundance of the white-colored *Echinomuricea* colonies was particularly high, with 3-4 colonies per meter square. Species composition of octocorals changed at the depth of 13-15 m and the dominant genera changed to *Viminella* and *Dichotella*. The fourth site with rich and diverse octocoral community is Breaker Reef (Fig. 2.5) located southeast of TPCMP. This site is characterized by having large boulders and rocks. As this is a very small reef, it is usually submerged under water surface with the upper part exposed only at spring low tide. Seven and nine genera of soft coral and gorgonian respectively were recorded in this site in a spot check. The southwest side of Breaker Reef was greatly dominated by Nephtheidae, i.e., *Dendronepthtya* and *Scleronephthya* colonies which contributed 8-10% of the total octocoral cover. A fairly rare genus, *Paraminabea*, was found at the depth of 17 m, and only one colony was recorded. Port Island, also called Chek Chau (Fig. 2.4), is located near the mouth of Tolo Channel. It is a red-colored island as it is mainly formed by red sedimentary rock. The southern part of this island supported the highest abundance and richness of octocorals in this site, with a total of four and 10 soft coral and gorgonian genera recorded respectively. The species composition in this site was mainly dominated by *Dendronephthya* and *Echinomuricea*. Two suspected species of *Dendronephthya* were recorded, and larger colonies (>45 cm tall) of these could be found in deeper region (-11- -13 m CD). *Echinomuricea* was the most common gorgonian genus found in Port Island and it dominated the deep water region (-15- -18 m CD). Quite a number of dead gorgonians were observed in the eastern side of the island. The reason for this is not clear.

2.3.4 The Most Common and the Rarest Octocoral Genera

The soft coral *Dendronephthya* and the gorgonian *Euplexaura* were the most widespread octocoral genera in these 30 sites surveyed (Table 2.5 & Appendix). *Dendronephthya* spp. were recorded in 29 of the 30 spot-checked sites except Pak Lap Tsui (Site 17). Colonies of *Dendronephthya* could be found in both shallow and deep water regions, with their estimated abundance being highest in Port Island (Site 5), Shek Ngau Chau (Site 8), Breaker Reef (Site 9), Wong Mau Chau (Site 10), Ma Wan (Site 28a) and Lung Shuen Pai (Site 30). The rocky substratum found in these sites favored their attachment and growth. *Euplexaura* spp. were recorded in 18 sites. They were more evenly distributed throughout the northern water of Hong Kong with no particular site having an exceptionally high abundance. This genus had the highest affinity to sites with hard and rocky substratum.

Sansibia, *Paraminabea* and *Elbeenus* were the rarest genera in Hong Kong's octocoral community. *Sansibia*, which belongs to family Xeniidae, is an encrusting soft corals. Small and soft polyps are united basally by a thin membrane growing tightly over the substratum. Patches of them could only be found in the shallow water regions (< -6 m CD) of TPCMP, but in no other places. For *Paraminabea*, only one colony each was encountered in Breaker Reef (Site 9) and Lung Shuen Pai (Site 30) respectively. Both of them were discovered in deeper water area (> -17 m CD) with low light. Colonies of *Elbeenus* were recorded only in the deeper water region (-13- -15 m CD) of Kang Lau Shek (Site 1) in TPCMP, and only one adult and one juvenile colonies were found.

2.4 Discussion

A total of 27 genera of octocorals (12 soft coral and 15 gorgonian genera) are now recorded from the northeastern to southeastern waters of Hong Kong. Compared with the previous studies (Zou & Scott 1982, Clark 1997, Fabricius & McCorry 2006), two genera of soft corals (*Carijoa* and *Elbeenus*) and two genera of gorgonians (*Leptogorgia* and *Viminella*) are newly recorded in this present study.

The top five sites which were found to support a high abundance and diversity of soft corals and gorgonians have two characteristics in common. Their substrata are mainly made up of big boulders and rocks. Layers of sedimentary rocks found in these sites always form a fairly steep slope in shallow area (~ -4 - -6 m CD) towards the deep water region. This habitat composition also provides a suitable substratum for settlement and growth of octocorals elsewhere (e.g. Chen & Chang 1991, Goh & Chou 1994, Mahadi *et al.* 2004). In the study at Cape D' Aguilar in southern Hong Kong, Clark (1997) observed that higher abundance and diversity of gorgonians were found in places with rocky substratum, and no colonies were found in sandy areas. Loose sand would likely result in the easy dislodgment of the gorgonians by water current. Similar observations were made in the present study. Soft corals and gorgonians were confined to firm and rocky substrata, like big boulders and bare rocks. None of them were found on sandy or muddy substrata.

The second common characteristic in these sites is the presence of strong water current. The water current in these sites are relatively stronger than those in the other sites surveyed (see Chapter 4 for more details). Optimal current speed was found to be important in influencing the distribution range of filter feeders (Sebens & Done 1993), and was essential and critical for the distribution and growth of octocorals (Fabricius & De'ath 1997). Suspension feeders like octocorals depend on currents to transport food particles through their filtering structure, the pinnules around their tentacles. Habitats where the ambient flow velocity offers the greatest advantage of feedings would bring the greatest benefits to marine sessile organisms. The highest feeding efficiency is usually demonstrated with the help of intermediate flow speed. Dai and Lin (1993) pointed out that feeding rates of gorgonians reached a peak value at intermediate flow (~8 cm/s). At slow flow, the volume of water filtered through the polyps was less, so that food encounter and intake was low. On the other hand, at high current speed, organisms would quit feeding and take the evasive action by retracting their polyps. That is why large number of octocorals only appears in habitats with intermediate current strength.

This present study showed that *Dendronephthya* was the most widespread octocoral genus in Hong Kong waters. This genus is very common worldwide and has also been observed to be the most abundant soft coral in the reef communities of the Red Sea (Benayahu 1985). Species of this genus are usually restricted to flow-exposed and wave-protected habitats. Some species could even grow in muddy estuaries and deep oceanic waters (Fabricius & Alderslade 2001). As *Dendronephthya* spp. do not possess any zooxanthellae, they capture and feed on phytoplankton. This mode of nutrition is completely different from that of other octocorals, which usually obtain their food through the photosynthesis of their symbionts or by intake of zooplankton (Fabricius *et al.* 1995a, 1995b). This adaptation allows species of *Dendronephthya* to be highly productive and fast growing in flow-exposed and even oligotrophic reef environment. The mode of asexual reproduction also plays an important role on the dominance of *Dendronephthya* (Dahan & Benayahu 1997). This soft coral exhibits clonal propagation that results in the autotomy of small-sized fragments. After detached from the mother colony, the root-like fragments could attach and occupy the suitable space immediately. This rapid and successful colonization strategy highly increases the dispersal efficiency of *Dendronephthya*.

The genus *Elbeenus*, a member of family Alcyoniidae, is a recently discovered taxon. This genus, with only one species *E. lauramartinae,* was first described in 2002 (Alderslade 2002) based only on two colonies collected from Palau in western Pacific at a water depth of 159 m. Two colonies of this genus were found in Kang Lau Shek (Site 1) in the present study at a water depth of only 13-15 m. The presence of

Elbeenus sp. in such a shallow water depth in Hong Kong warrants further investigations into the species identification of these materials.

Hong Kong, although considered to be relatively poor in marine biodiversity when compared with tropical places like Indonesia, supports a number of rare or unusual octocoral species. In order to better protect and conserve the octocoral fauna of Hong Kong, it is essential to establish a reference collection of this group of organisms. Thus, a systematical evaluation of Hong Kong octocoral species should be carried out. Additional relevant literature for use in species identification will be obtained. Comparison with existing octocoral species in different major museums of the world should be pursued in order that verification of the species identification of Hong Kong materials can be completed in the near future.

2.5 Summary

The present study provided an up-to-date Hong Kong octocoral checklist, with a record of 12 genera of soft corals in five families and 15 genera of gorgonians in five families. Of these, two soft coral genera (*Carijoa* and *Elbeenus*) and two gorgonian genera (*Leptogorgia* and *Viminella*) were new zoographical records for Hong Kong.

This study also revealed that the distribution and abundance of octocorals were closely related to sites with more extensive rocky substratum.

Table 2.1 List of the 12 genera of soft corals recorded in Hong Kong as reported in the present study. Those with asterisk are the new zoogeographical records for Hong Kong.

Family	Genus
Alcyoniidae Lamouroux, 1812	*Cladiella* Gray, 1869
	**Elbeenus* Alderslade, 2002
	Lobophytum Marenzeller, 1886
	Paraminabea Williams & Alderslade, 1999
	Sarcophyton Lesson, 1834
	Sinularia May, 1898
Clavulariidae Hickson, 1894	**Carijoa* F. Müller, 1867
Nephtheidae Gray, 1862	*Dendronephthya* Kükenthal, 1905
	Scleronephthya Studer, 1887
Nidaliidae Gray, 1869	*Chironephthya* Wright & Studer, 1889
	Nephthyigorgia Kükenthal, 1910
Xeniidae Ehrenberg, 1828	*Sansibia* Alderslade, 2000
Total **5**	**12**

Table 2.2 List of the 15 genera of gorgonians recorded in Hong Kong as reported in the present study. Those with asterisk are the new zoogeographical records for Hong Kong.

Family	Genus
Acanthogorgiidae Gray, 1859	*Acanthogorgia* Gray, 1857
	Anthogorgia Verrill, 1868
Ellisellidae Gray 1859	*Dichotella* Gray, 1870
	Ellisella Gray, 1858
	Junceella Valenciennes, 1855
	Verrucella Milne Edwards & Haime, 1857
	* *Viminella* Gray, 1870
Gorgoniidae Lamouroux, 1812	**Leptogorgia* Grasshoff, 1988
Plexauridae Gray, 1859	*Astrogorgia* Verrill, 1868
	Echinogorgia Kükenthal, 1865
	Echinomuricea Verrill, 1869
	Euplexaura Verrill, 1869
	Menella Gray, 1870
	Paraplexaura Kükenthal, 1909
Subergorgiidae Gray, 1859	*Subergorgia* Gray, 1857
Total **5**	**15**

Table 2.3 GPS readings of the 30 sites spot-checked and surveyed in northeastern to southeastern waters of Hong Kong in the present study. Please refer to Figures 2.1-2.12 and the Appendix for detailed description of each site.

Site No. and Name	GPS readings	Site No. and Name	GPS readings
1. Kang Lau Shek	N 22° 32' 446" E 114° 26' 584"	18. Wong Nai Chau	N 22° 20' 704" E 114° 22' 220"
2. Lan Guo Shui	N 22° 32' 179" E 114° 26' 333"	19. Kong Tau Pai	N 22° 20' 249" E 114° 22' 598"
3. Long Lok Shui	N 22° 32' 344" E 114° 25' 631"	20. Town Island	N 22° 20' 371" E 114° 22' 032"
4. Round Island	N 22° 32' 440" E 114° 19' 937"	21. Wang Chau	N 22° 19' 834" E 114° 22' 537"
5. Port Island	N 22° 29' 854" E 114° 21' 697"	22. Basalt Island	N 22° 18' 789" E 114° 22' 197"
6. Grass Island	N 22° 28' 420" E 114° 22' 266"	23. Bluff Island	N 22° 18' 856" E 114° 20' 917"
7. Kung Chau	N 22° 29' 056" E 114° 22' 322"	24. Ma Tsai Pai	N 22° 19' 639" E 114° 19' 397"
8. Shek Ngau Chau	N 22° 28' 608" E 114° 25' 612"	25. Unnamed Island	N 22° 18' 241" E 114° 19' 407"
9. Breaker Reef	N 22° 27' 657" E 114° 25' 224"	26. Trio Island	N 22° 18' 068" E 114° 19' 289"
10. Wong Mau Chau	N 22° 26' 841" E 114° 23' 732"	27. Pak Pai	N 22° 18' 543" E 114° 18' 627"
11. Mai Fan Tsui	N 22° 26' 841" E 114° 23' 732"	28a. North Ninepin Ma Wan	N 22° 16' 318" E 114° 20' 994"
12. Tuen Tsui	N 22° 26' 187" E 114° 24' 107"	28b. North Ninepin Sai Chau Mei	N 22° 15' 870" E 114° 20' 700"
13. Lan Tau Pai	N 22° 24' 339" E 114° 23' 289"	28c. North Ninepin Hoi Tam Hau	N 22° 15' 755" E 114° 20' 927"
14. Tsim Chau	N 22° 24' 145" E 114° 23' 204"	29a. South Ninepin Kwo Chau Wan	N 22° 15' 562" E 114° 21' 032"
15. Tai Chau	N 22° 24' 145" E 114° 23' 204"	29b. South Ninepin Tai Chau Mei	N 22° 15' 337" E 114° 20' 794"
16. Conic Island	N 22° 21' 784" E 114° 23' 459"	29c. South Ninepin Stone Wall	N 22° 15' 290" E 114° 21' 181"
17. Pak Lap Tsai	N 22° 21' 056" E 114° 22' 080"	30. East Ninepin Lung Shuen Pai	N 22v 15' 897" E 114° 22' 659"

Table 2.4 Summary list showing the number of octocoral genera recorded in Sites 1 – 30. Please refer to Figures 2.1-2.12 and the Appendix for the site location and details.

Site no.	Site	Soft Coral Genera	Gorgonian Genera	Total no.
1	Kang Lau Shek	8	9	17
2	Lan Guo Shui	6	12	18
3	Long Lok Shui	6	13	19
4	Round Island	1	4	5
5	Port Island	4	10	14
6	Grass Island	1	3	4
7	Kung Chau	1	0	1
8	Shek Ngau Chau	7	6	13
9	Breaker Reef	7	9	16
10	Wong Mau Chau	6	7	13
11	Mai Fan Tsui	1	2	3
12	Tuen Tsui	1	0	1
13	Lan Tau Pai	3	5	8
14	Tsim Chau	2	2	4
15	Tai Chau	4	2	6
16	Conic Island	1	2	3
17	Pak Lap Tsai	1	1	2
18	Wong Nai Chau	1	1	2
19	Kong Tau Pai	2	0	2
20	Town Island	1	0	1
21	Wang Chau	1	1	2
22	Basalt Island	1	0	1
23	Bluff Island	2	0	2
24	Ma Tsai Pai	1	0	1
25	Unnamed Island	1	0	1
26	Trio Island	1	2	3
27	Pak Pai	1	0	1
28a	North Ninepin-Ma Wan	2	1	3
28b	North Ninepin-Sai Chau Mei	2	1	3
28c	North Ninepin-Hoi Tam Hau	2	0	2
29a	South Ninepin-Kwo Chau Wan	2	0	2
29b	South Ninepin-Tai Chau Mei	0	0	0
29c	South Ninepin-Stone Wall	1	7	8
30	East Ninepin-Lung Shuen Pai	5	6	11

Table 2.5 List of octocoral genera recorded from Hong Kong and the site location where these records are made. The total number of sites where each genus is recorded is given in ( ). For the name and details of each site, please refer to Figures 2.1-2.12 and the Appendix.

Family	Genus	Site no.	Total	Rarity
Soft Corals:	*Cladiella*	1, 2, 3, 8, 9, 10, 15	(7)	Uncommon
Alcyoniidae	*Elbeenus*	1	(1)	Rare
	Lobophytum	1, 2, 3, 8, 9, 10, 13, 14,	(10)	Common
	Paraminabea	9, 30	(2)	Rare
	Sarcophyton	1, 2, 3, 10	(4)	Uncommon
	Sinularia	1, 2, 3, 5, 8, 9, 10, 13, 15,	(11)	Uncommon
Clavulariidae	*Carijoa*	5, 8, 9, 10, 30	(5)	Uncommon
Nephtheidae	*Dendronephthya*	1-16, 18-30	(29)	Abundant
	Scleronephthya	8, 9, 28, 29, 30	(5)	Uncommon
Nidaliidae	*Chironephthya*	1, 3	(2)	Rare
	Nephthyigorgia	1, 3, 5, 8, 30	(5)	Uncommon
Xeniidae	*Sansibia*	1, 2, 3	(3)	Rare
Gorgonian:	*Acanthogorgia*	1, 2, 3, 6, 11, 29, 30	(7)	Uncommon
Acanthogorgiidae	*Anthogorgia*	1, 2, 3, 5, 8, 9, 29, 30	(8)	Uncommon
Ellisellidae	*Dichotella*	1, 5, 9, 10	(4)	Rare
	Ellisella	2, 5	(2)	Rare
	Junceella	2, 8	(2)	Rare
	Verrucella	3, 5	(2)	Rare
	Viminella	1,2, 3, 5, 9	(5)	Uncommon
Gorgoniidae	*Leptogorgia*	2, 3, 13	(3)	Rare
Plexauridae	*Astrogorgia*	1, 2, 3, 5, 10, 29, 30	(7)	Uncommon
	Echinogorgia	1, 2, 3, 4, 5, 8, 10	(7)	Uncommon
	Echinomuricea	1-6, 8-10, 13, 14, 16, 26,	(15)	Dominant
	Euplexaura	1-5, 8-10, 13-18, 21 26,	(18)	Dominant
	Menella	1, 2, 3, 5, 9, 10, 29	(7)	Uncommon
	Paraplexaura	1-6, 8-10, 11, 13, 15, 28,	(15)	Dominant
Subergorgiidae	*Subergorgia*	3, 13	(2)	Rare

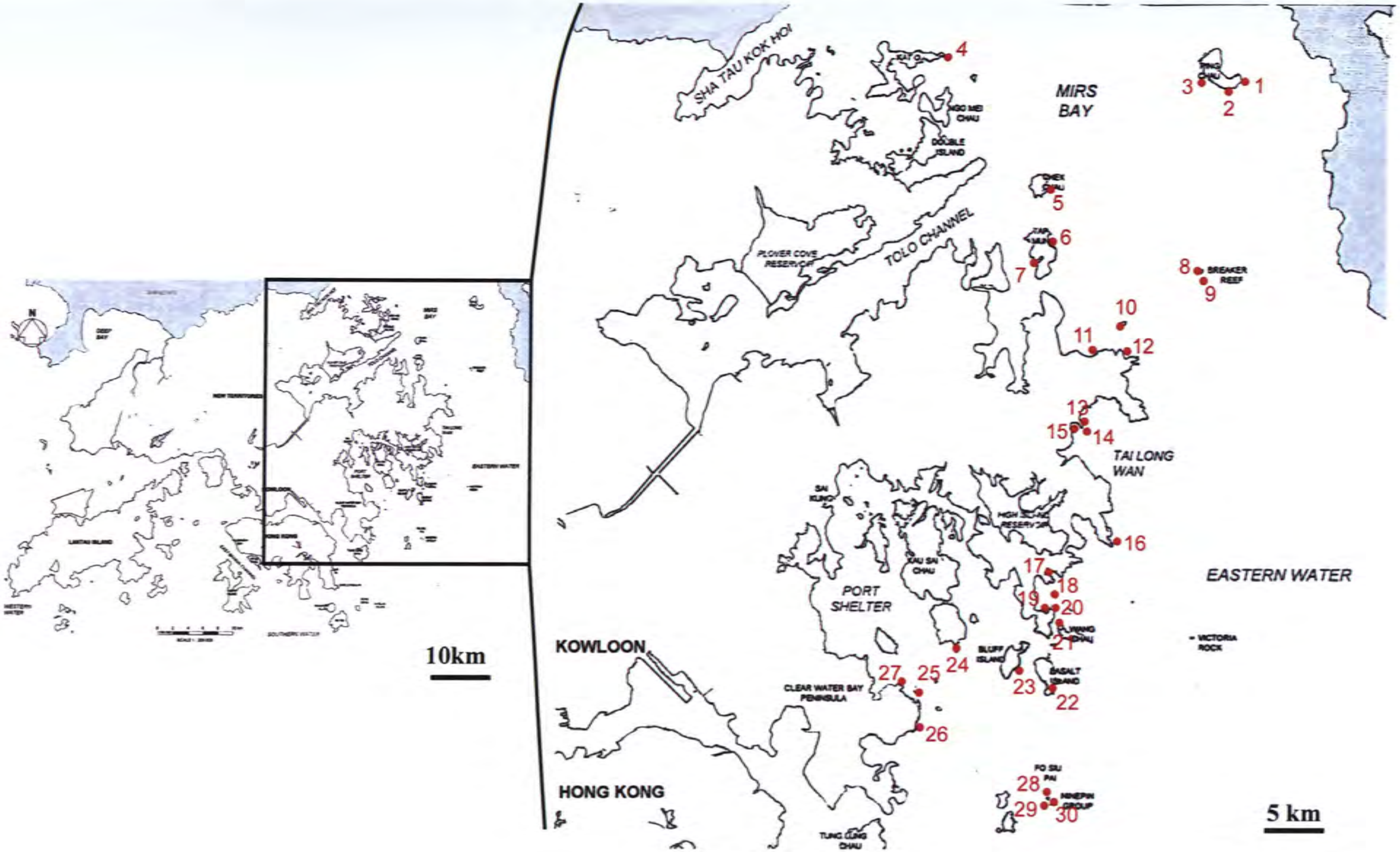


Figure 2.1 Map showing all the sites (with their corresponding number) spot-checked and surveyed in Northeastern to Southeastern waters of Hong Kong. (**1**. Kang Lau Shek, **2**. Lan Guo Shui, **3**. Long Lok Tsui, **4**. Round Island, **5**. Port Island, **6**. Grass Island, **7**. Kung Chau, **8**. Shek Ngau Chau, **9**.Breaker Reef, **10**.Wong Mau Chau, **11**. Mai Fan Tsui, **12.** Tuen Tsui, **13.** Lan Tau Pai, **14**. Tsim Chau, **15**. Tai Chau, **16**. Conic Island, **17.** Pak Lap Tsai, **18**. Wong Nai Chau, **19**. Kong Tau Pai, **20.** Town Island, **21.** Wang Chau, **22.** Basalt Island, **23**. Bluff Island, **24.** Ma Tsai Pai, **25.** Unnamed Island, **26.** Trio Island, **27**. Pak Pai, **28.** North Ninepin Island, **29**. South Ninepin Island, **30.** East Ninepin Island.) For details of the area surveyed in each site, please refer to Figures 2.2 to 2.12. The GPS readings of each site are given in Table 2.3.

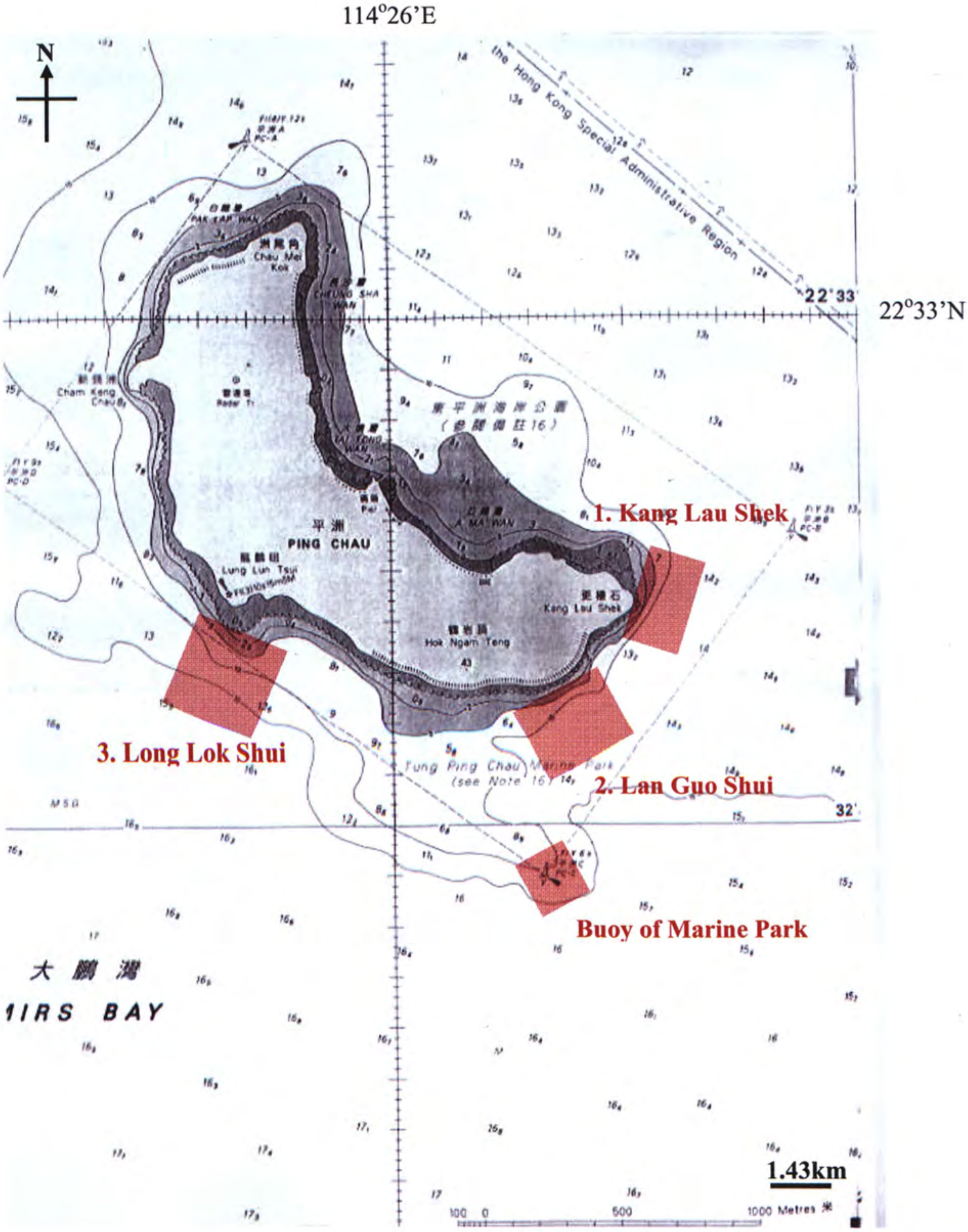


Figure 2.2 Map showing the water areas surveyed (red shaded areas) in site Nos. 1-3 (Kang Lau Shek, Lan Guo Shui and Long Lok Shui) within Tung Ping Chau Marine Park. For GPS readings of the sites, please refer to Table 2.3.

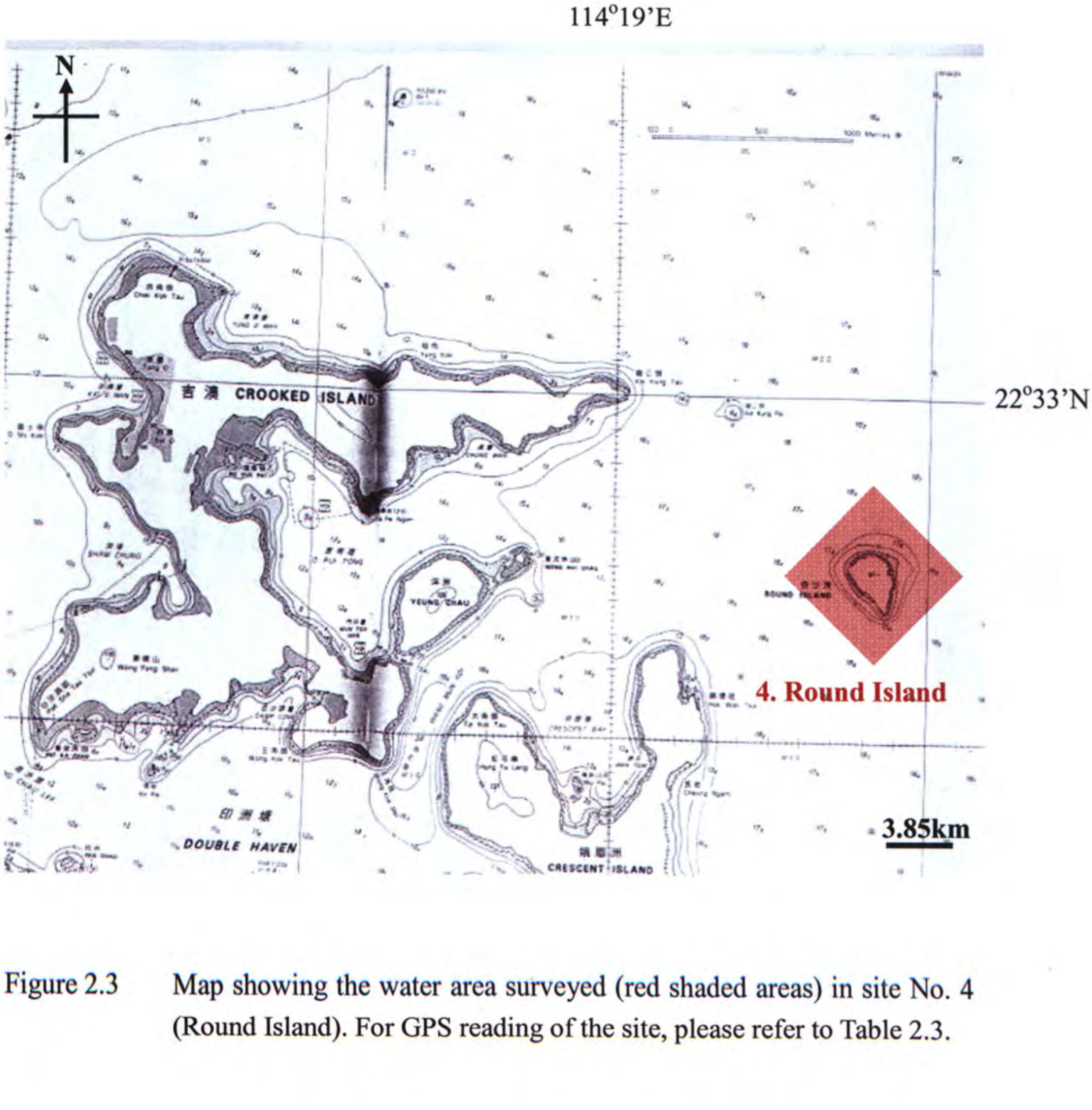


Figure 2.3 Map showing the water area surveyed (red shaded areas) in site No. 4 (Round Island). For GPS reading of the site, please refer to Table 2.3.

114°21'E

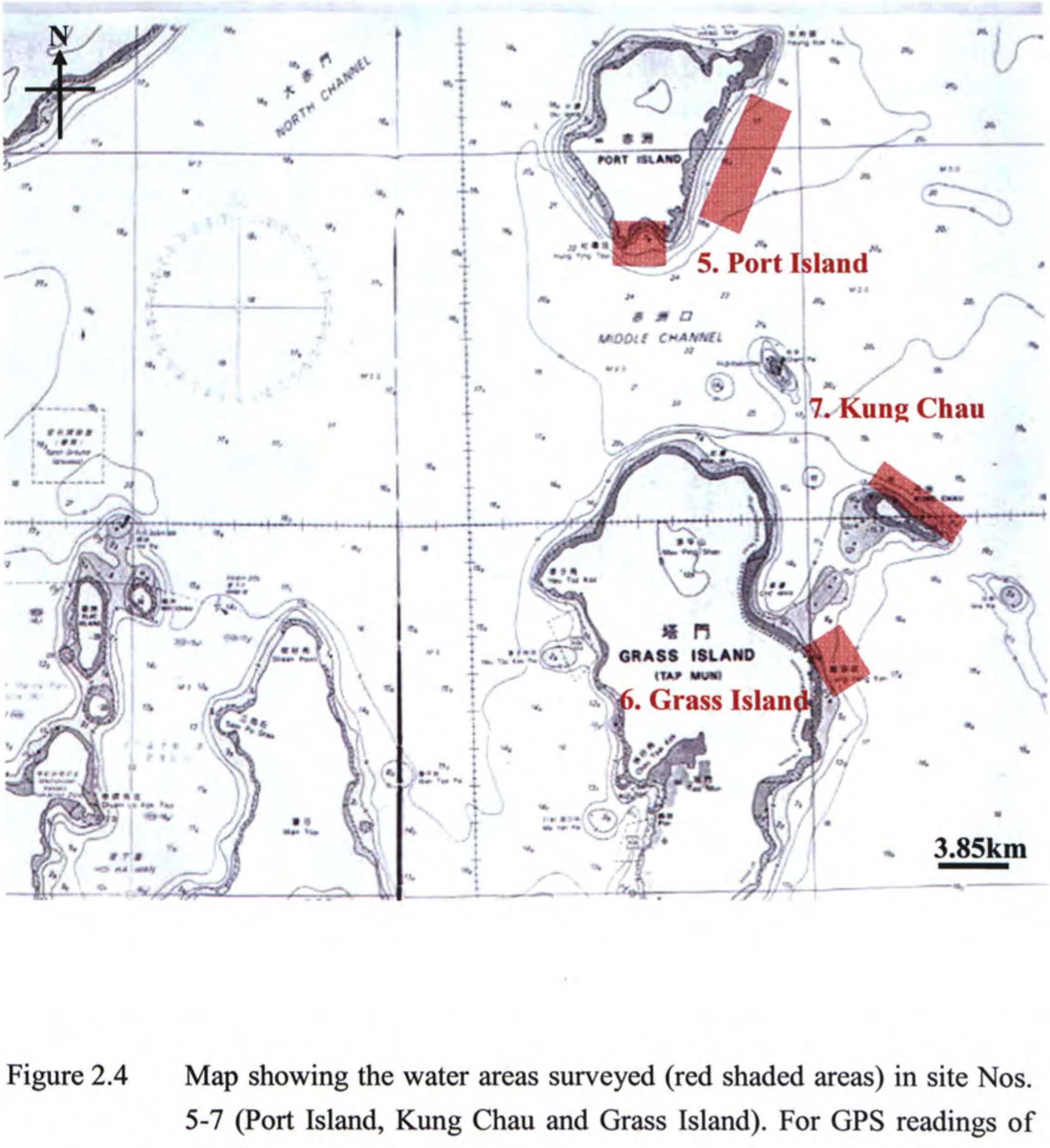


Figure 2.4 Map showing the water areas surveyed (red shaded areas) in site Nos. 5-7 (Port Island, Kung Chau and Grass Island). For GPS readings of the sites, please refer to Table 2.3.

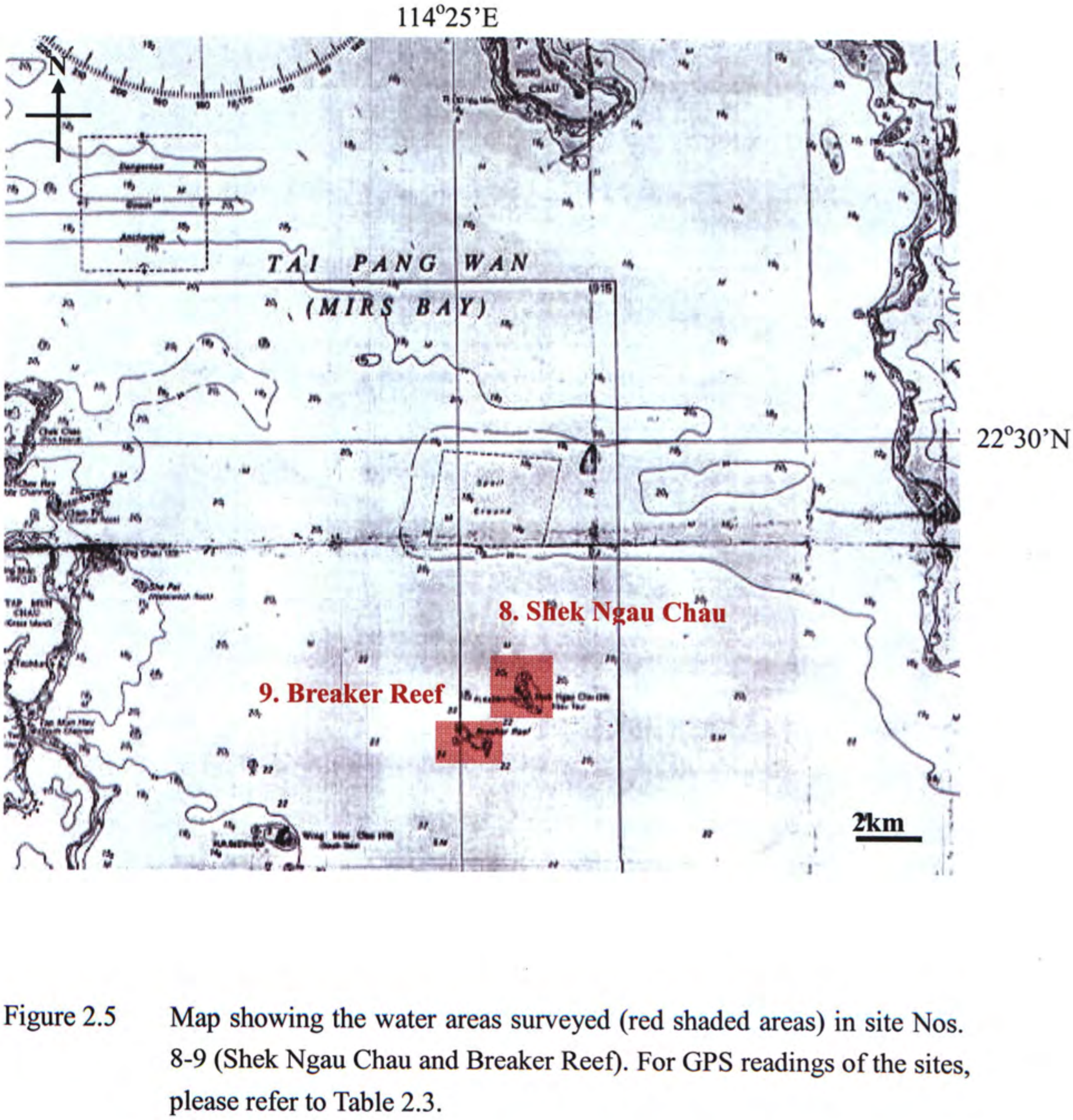


Figure 2.5 Map showing the water areas surveyed (red shaded areas) in site Nos. 8-9 (Shek Ngau Chau and Breaker Reef). For GPS readings of the sites, please refer to Table 2.3.

114°23'E

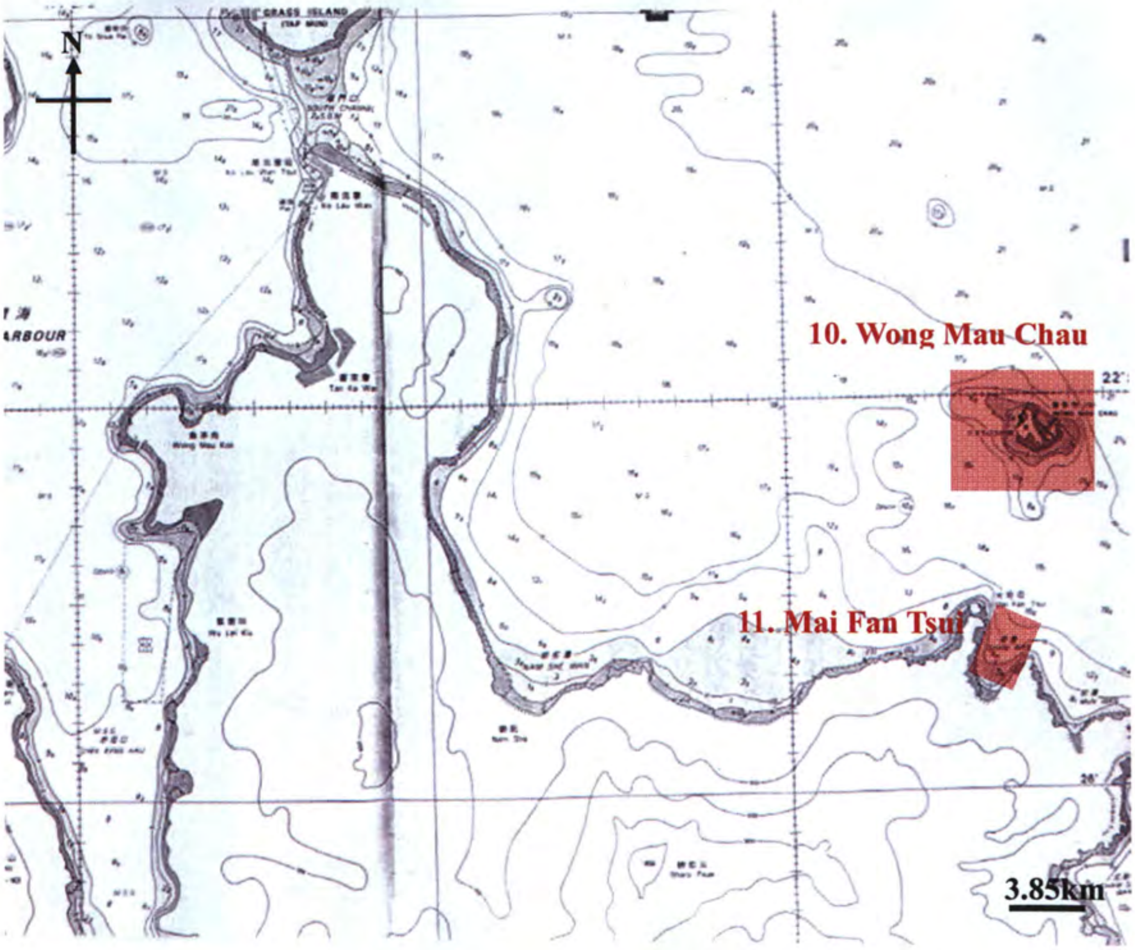


Figure 2.6 Map showing the water areas surveyed (red shaded areas) in site Nos.10-11 (Wong Mau Chau and Mai Fan Tsui). For GPS readings of the sites, please refer to Table 2.3.

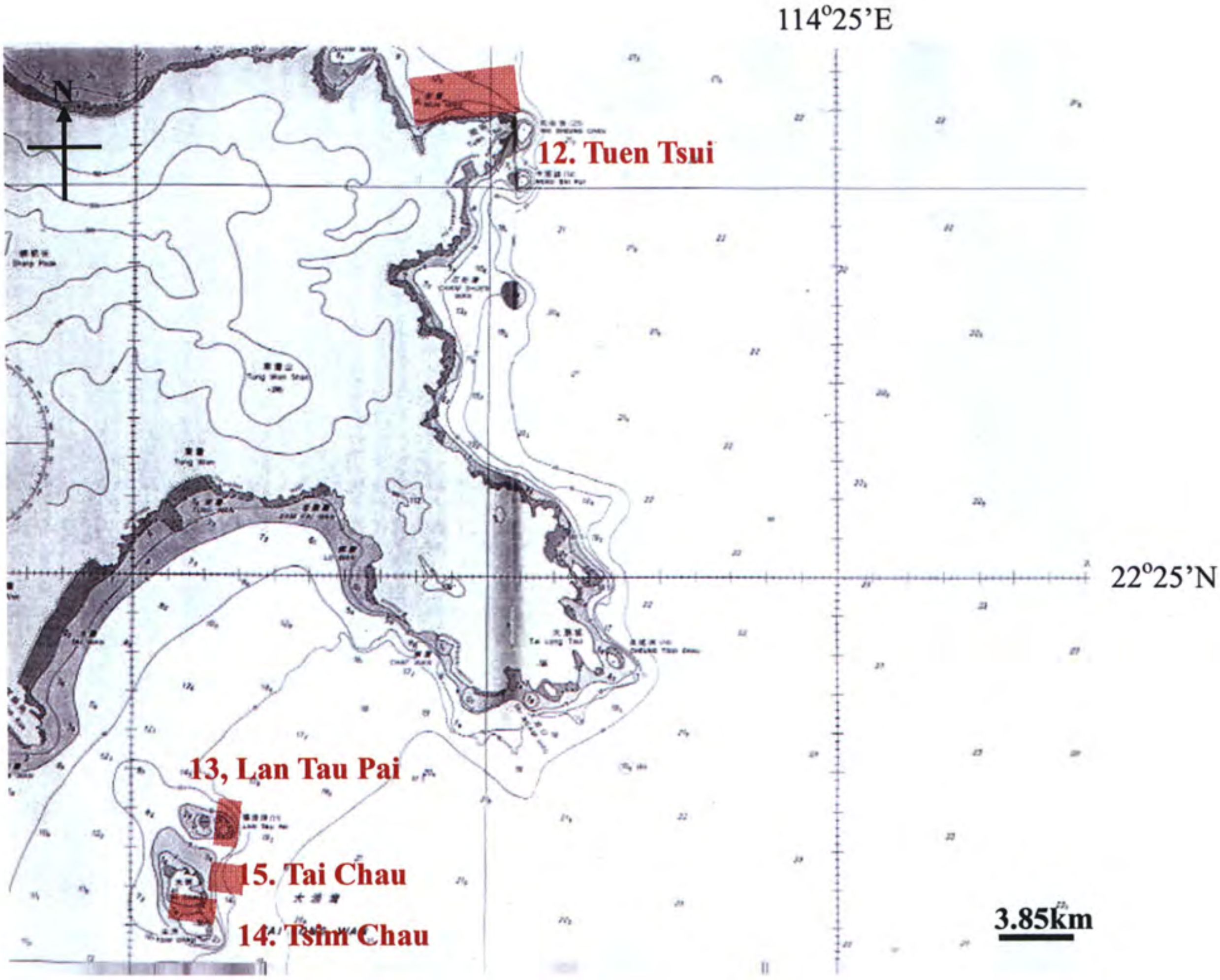


Figure 2.7 Map showing the water areas surveyed (red shaded areas) in site Nos.12-15 (Tuen Tsui, Lan Tau Pai, Tsim Chau and Tai Chau). For GPS readings of the sites, please refer to Table 2.3.

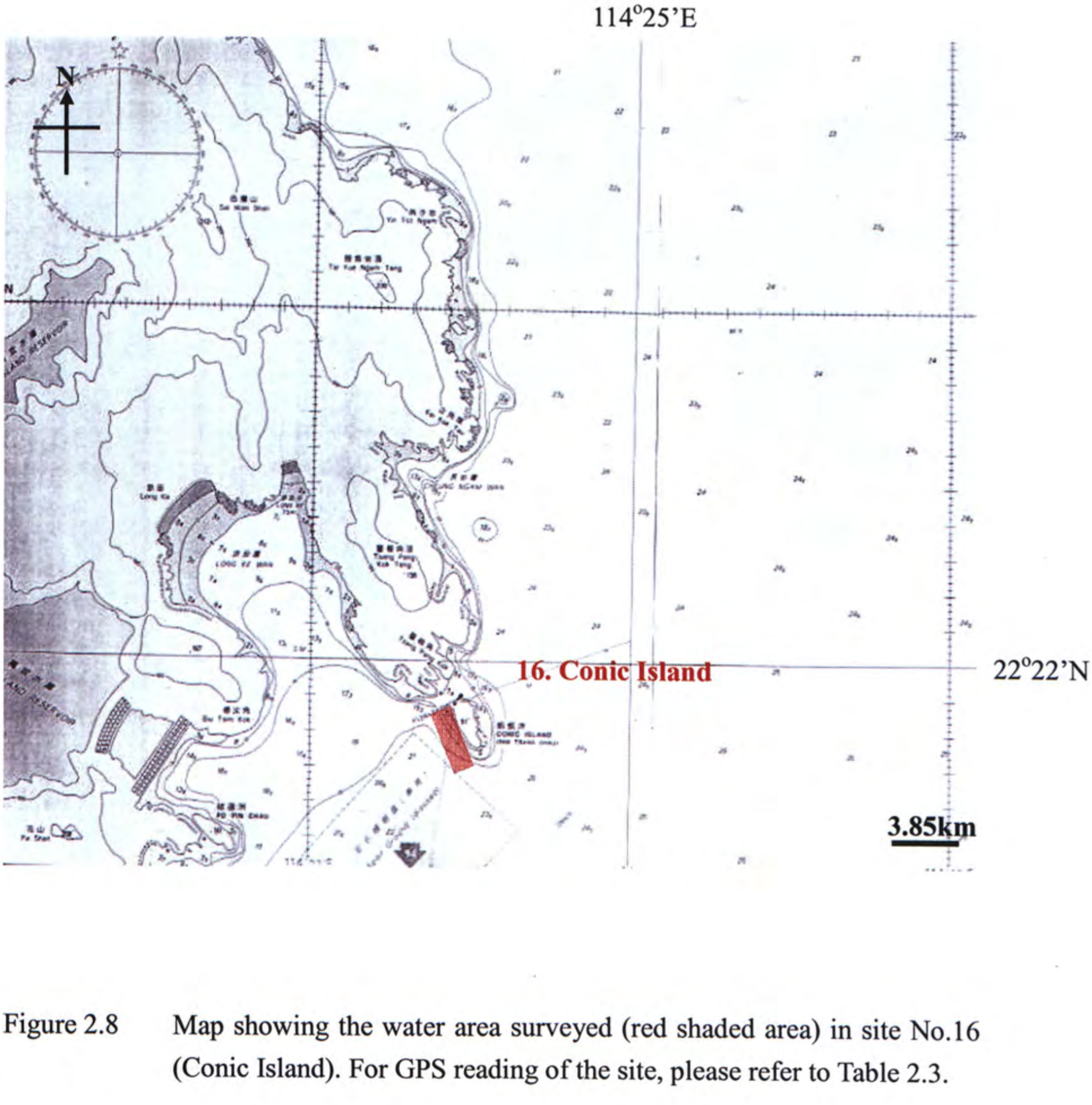


Figure 2.8 Map showing the water area surveyed (red shaded area) in site No.16 (Conic Island). For GPS reading of the site, please refer to Table 2.3.

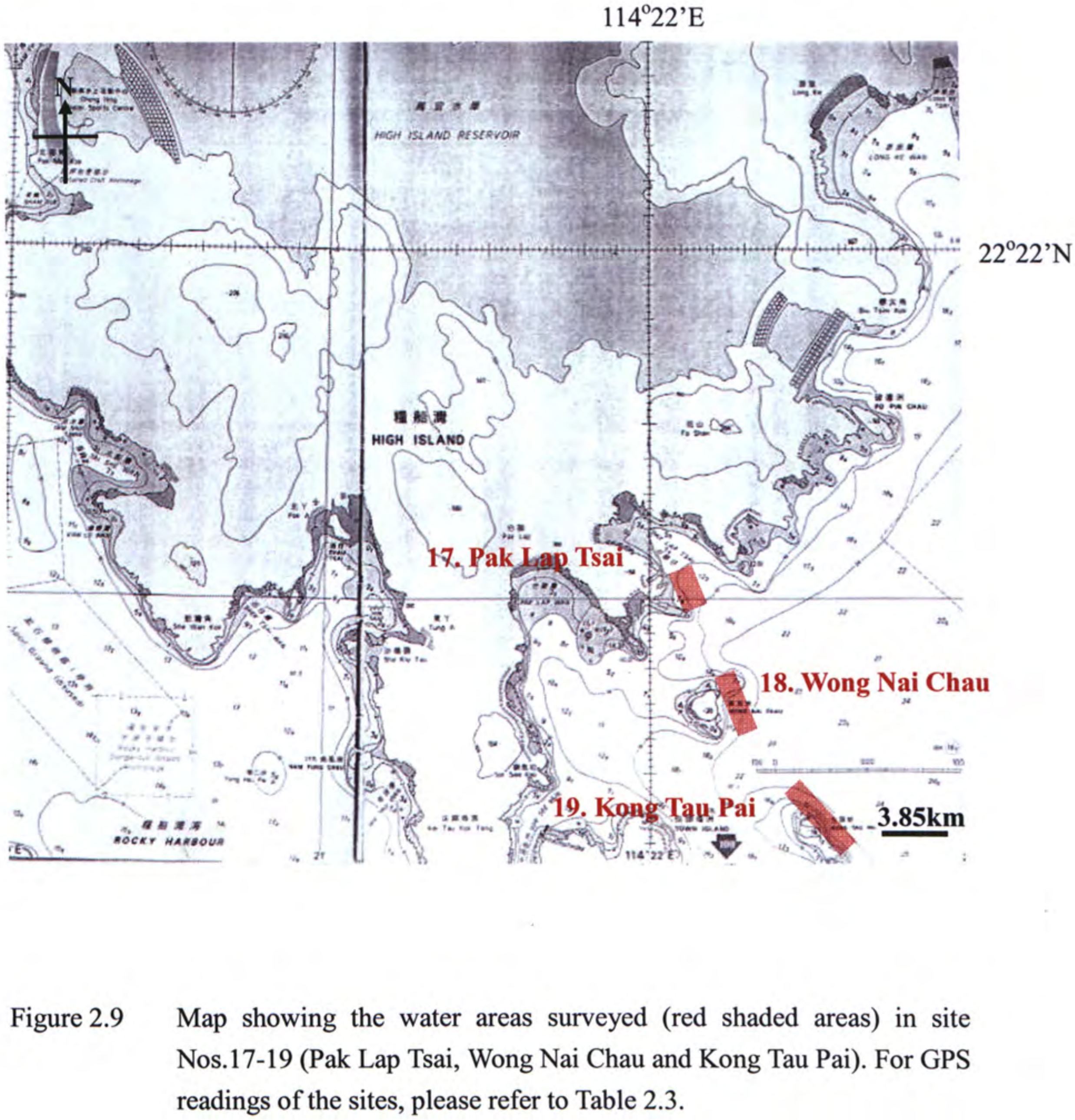


Figure 2.9 Map showing the water areas surveyed (red shaded areas) in site Nos.17-19 (Pak Lap Tsai, Wong Nai Chau and Kong Tau Pai). For GPS readings of the sites, please refer to Table 2.3.

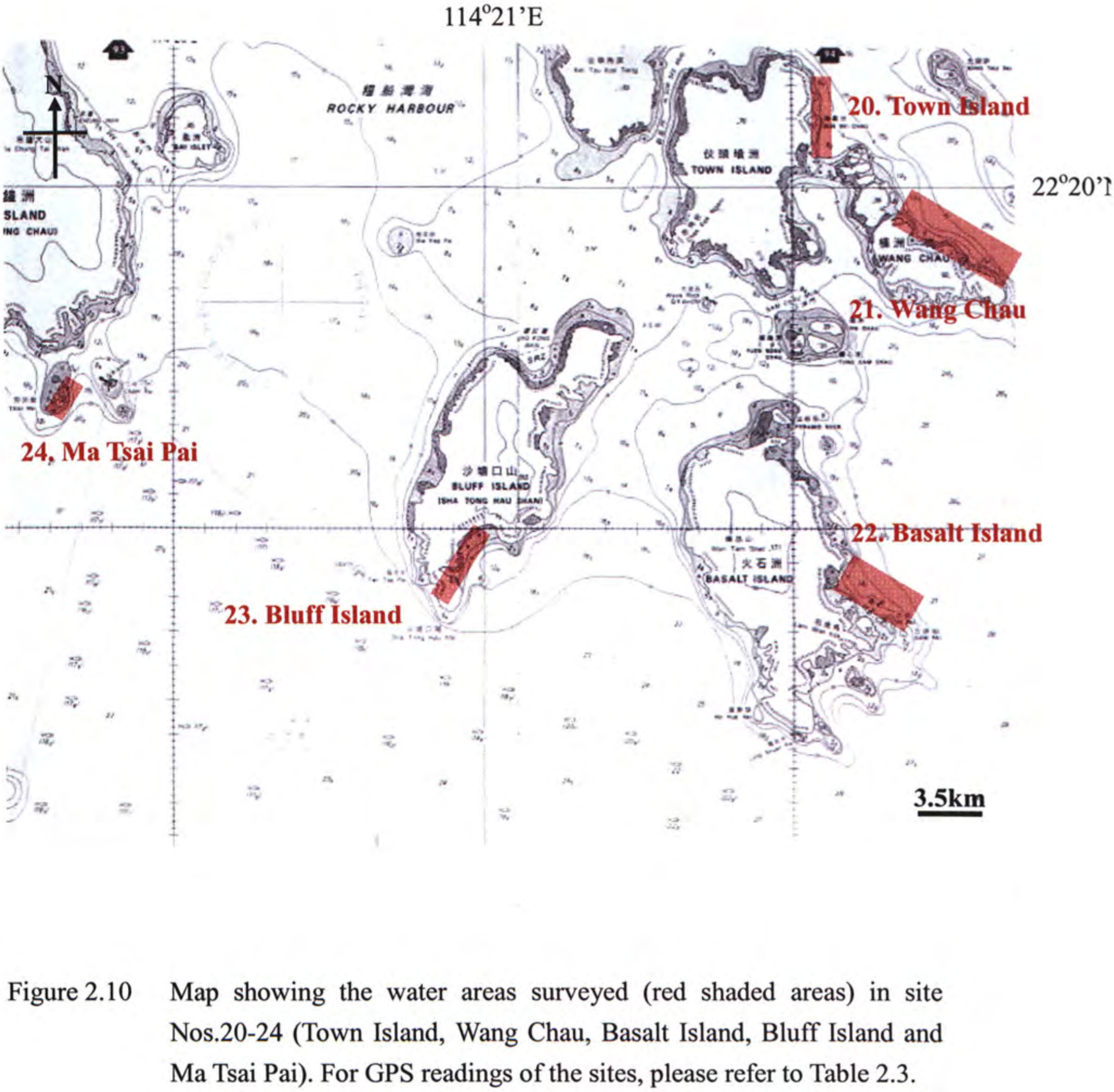


Figure 2.10 Map showing the water areas surveyed (red shaded areas) in site Nos.20-24 (Town Island, Wang Chau, Basalt Island, Bluff Island and Ma Tsai Pai). For GPS readings of the sites, please refer to Table 2.3.

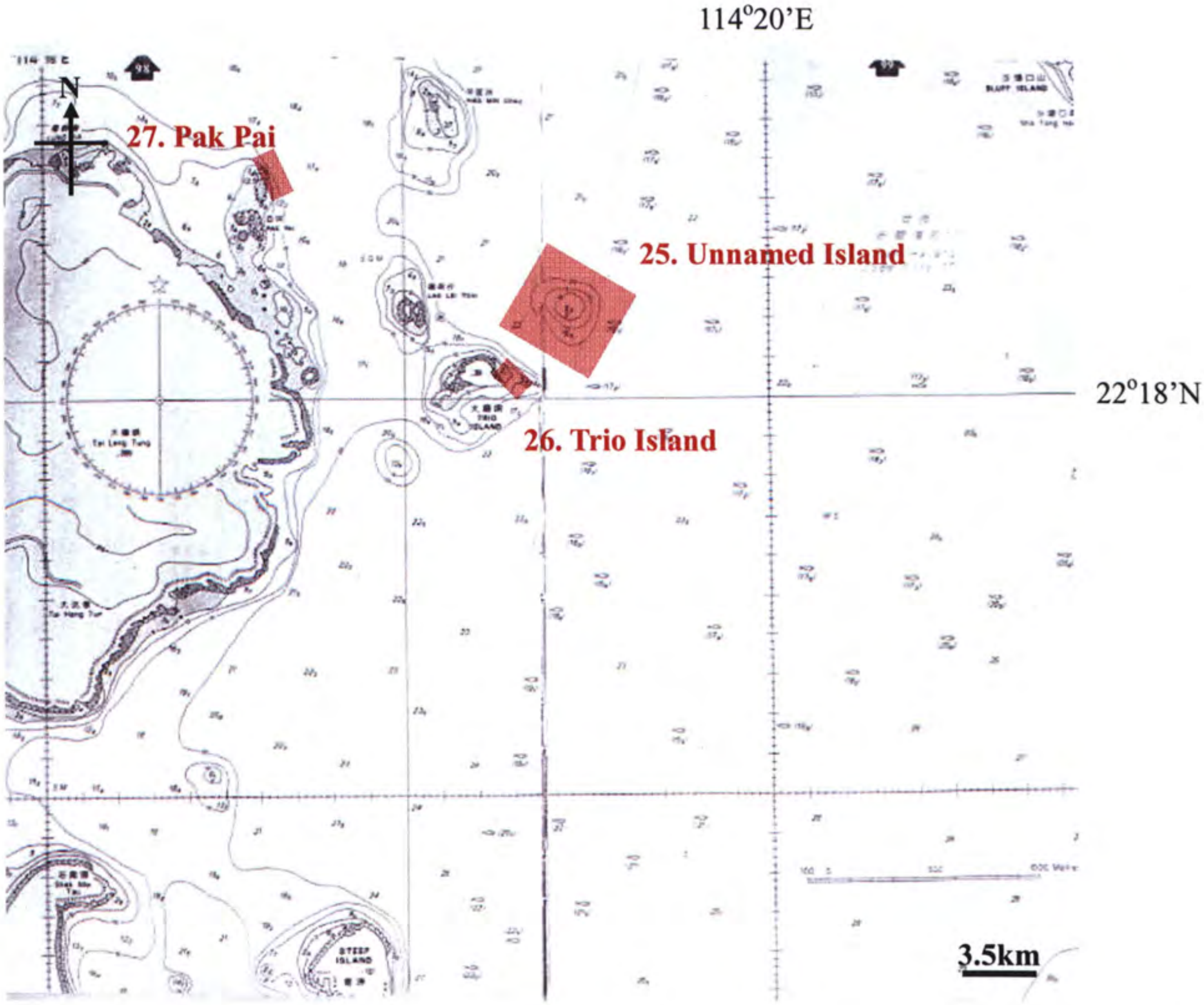


Figure 2.11 Map showing the water areas surveyed (red shaded areas) in site Nos.25-27 (Unnamed Island, Trio Island and Pak Pai). For GPS readings of the sites, please refer to Table 2.3.

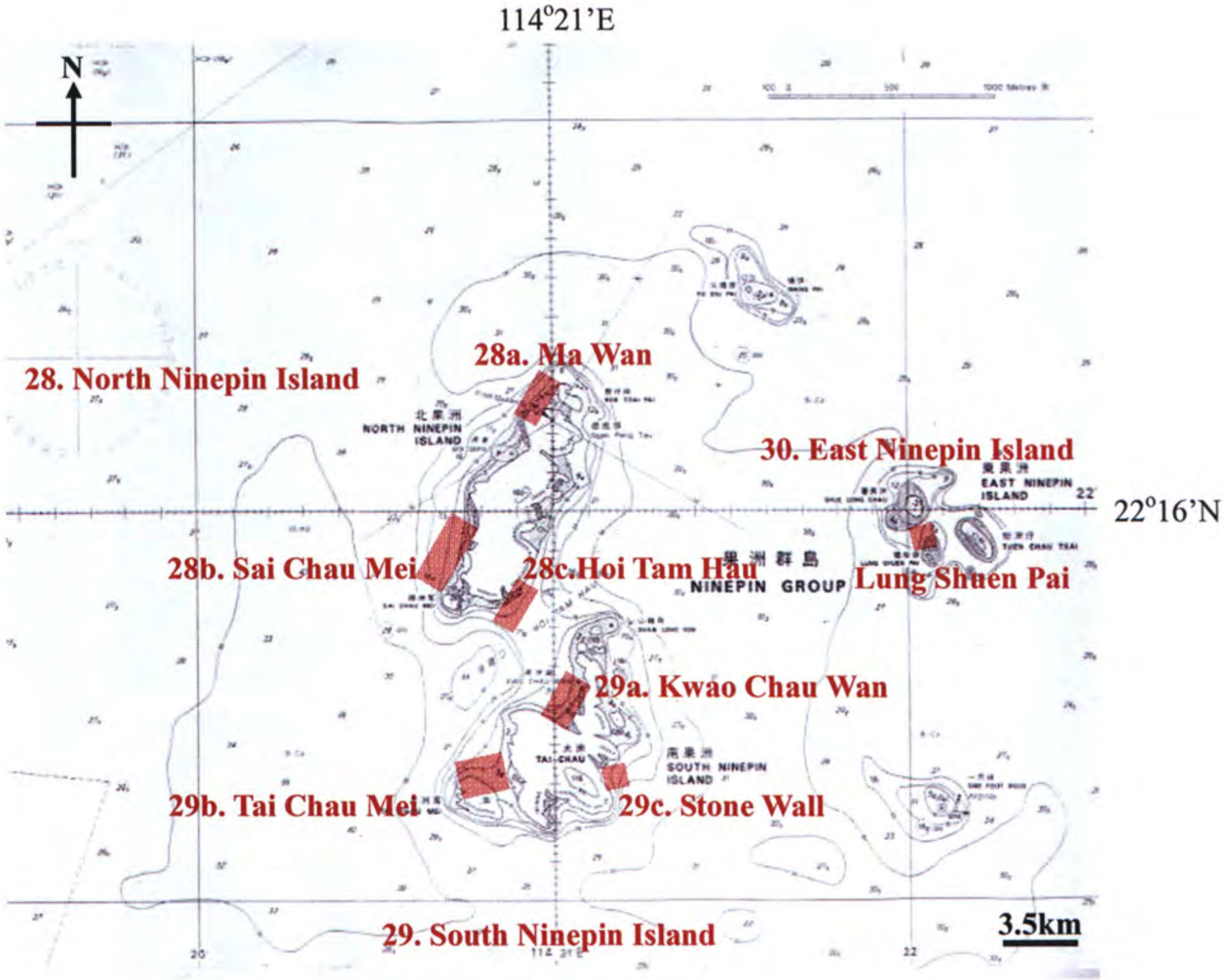


Figure 2.12 Map showing the water areas surveyed (red shaded areas) in site Nos.28-30 (North, South and East Ninepin Island) within Ninepin Group. For GPS readings of the sites, please refer to Table 2.3.

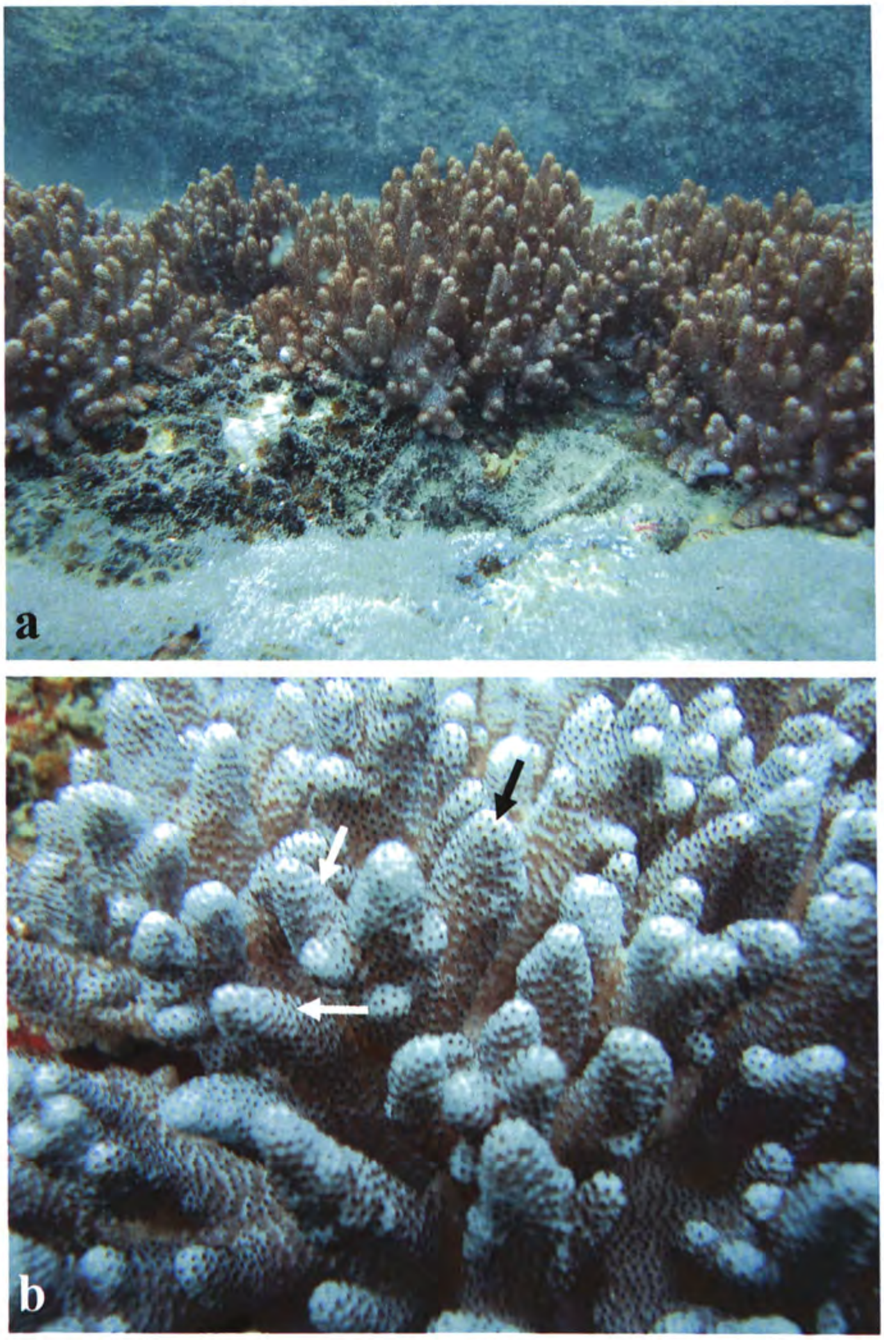


Figure 2.13 Underwater photos of living *Cladiella* sp. **(a)** Lobate/ digitated colonies in shallow water areas. **(b)** Colony that turns grey or pale brown when contracted. Numerous dark pits (arrows) on the colony surface are caused by the complete retraction of the polyps.

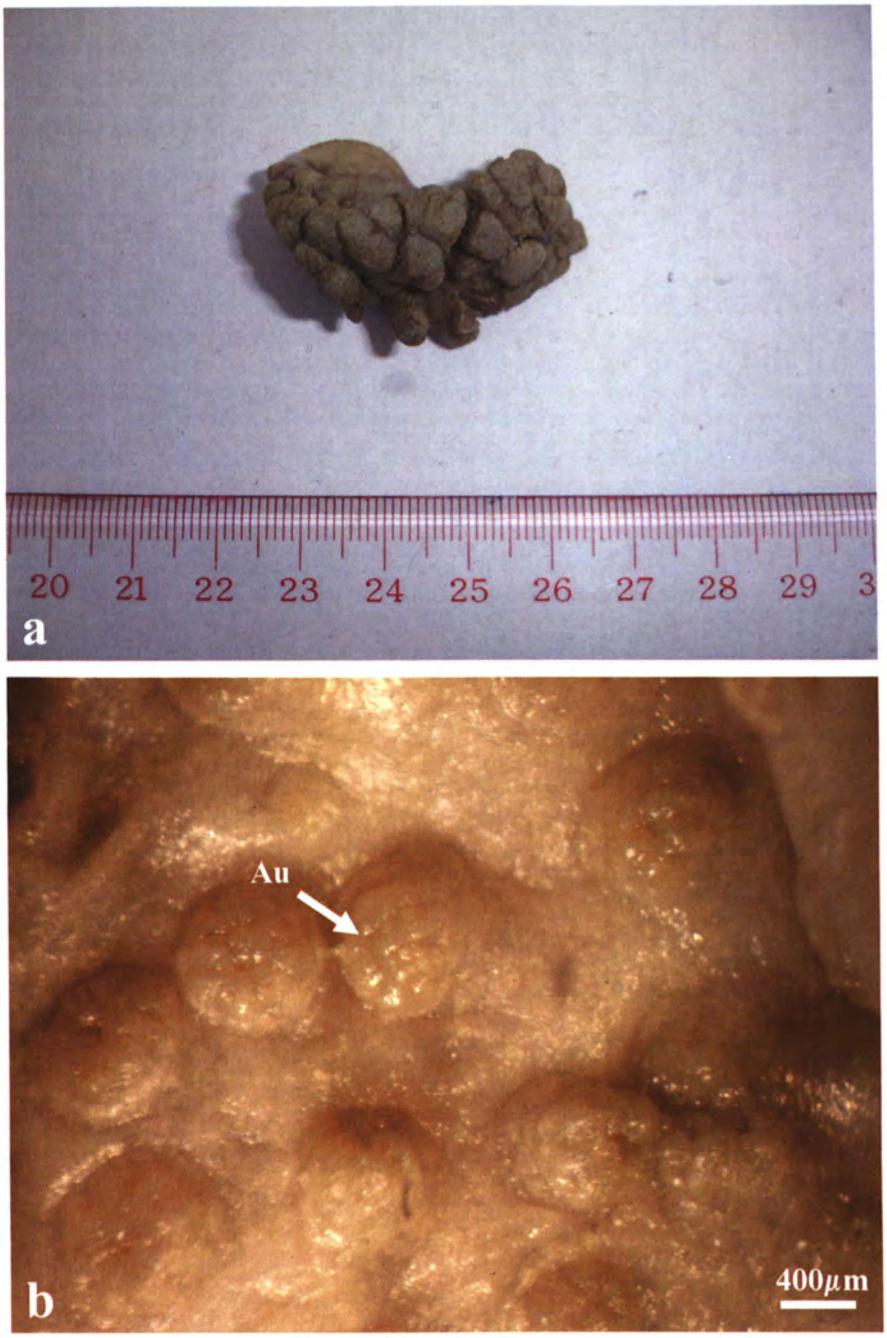


Figure 2.14 Preserved material of *Cladiella* sp. **(a)** Colony contracted after preservation with the loss of zooxanthellae. **(b)** Close-up of the retracted autozooids (Au) observed under the dissecting microscope (25x).

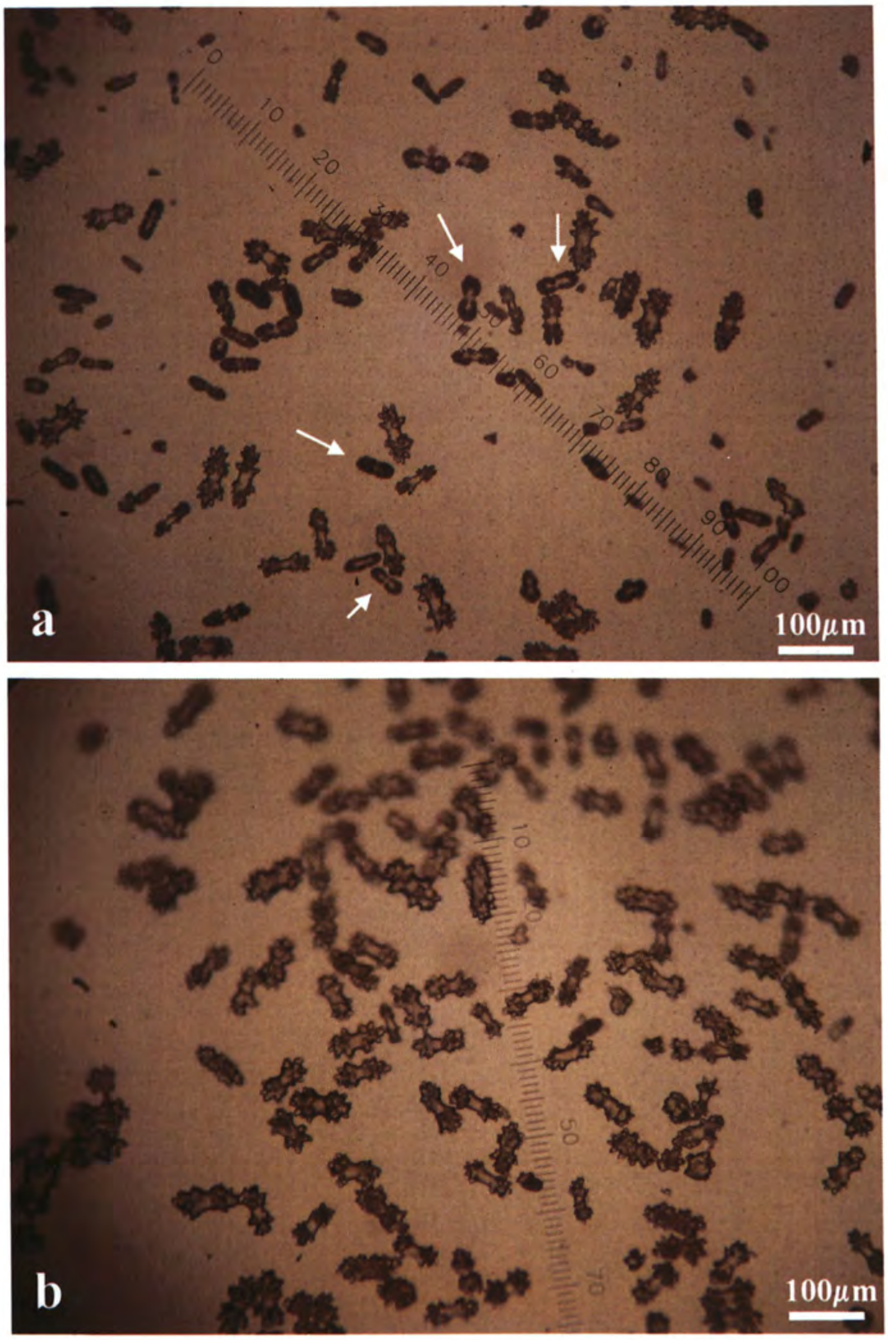


Figure 2.15 Colorless sclerites of *Cladiella* sp. under the compound microscope (100x). **(a)** Minute disks or figure-eights, with roughened dumbbell shape sclerites from the polyp. The center of the disk is lighter because the calcium carbonate in this region is less dense. **(b)** Dumbbells with double heads and waist from the surface and interior parts of the colony. Heads of the sclerites are warty.

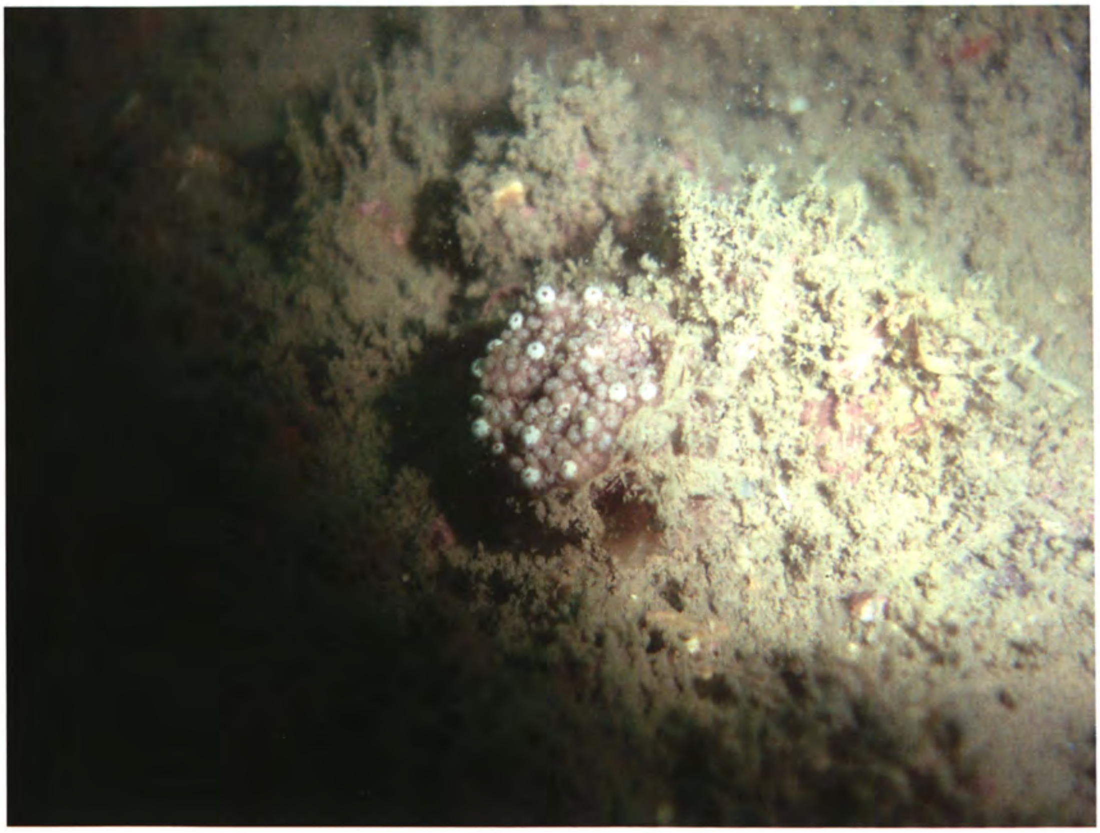


Figure 2.16 Underwater photo of living *Elbeenus* sp. The colony is contracted and in beige color. This genus could only be found at -13 - -15 m CD in Kang Lau Shek, Tung Ping Chau Marine Park (Site 1).

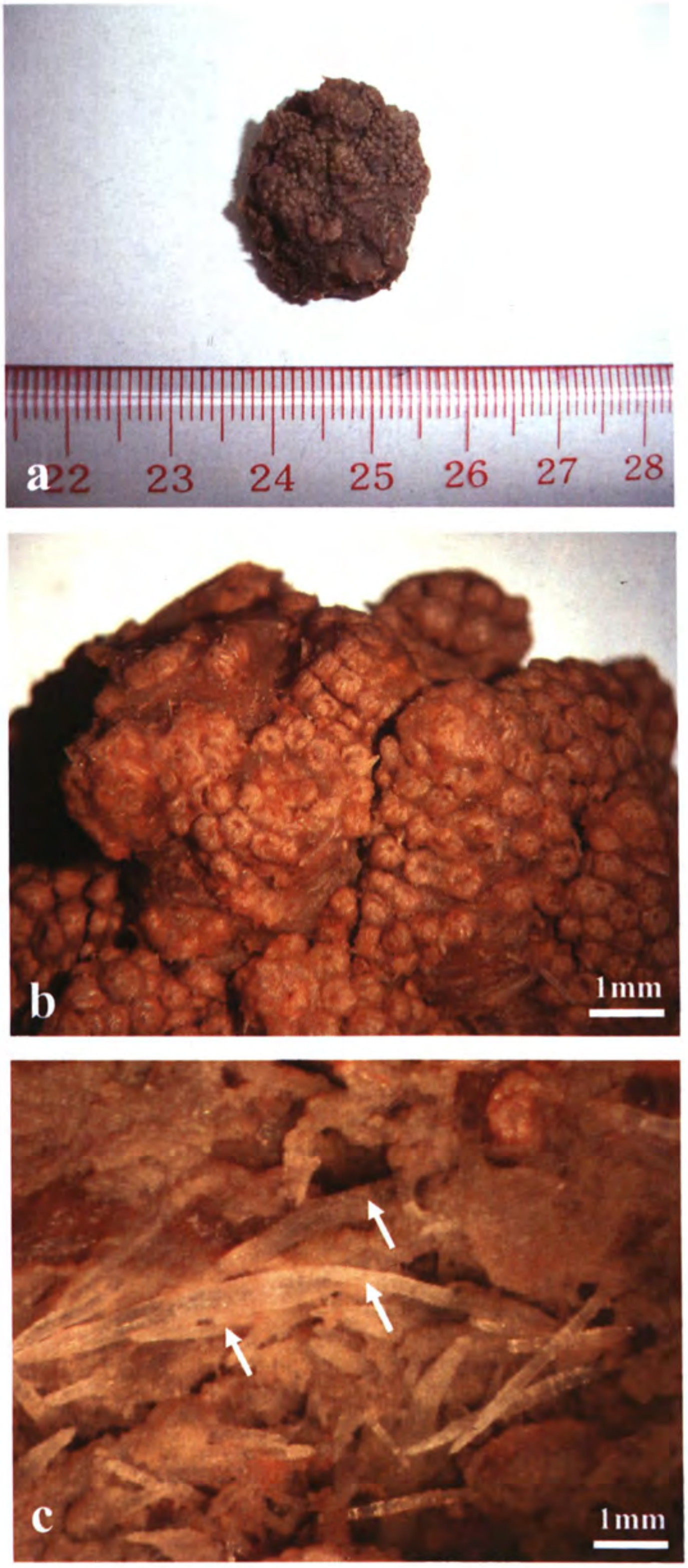


Figure 2.17 Preserved material of *Elbeenus* sp. **(a)** Colony contracted after preservation. **(b)** Close-up of the retracted polyps observed under the dissecting microscope (10.5x). **(c)** Large and pointed sclerites (arrows) found in the basal part of the colony (10.5x).

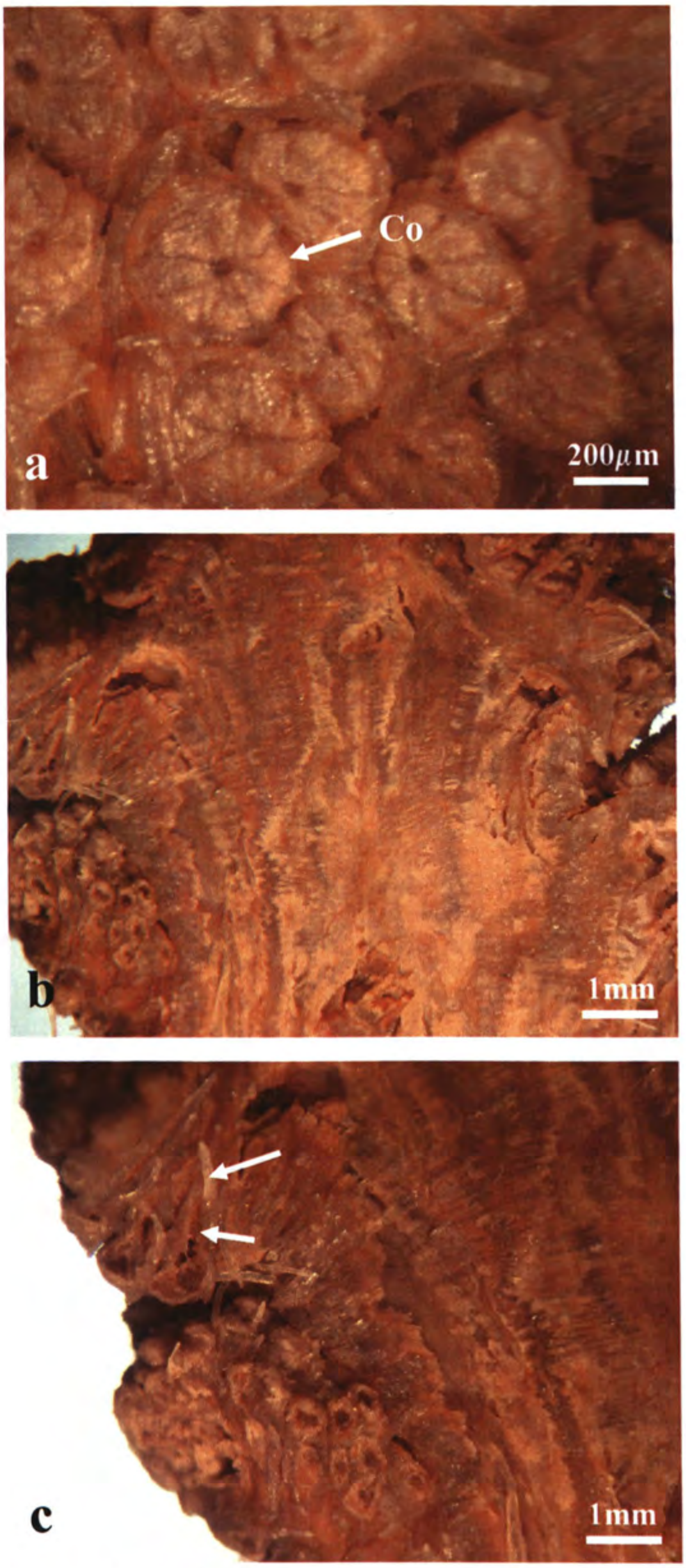


Figure 2.18 Preserved material of *Elbeenus* sp. observed under the dissecting microscope. **(a)** Contracted polyps with prominent collaret (Co) surrounded by pointed sclerites (45x). **(b)** Mesentery of the colony possesses few sclerites (10.5x). **(c)** Spindles (arrows) on the surface of the colony (10.5x).

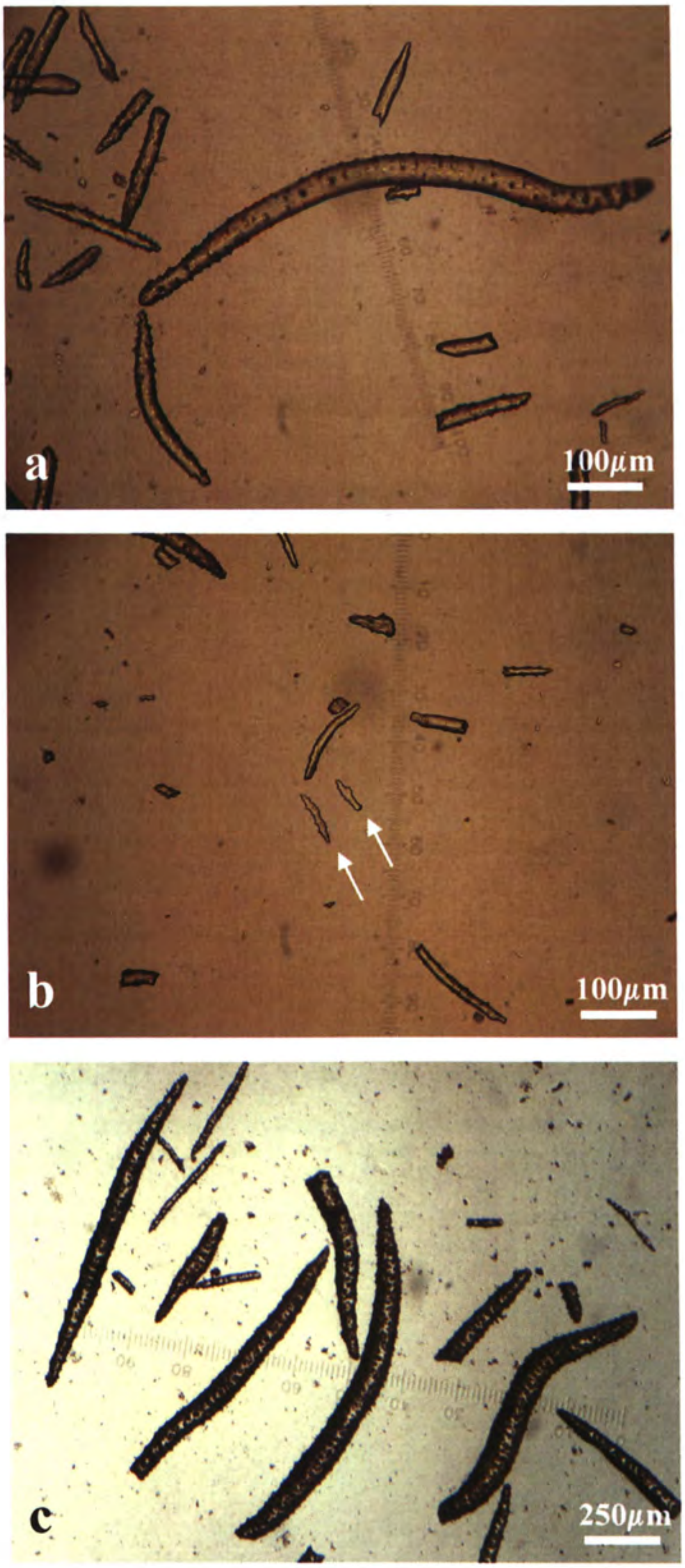


Figure 2.19 Colorless sclerites of *Elbeenus* sp. observed under the compound microscope. **(a)** Pointed and smooth sclerites, associated only with few warts, from the polyps and collaret (100x). **(b)** Small and flattened sclerites (arrows) from the tentacles (100x). **(c)** Larger and more warty sclerites from basal part of the colony (40x).

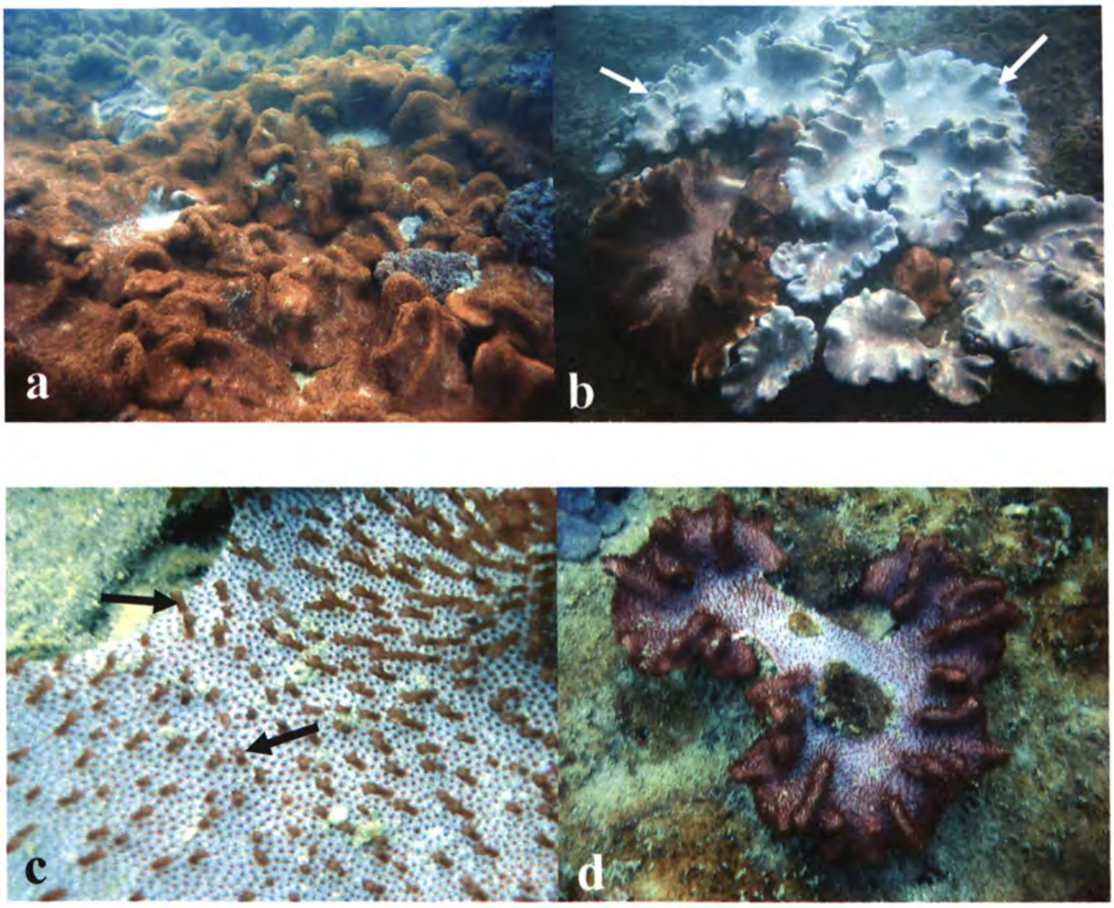


Figure 2.20 Underwater photos of living *Lobophytum* sp. **(a)** Monospecfic carpet formed over hard substratum; **(b)** Expanded colonies (brown) and contracted colonies (grey), with small lobes or ridges (arrows) arranged along the margin of the polyp area. **(c)** Extended tube-liked autozooids (arrow) surrounded by small and numerous dark pits, the retracted siphonozooids. **(d)** Colony undergoing asexual reproduction – fission.

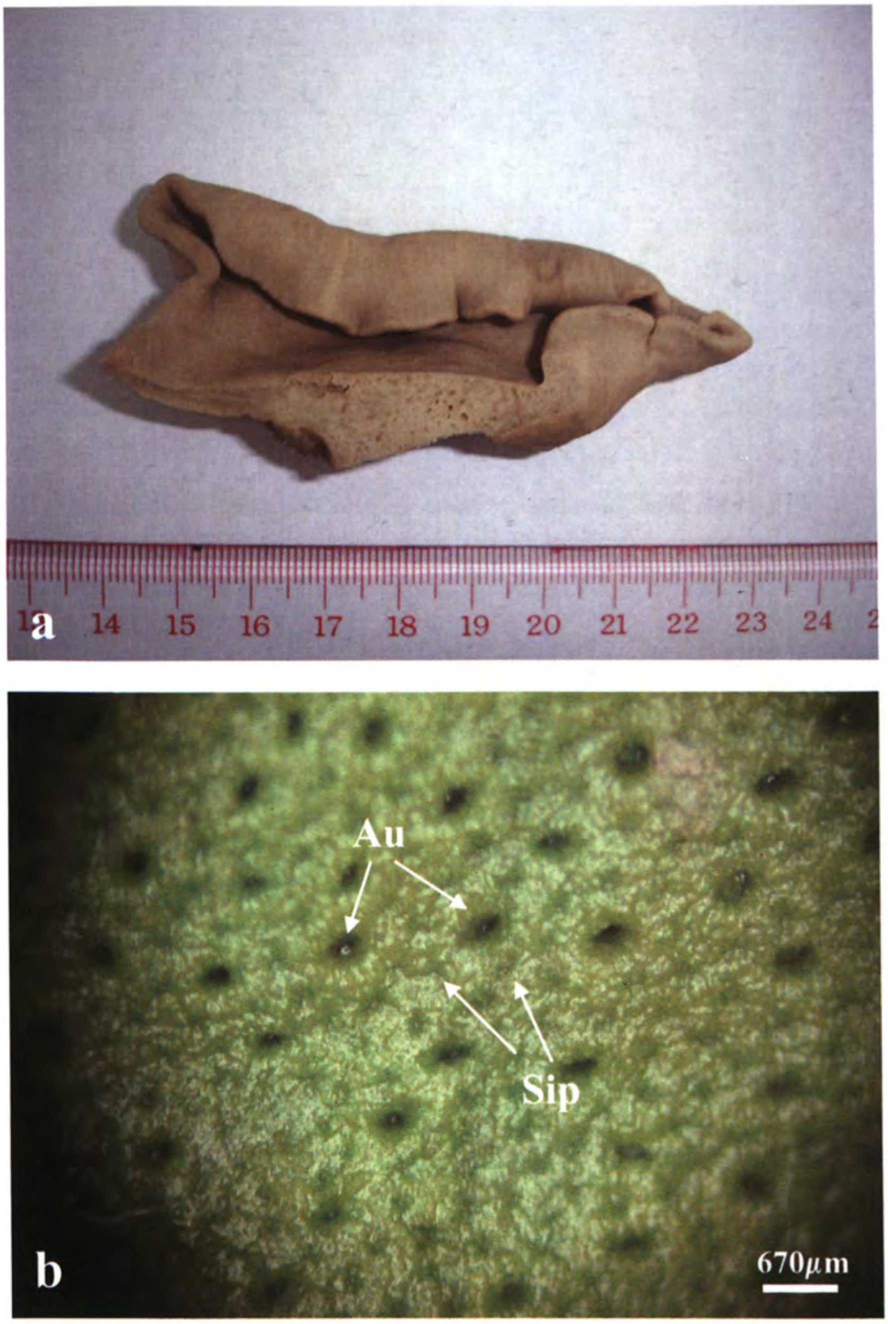


Figure 2.21 Preserved material of *Lobophytum* sp. **(a)** Colony contracted after preservation with the loss of zooxanthellae. Cross section of the mesentery is shown. **(b)** Close-up of the surface of the polyp region observed under the dissecting microscope (15x). The autozooids (Au) are completely retracted leaving some dark pits. The lighter dots surround the autozooids are the opening of the siphonozooids (Sip).

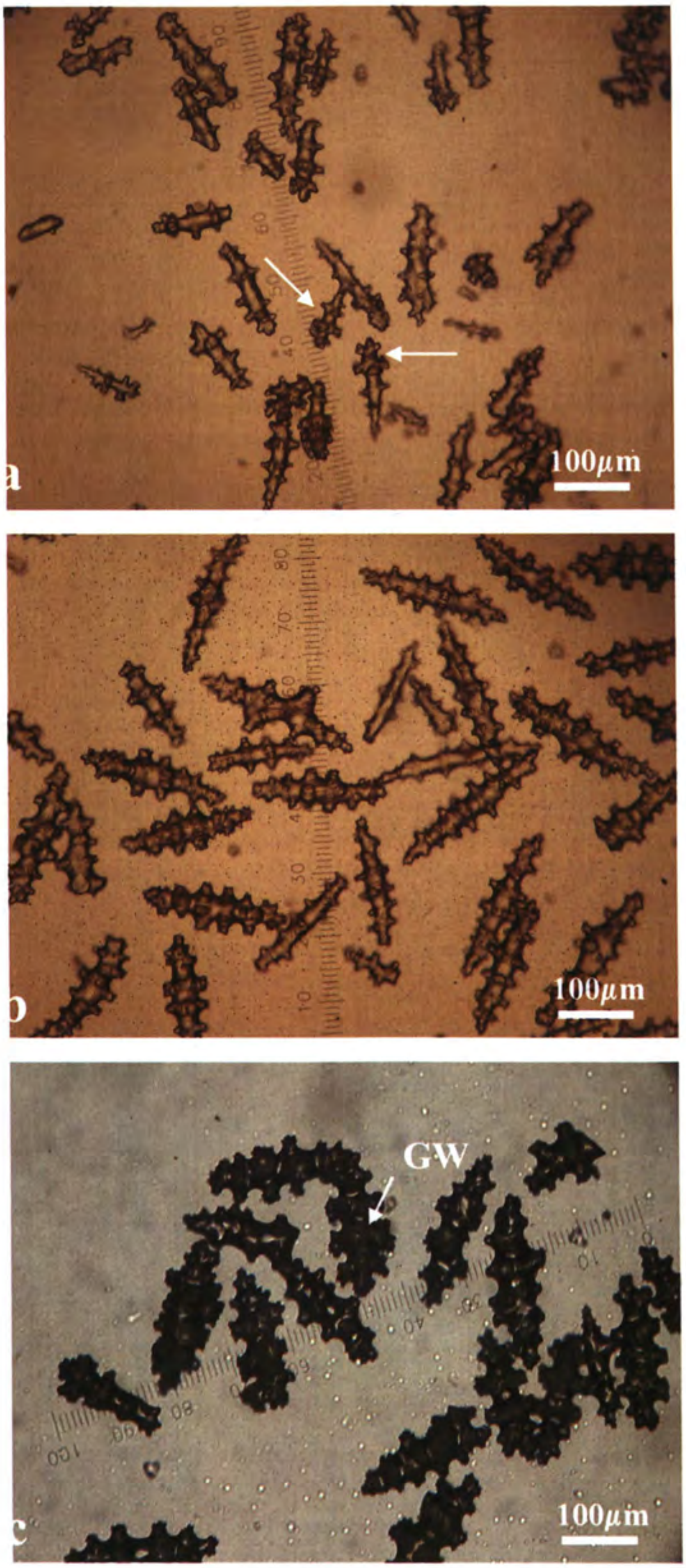


Figure 2.22 Colorless sclerites of *Lobophytum* sp. observed under the compound microscope (100x). **(a)** Poorly-formed clubs from the surface of polyp regions. **(b)** Pointed spindles from the interior of the lobes. **(c)** Fatter and more robust spindles in the base interior, often with girdles of warts (GW).

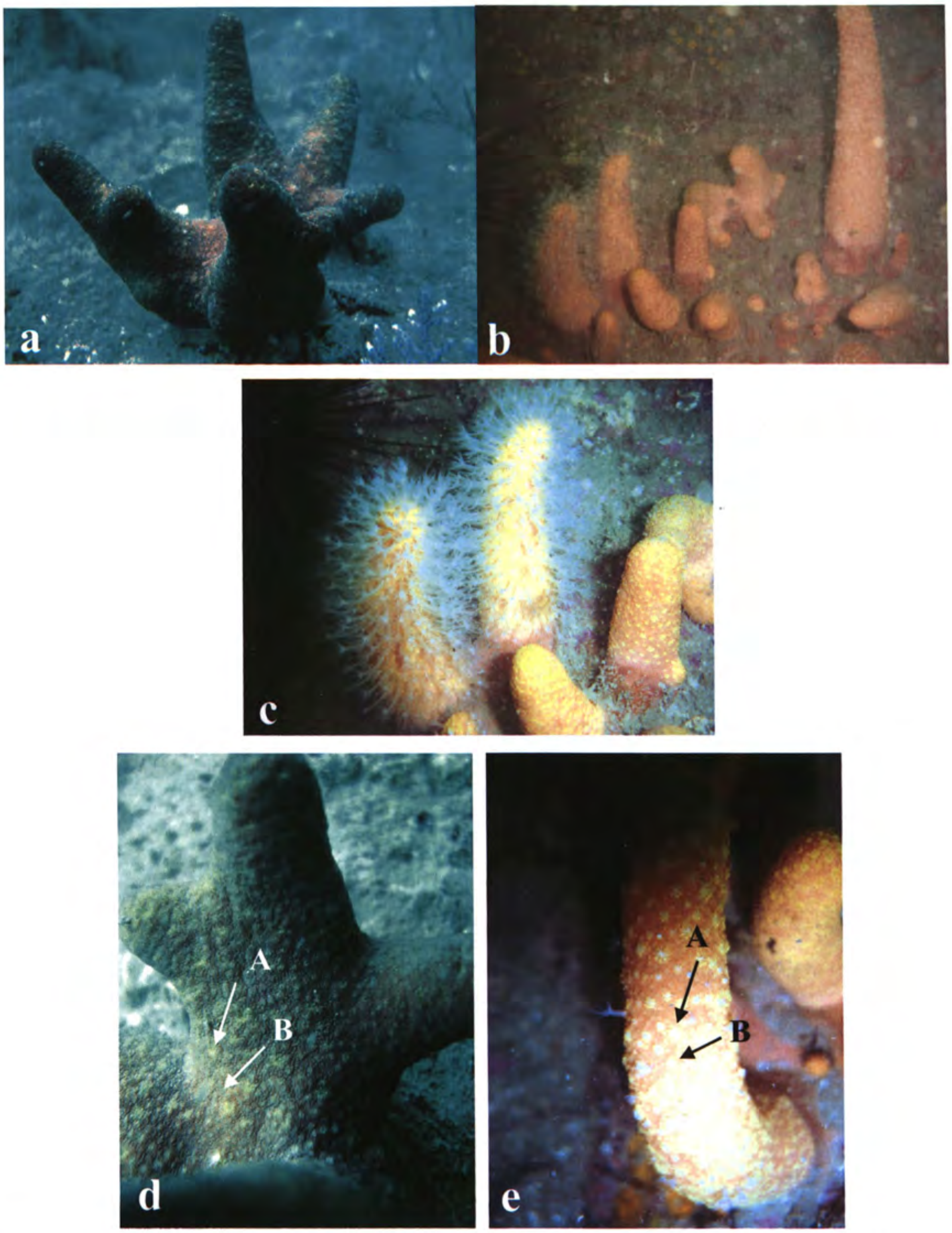


Figure 2.23 Underwater photos of two suspected species of living *Paraminabea*. **(a)** Colony of *Paraminabea* sp. A is sparsely branched and red in color, found at -18 m CD in Breaker's Reef. **(b)** Colony of *Paraminabea* sp. B is finger-liked and yellow in color, growing in shady area at -19 m CD of Ninepin East. **(c)** White autozooids of *Paraminabea* sp. B are large and have relatively long bodies. Dimorphic polyps of **(d)** *Paraminabea* sp. A and **(e)** *Paraminabea* sp. B showing both the autozooids (arrow A) and siphonozooids (arrow B).

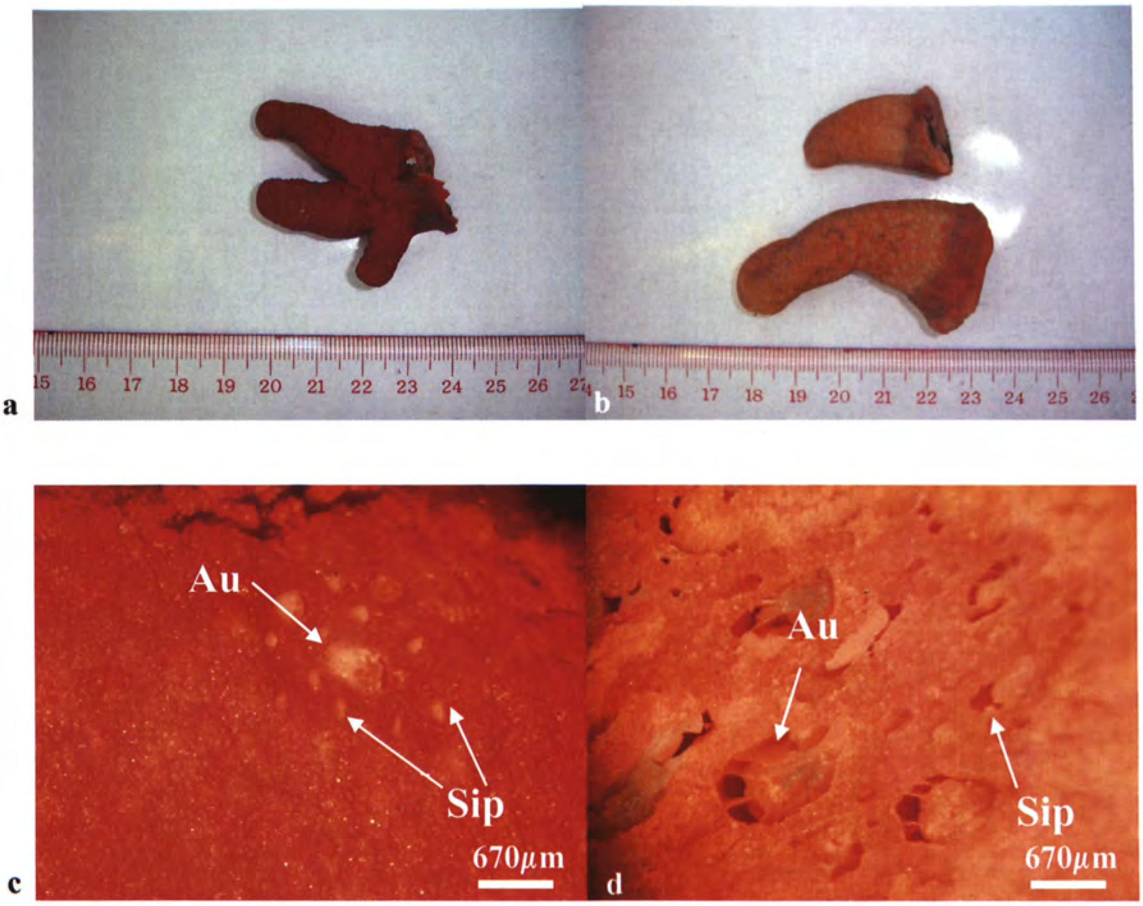


Figure 2.24 Preserved material of *Paraminabea*. Completely retracted polyps of **(a)** sp. A and **(b)** sp. B after preservation. Close-up of the surface of colony of **(c)** sp. A and **(d)** sp. B under the dissecting microscope (15x) showing autozooids (Au) being surrounded by the siphonozooids (Sip).

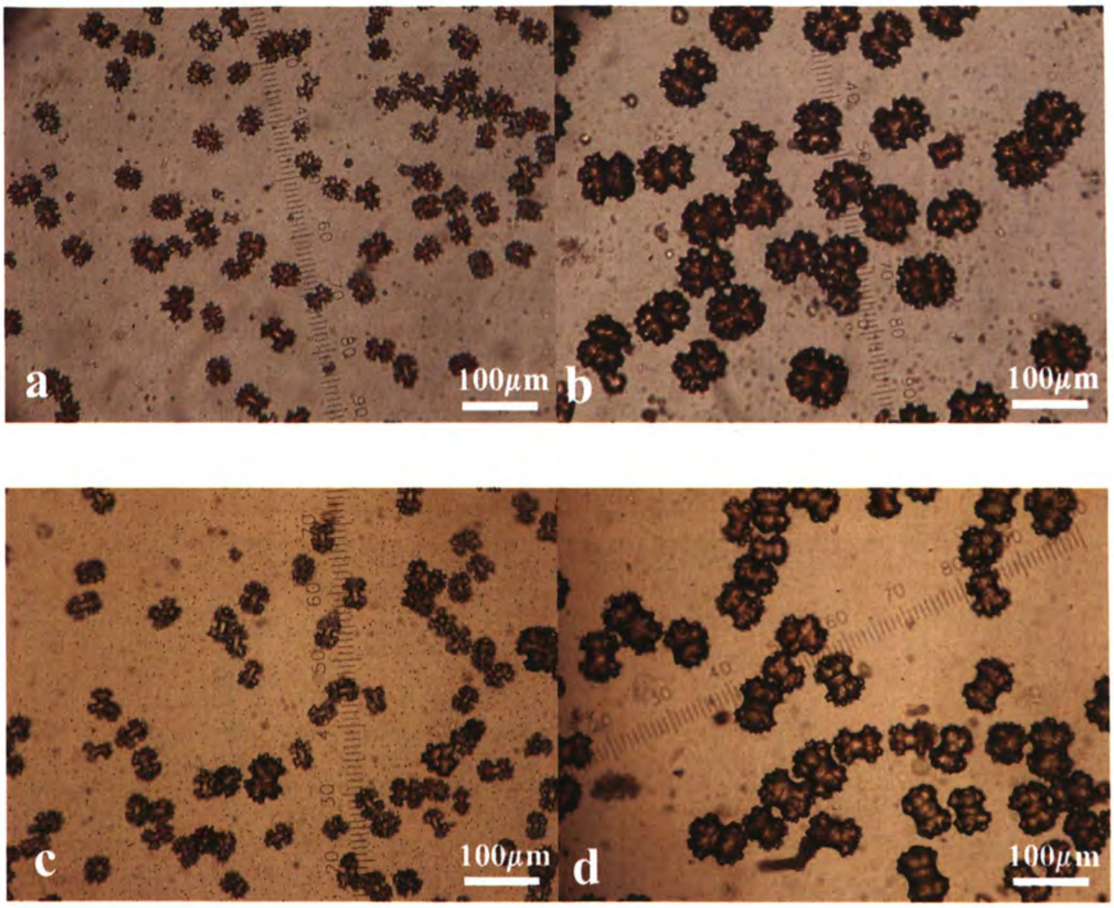


Figure 2.25 Colored 6- or 8- radiate tuberculate spheroid sclerites of *Paraminabea* spp. observed under the compound microscope (100x). Sclerites of *Paraminabea* sp. A from **(a)** the surface and, **(b)** the interior part of the colony. Sclerites of *Paraminabea* sp. B with a longer waist from **(c)** the surface part and, **(d)** the interior part of the colony.

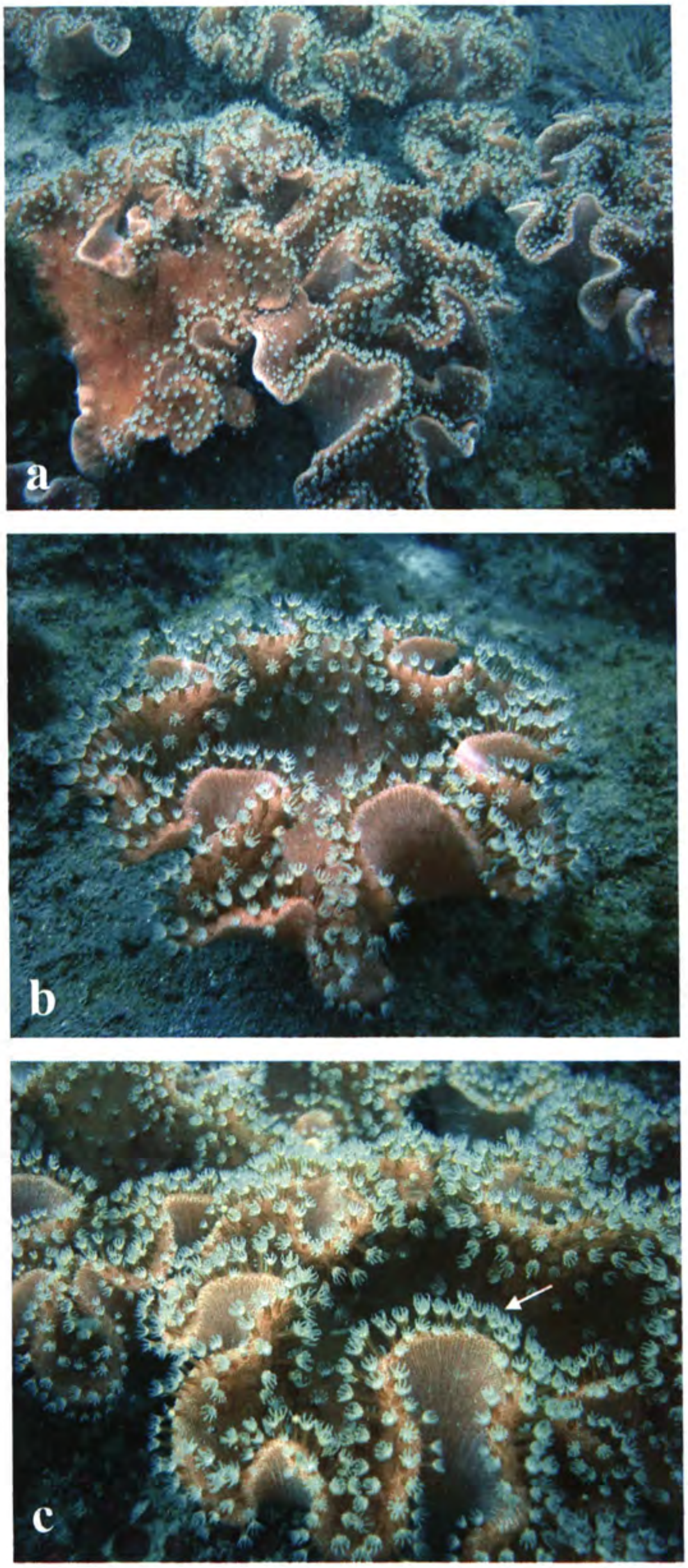


Figure 2.26 Underwater photos of living *Sarcophyton* sp. showing **(a),** typical colonies that are soft and fleshy with mushroom-like appearance; **(b),**. convoluted or curvy polypary of the colony with folding edges and **(c),** long polyps (arrow) located only on the upper side of polypary.

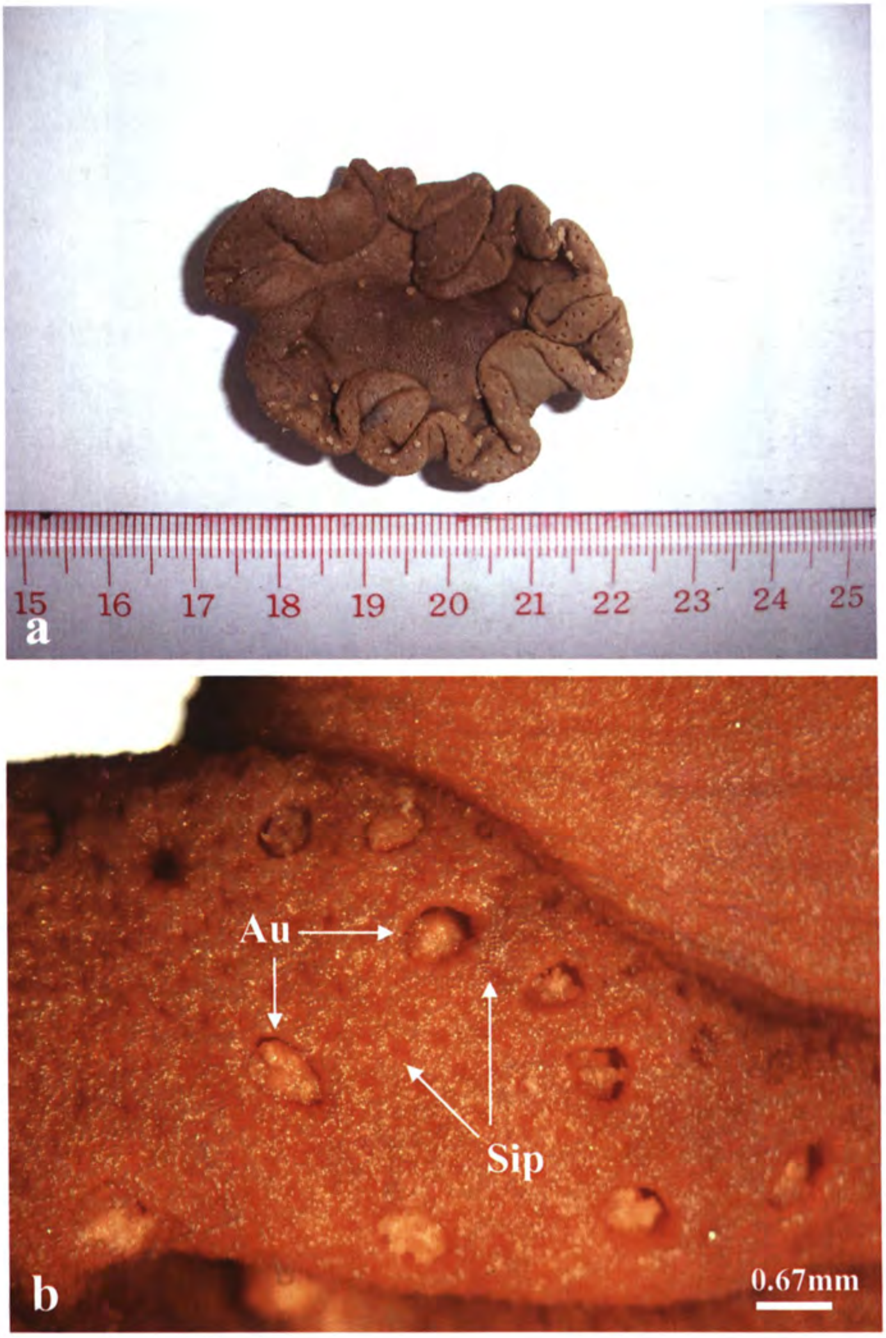


Figure 2.27 Preserved material of *Sarcophyton* sp.. **(a)** colony contracted after preservation. Some autozooids are not completely retracted. **(b)** Close-up of polypary surface observed under the dissecting microscope (15x) showing autozooids (Au) being surrounded by the siphonozooids (Sip).

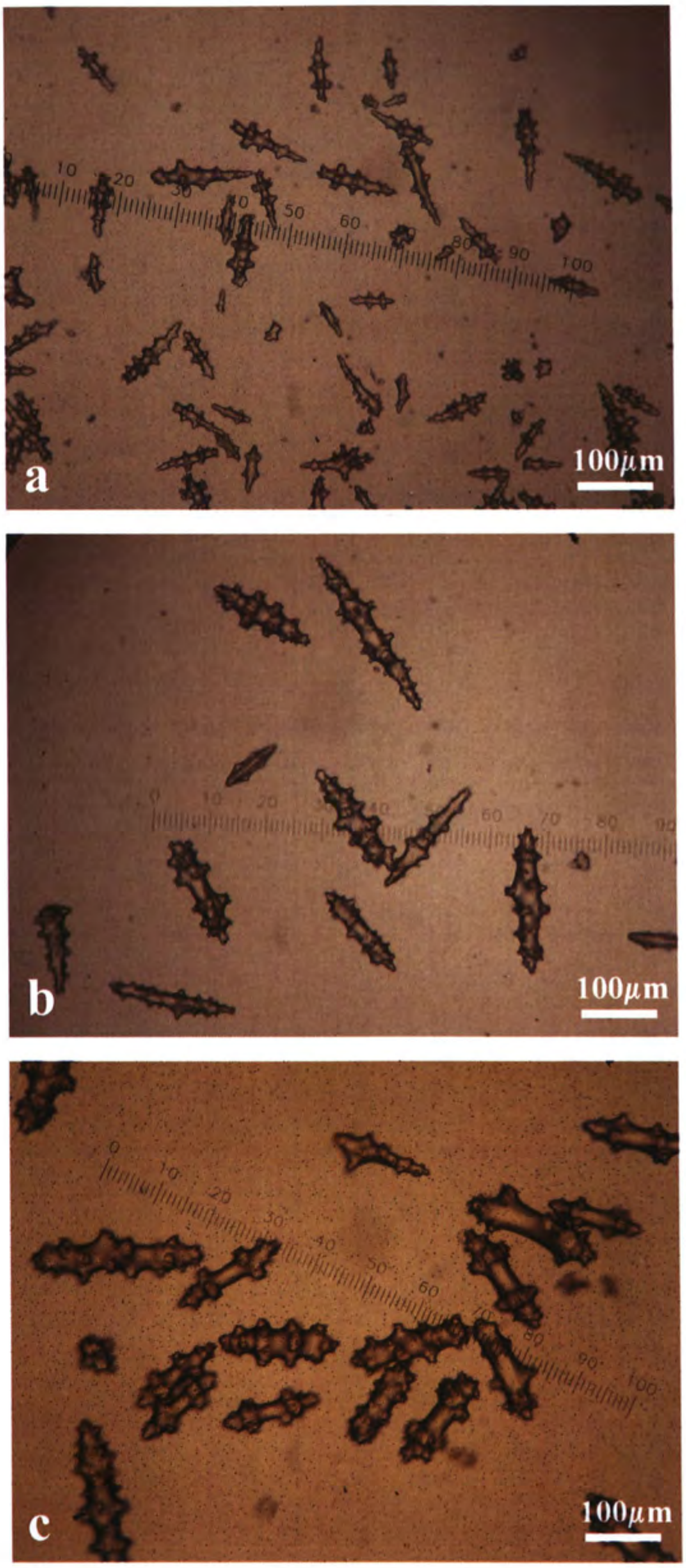


Figure 2.28 Colorless sclerites of *Sarcophyton* sp. observed under the compound microscope (100x). **(a)** Well-formed clubs with sharply pointed head from the surface of polyp regions; **(b)** Spindles and sticks from the interior of polypary. **(c)** Fatter and shorter spindles from the stalk interior.

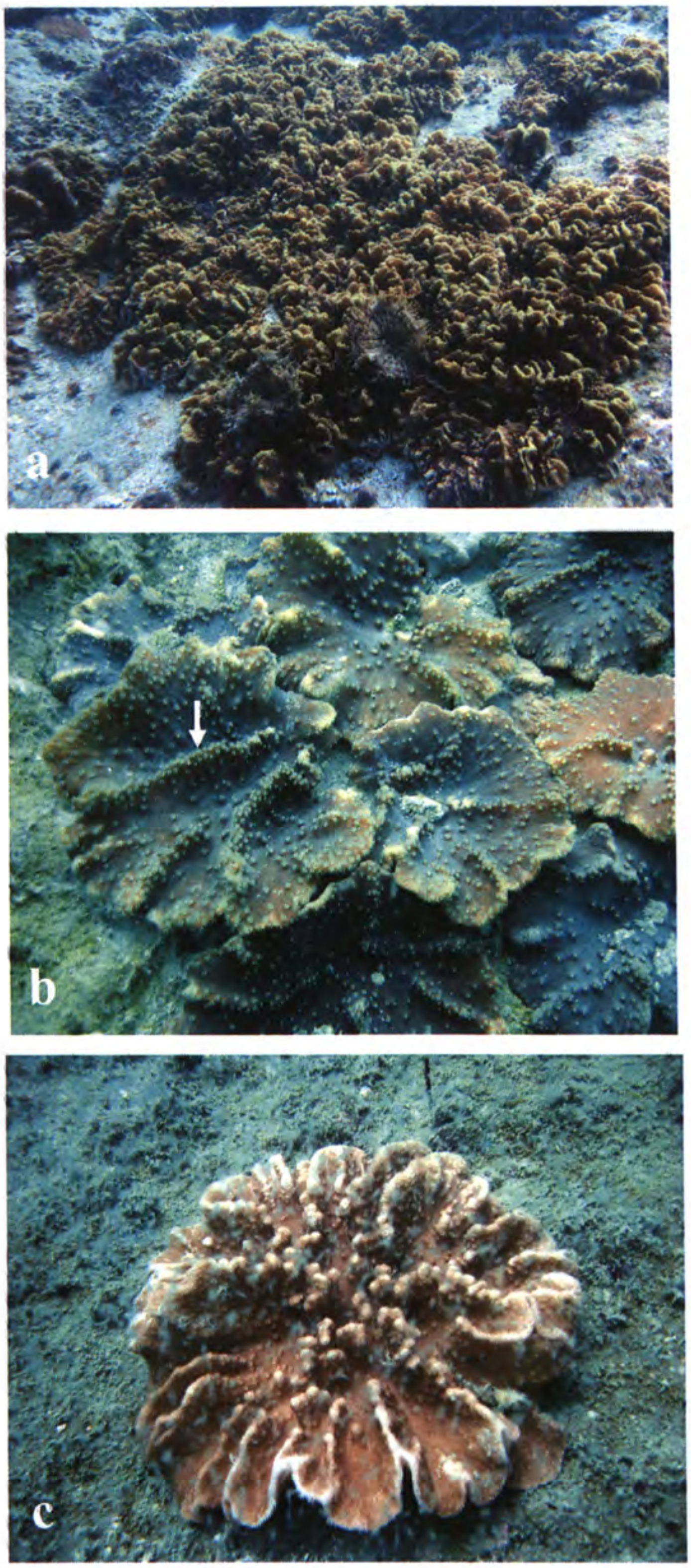


Figure 2.29 Underwater photos of living *Sinularia brassica* showing **(a)** monospecific carpet on hard substratum; **(b)** typical growth form found in Hong Kong that is characterized by being encrusting, with some ridges (arrow) on the margin of the upper surface and, **(c)** extended autozooids with short body and short tentacles.

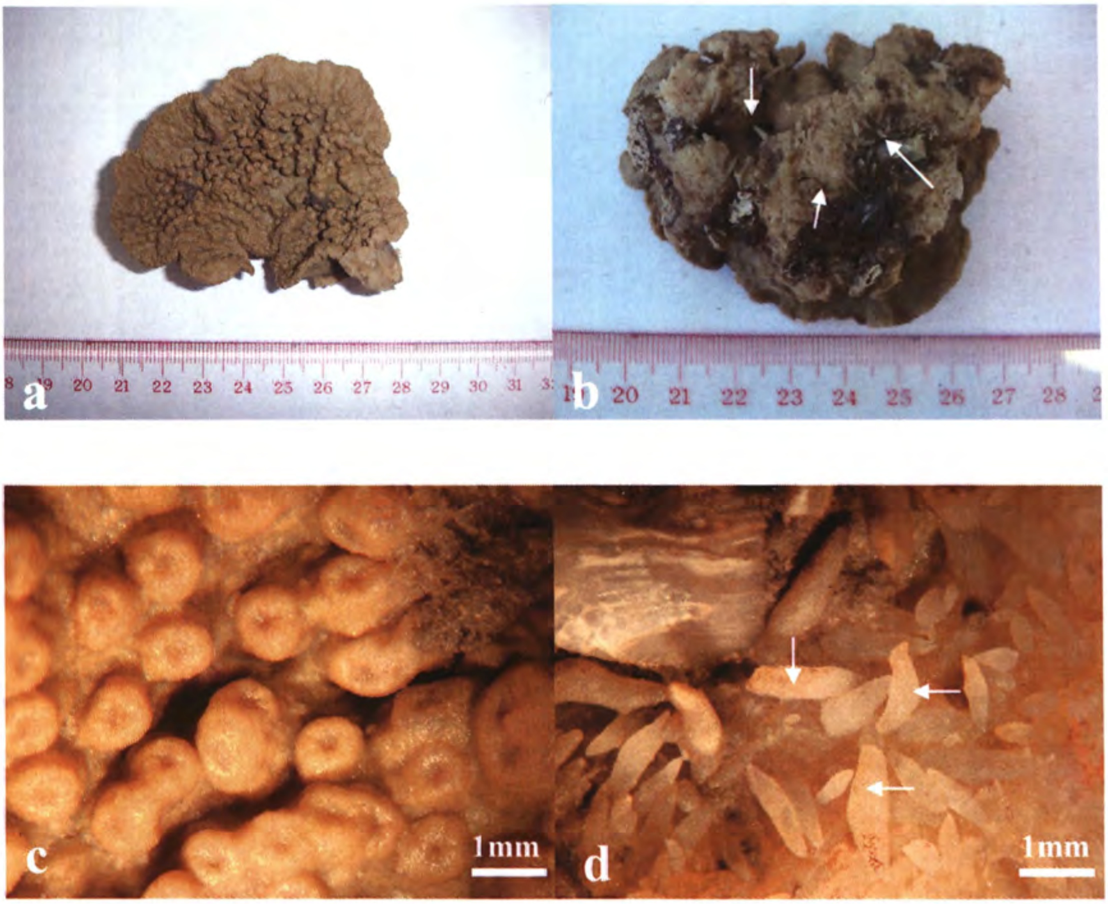


Figure 2.30 Preserved material of *Sinularia brassica*. **(a)** Colony tightly contracted after preservation. **(b)** Basal area of the colony showing large sclerites (arrows) observable with naked eyes. **(c)** Close-up of colony surface under the dissecting microscope (10.5x) showing retracted autozooids. **(d)** Large sclerites (arrows) present in the basal part of the colony.

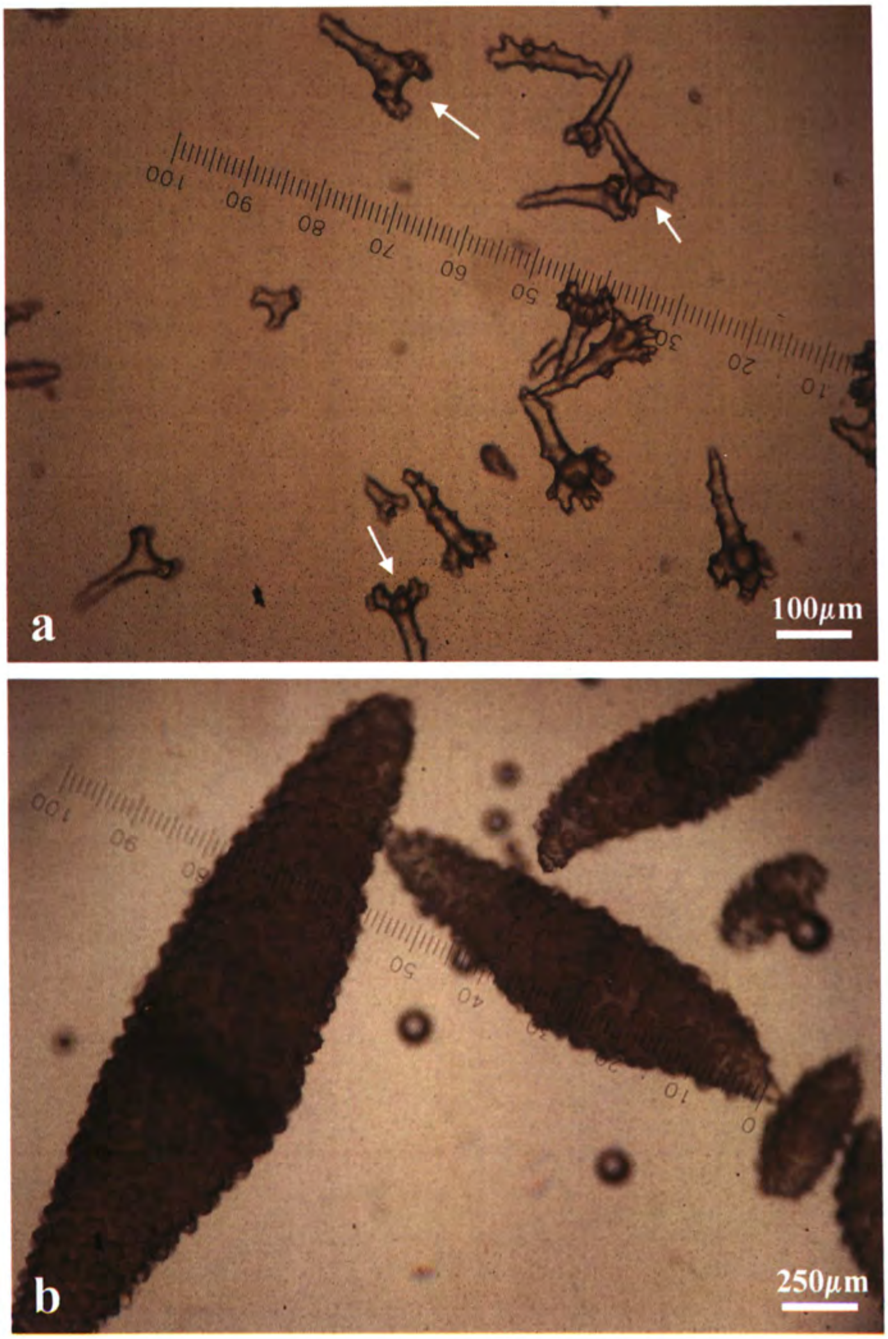


Figure 2.31 Colorless sclerites of *Sinularia brassica* observed under the compound microscope. **(a)** Distinct, well-formed clubs with sharply pointed heads. from the surface of polyp-bearing part of the colony. These sclerites carry a very unique feature characteristic of this species; the heads of the clubs are generally in V-shape (arrows) (100x). **(b)** Large and complexly warted spindles from the interior and basal parts of the colony (40x).

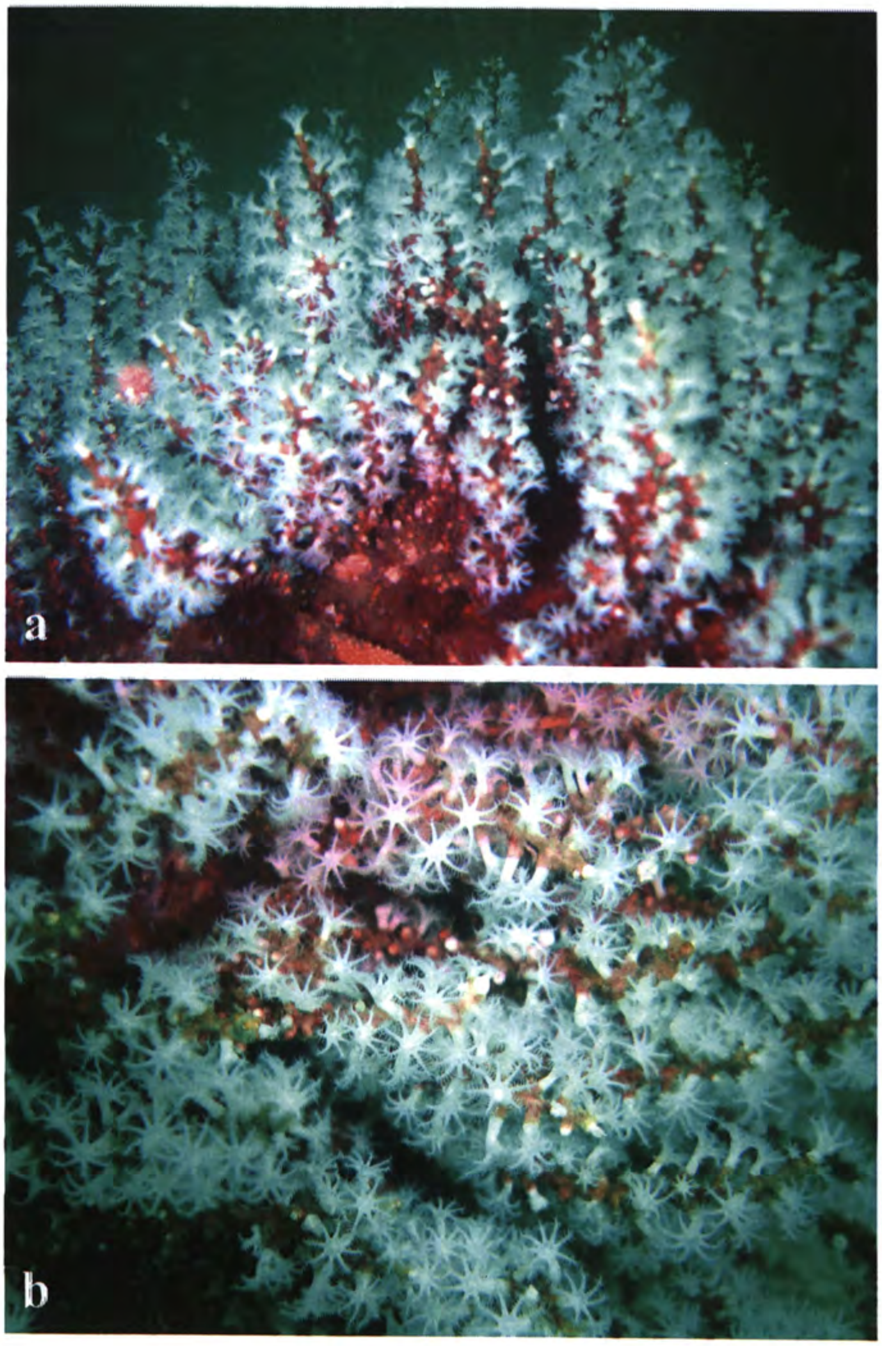


Figure 2.32 Underwater photos of colonies of living *Carijoa* sp. at 15m deep in Ninepin East. **(a)** The typical growth form. **(b)** The extended polyps.

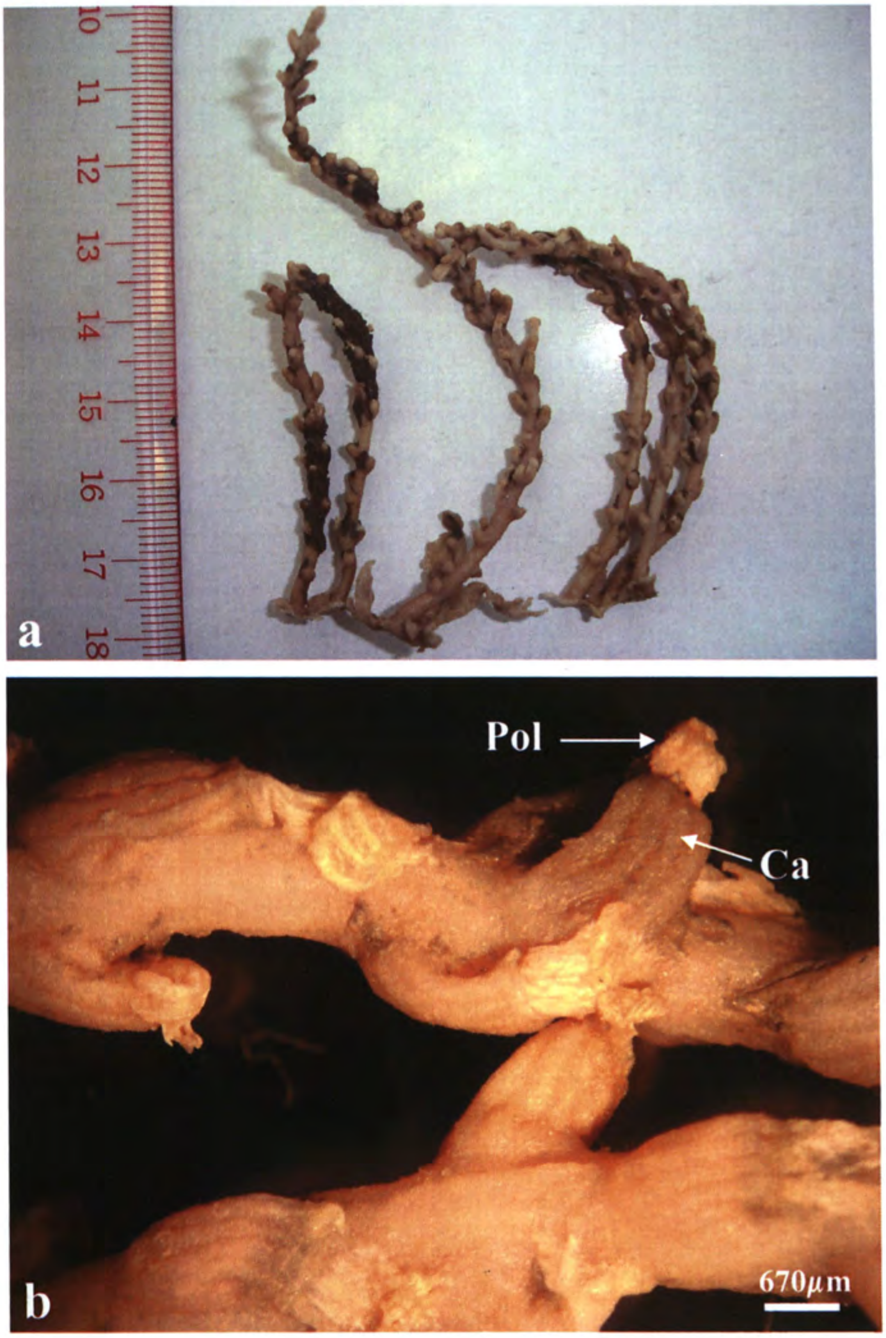


Figure 2.33 Preserved material of *Carijoa* sp. **(a)** Brown color of the living colony lost after preservation. **(b)** Close-up of the prominent calyces (Ca) and the polyps (Pol) observed under the dissecting microscope (15x).

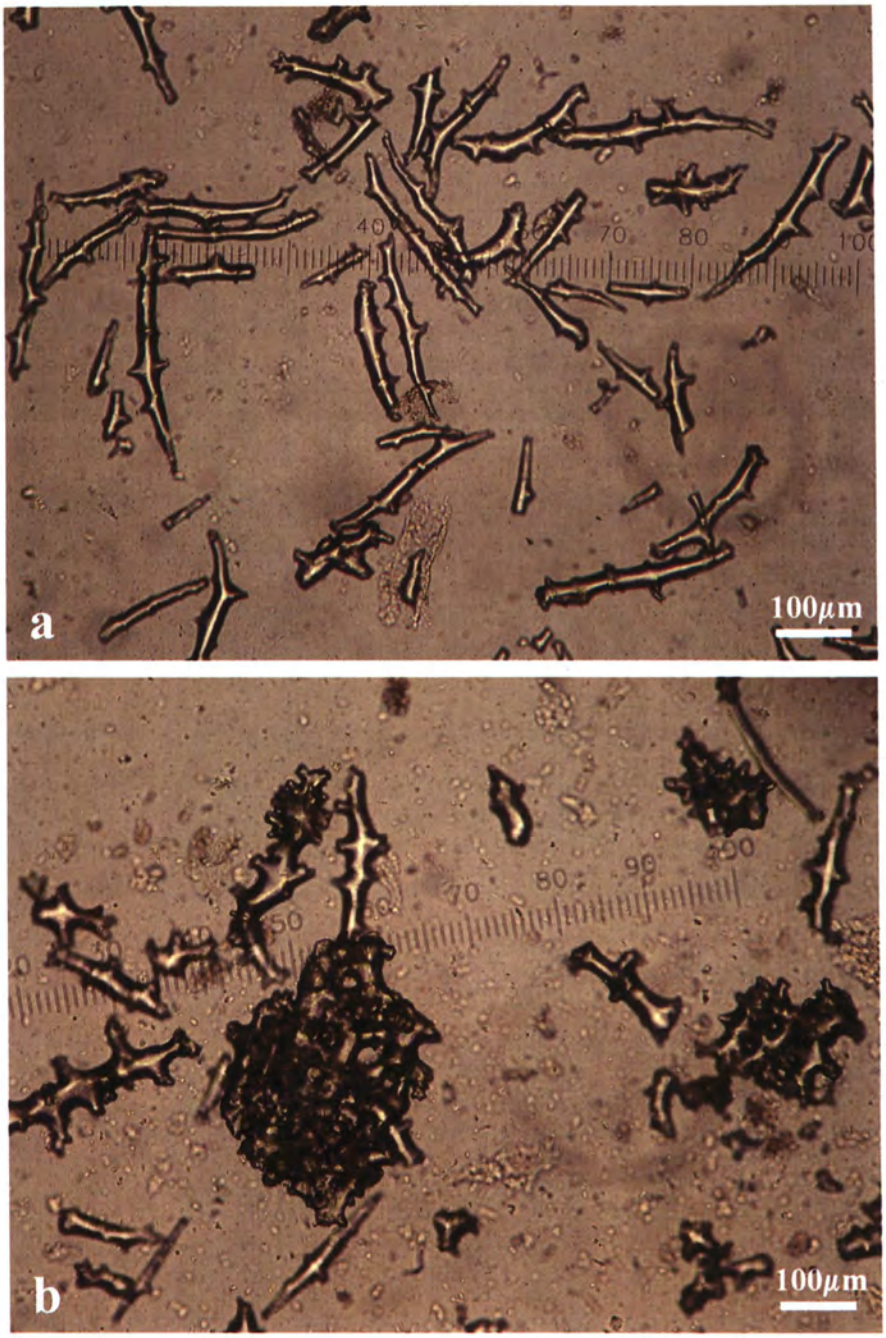


Figure 2.34 Colorless sclerites of *Carijoa* sp. observed under the compound microscope (100x). (a) Slender and rod-like sclerites, smooth appearance ornamented with few thorns and prickles. (b) Clumps of interlocking sclerites.

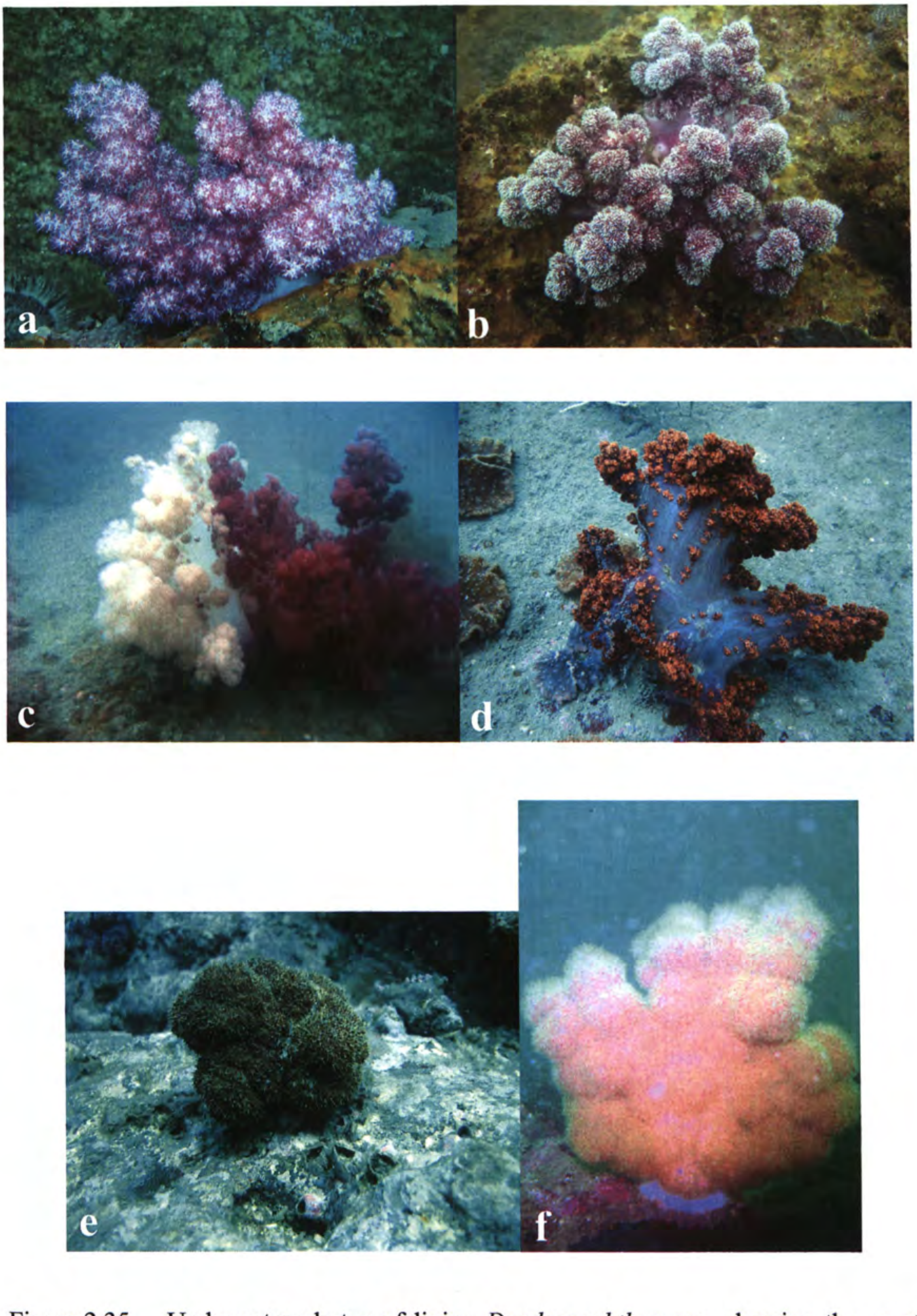


Figure 2.35 Underwater photos of living *Dendronephthya* spp. showing the great variety of color morphs of this genus **(a)-(f)**. These colonies all belong to the glomerate growth form: The polyps are grouped into bundles and assemblages to form large, distinctly rounded bunches.

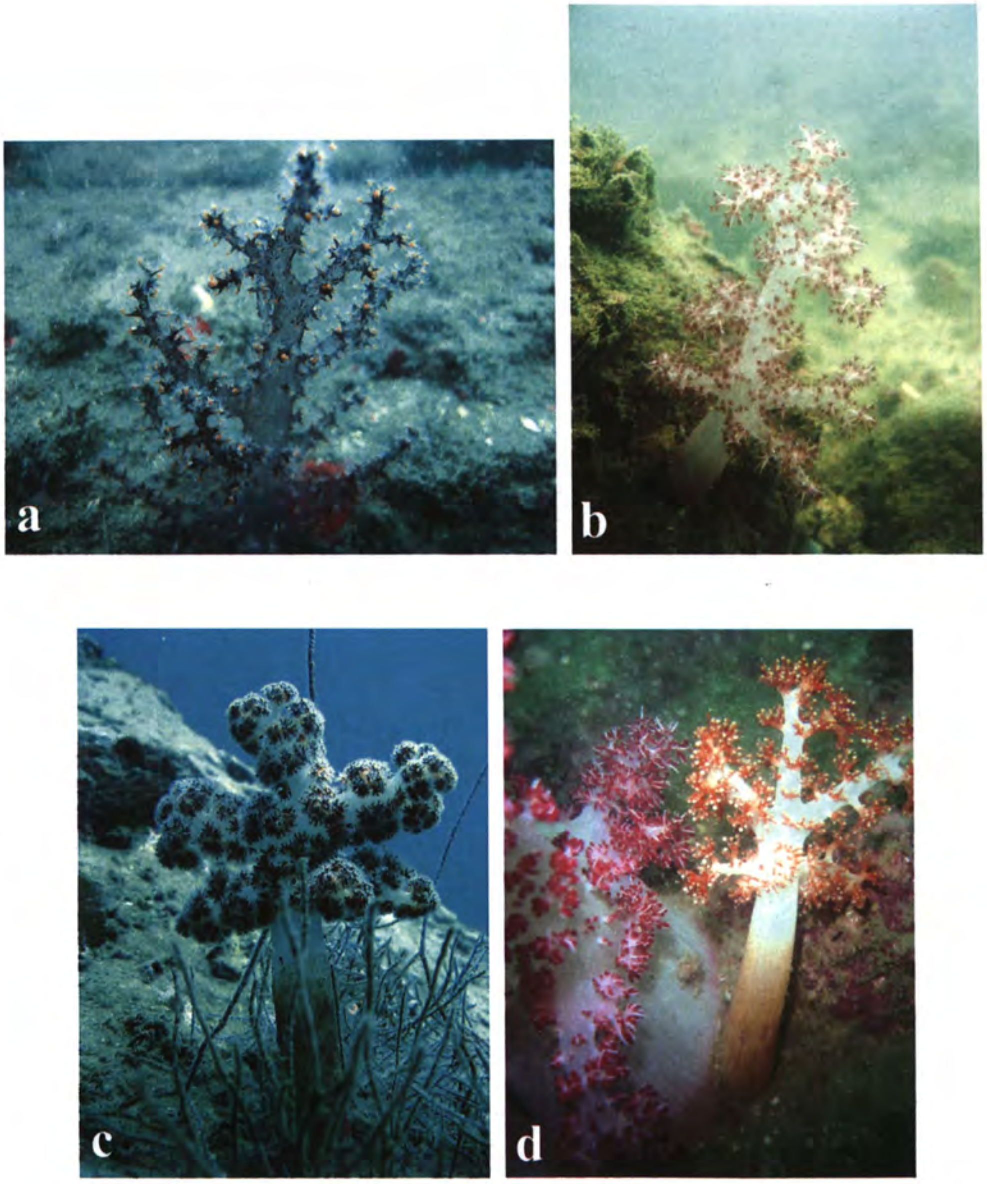


Figure 2.36 Underwater photos of living *Dendronephthya* spp. with divaricate growth form **(a)** & **(b)** characterized by sparse and arborescent branching with slender ramification. The polyps are in small insignificant bundles. **(c)** & **(d)** *Dendronephthya* spp. with umbellate growth form. Polyp bundles are closely arranged at the same level on the ends of the twigs, forming an umbrella-shaped colony.

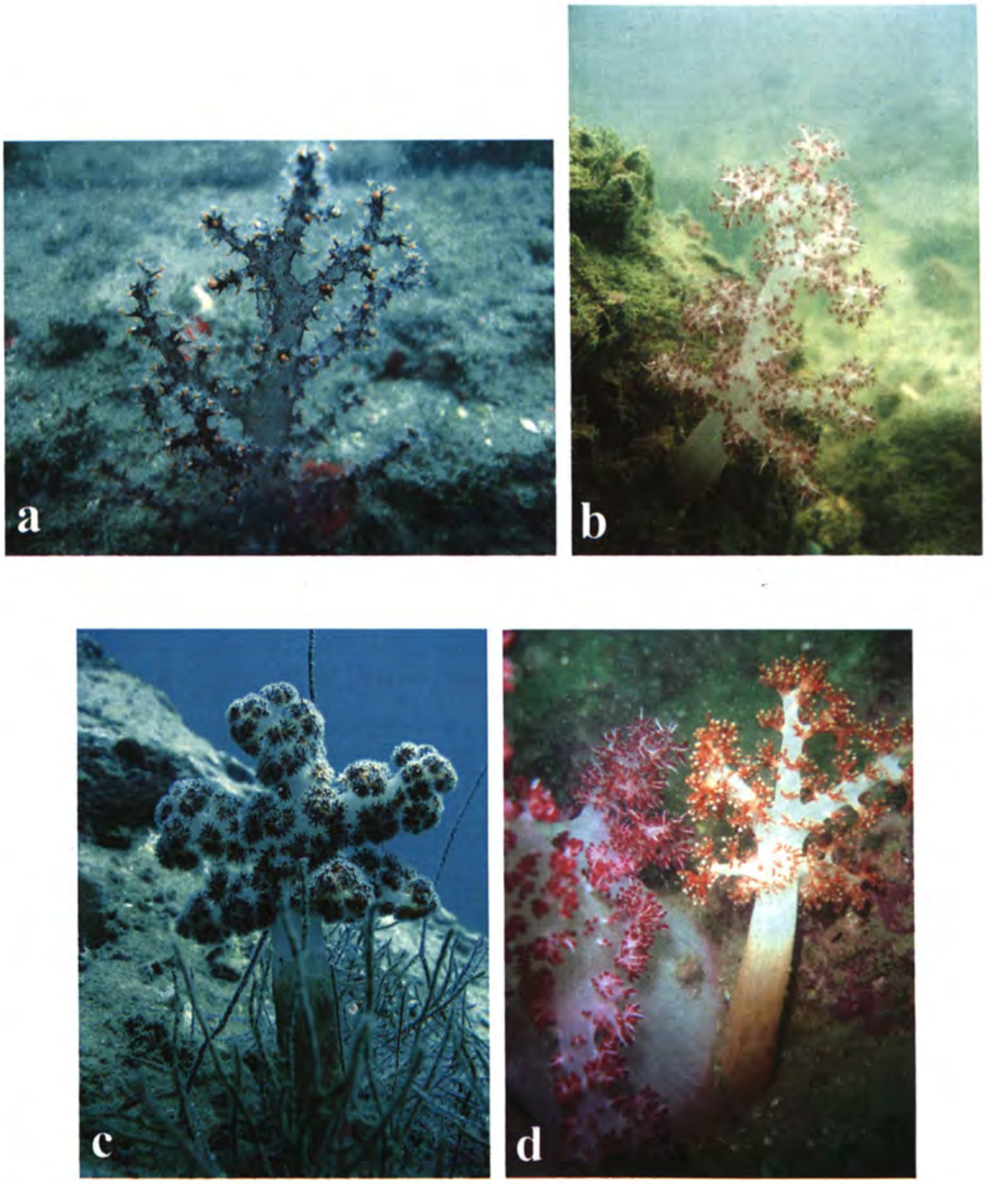


Figure 2.36 Underwater photos of living *Dendronephthya* spp. with divaricate growth form **(a)** & **(b)** characterized by sparse and arborescent branching with slender ramification. The polyps are in small insignificant bundles. **(c)** & **(d)** *Dendronephthya* spp. with umbellate growth form. Polyp bundles are closely arranged at the same level on the ends of the twigs, forming an umbrella-shaped colony.

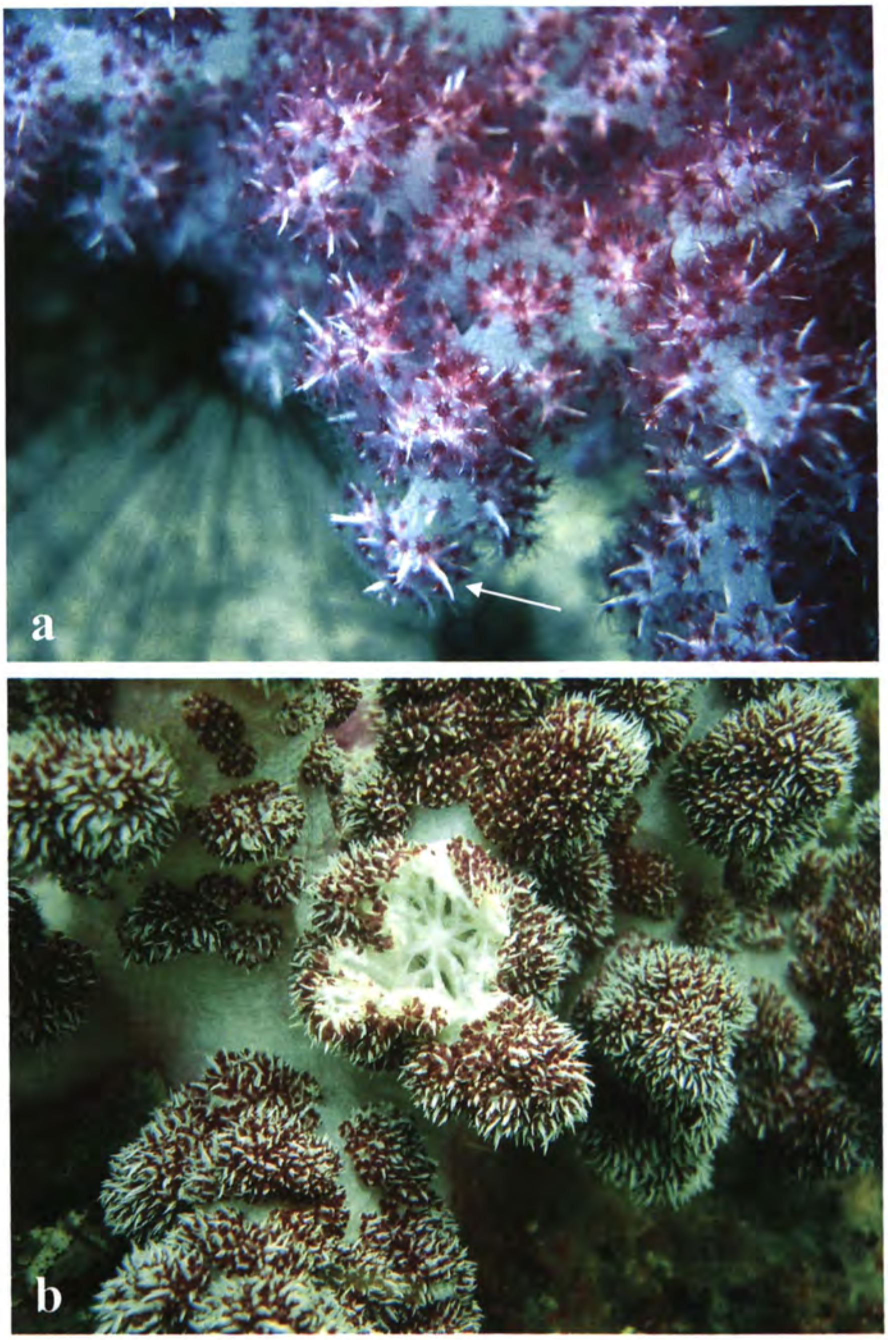


Figure 2.37 Underwater photos of living *Dendronepthya* sp. A (a) and sp. B (b). In sp. A **(a)**, the polyps usually grow in small bundles on the terminal twigs, with supporting bundles (arrow) generally projected far out of the head. In sp. B **(b)** Siphononal canals shown after a part of the twig is cut off.

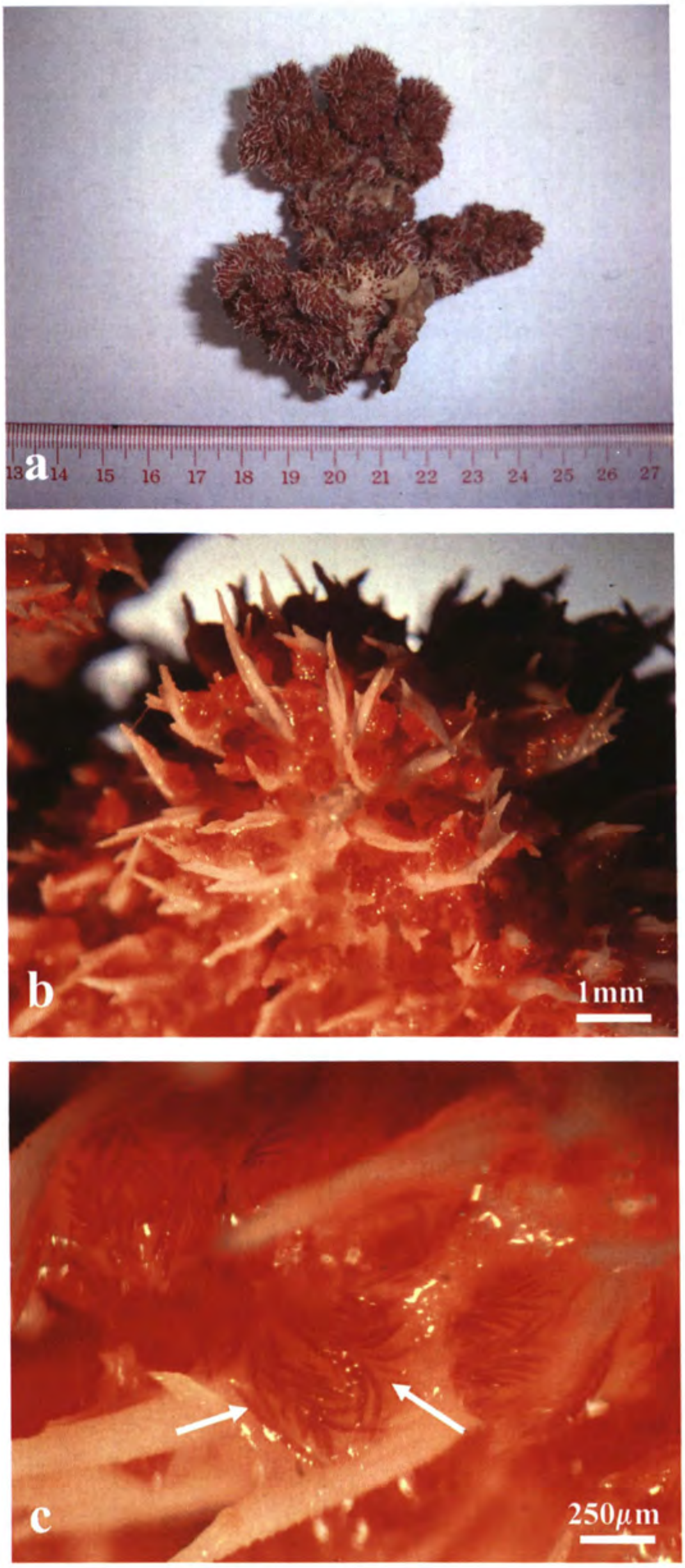


Figure 2.38 Preserved material of *Dendronephthya* sp. A. **(a)** Colony shrinks into a much smaller size after preservation. **(b)** The polyps and the supporting bundles under the dissecting microscope (10.5x). **(c)** Complex set of sclerites arranged in a special way called non-symmetrically in eight points (arrows) (40x).

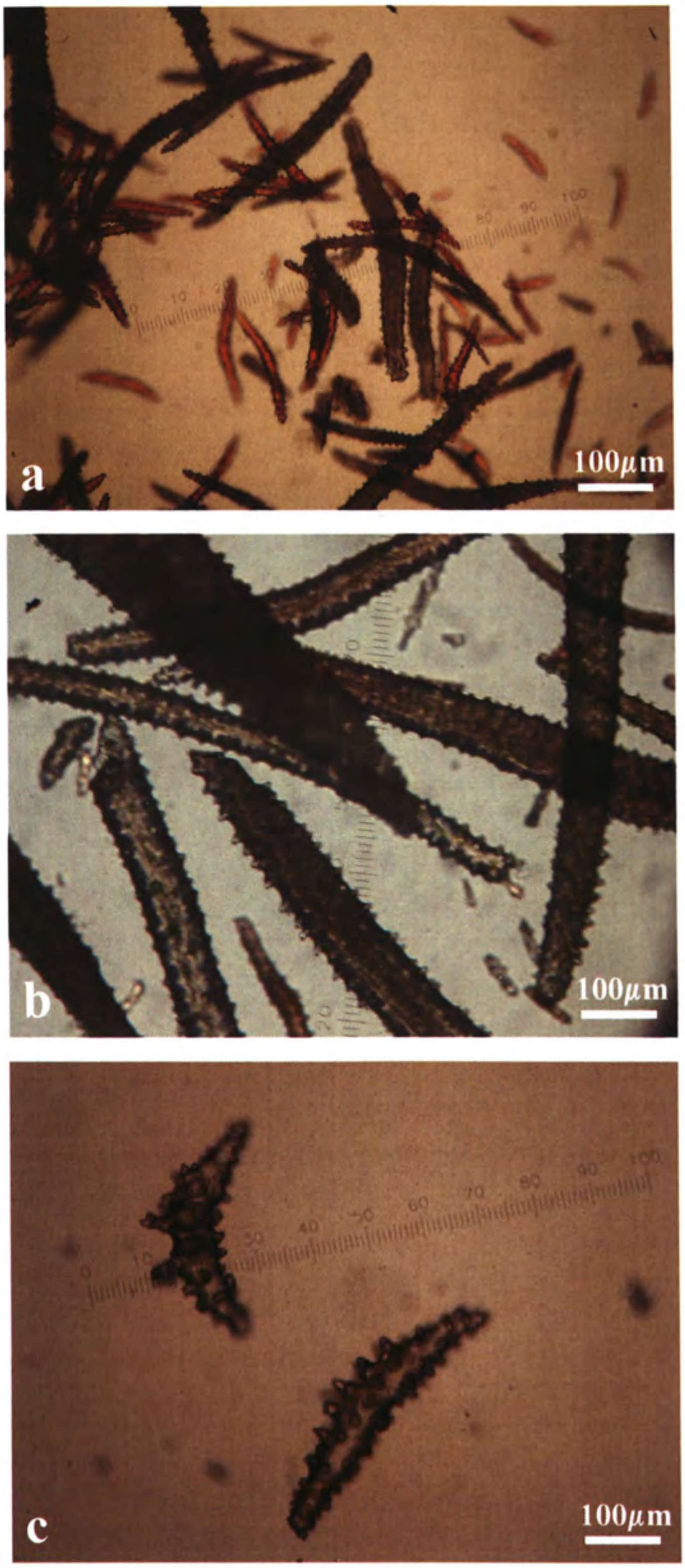


Figure 2.39 Colored sclerites of *Dendronephthya* sp.A observed under the compound microscope (100x). **(a)** Rods or spindles from the polyp heads. Some are bent. **(b)** Large and spindle-shaped sclerites from the supporting bundles. **(c)** Thick and warty spindles in the stalk surface.

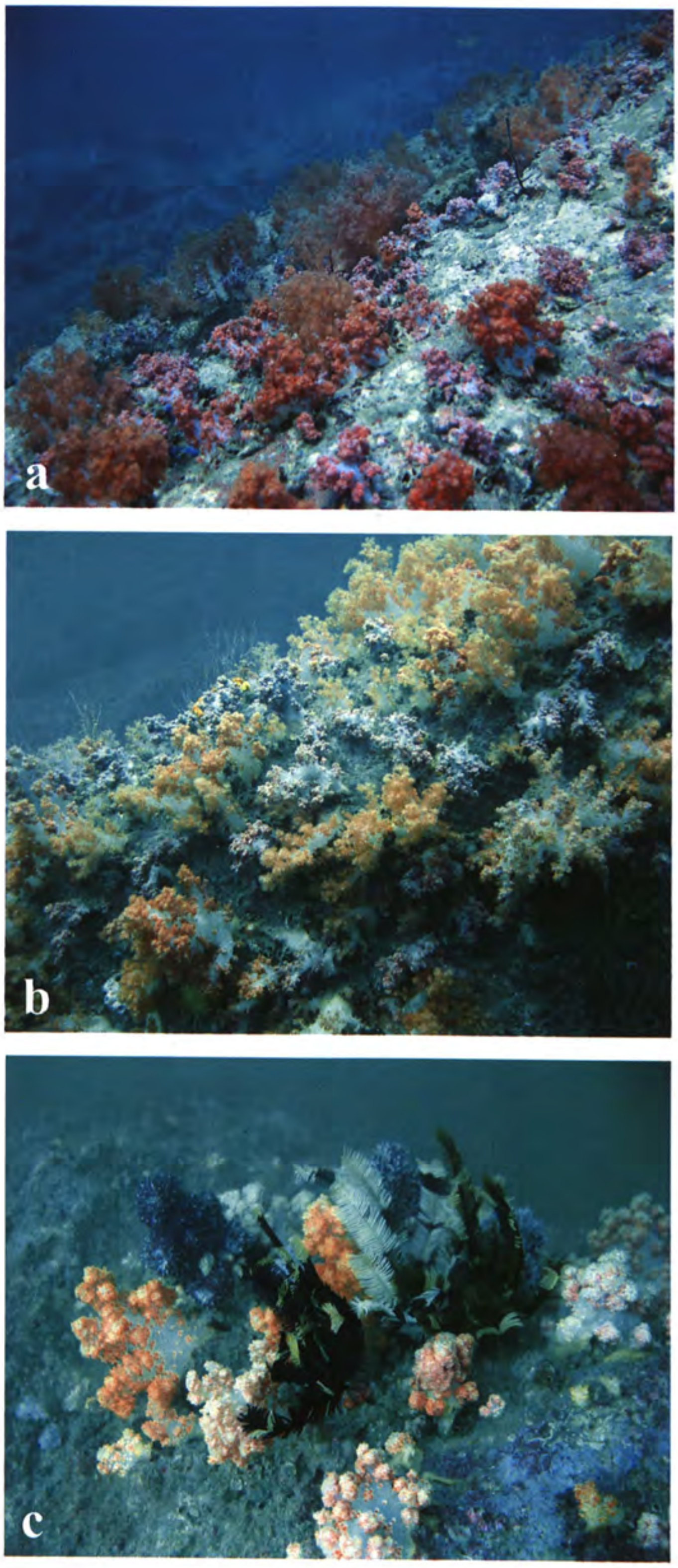


Figure 2.40 High coverage of *Scleronephthya* spp. in **(a)** & **(b)** Breaker's Reef and **(c)** Ninepin North.

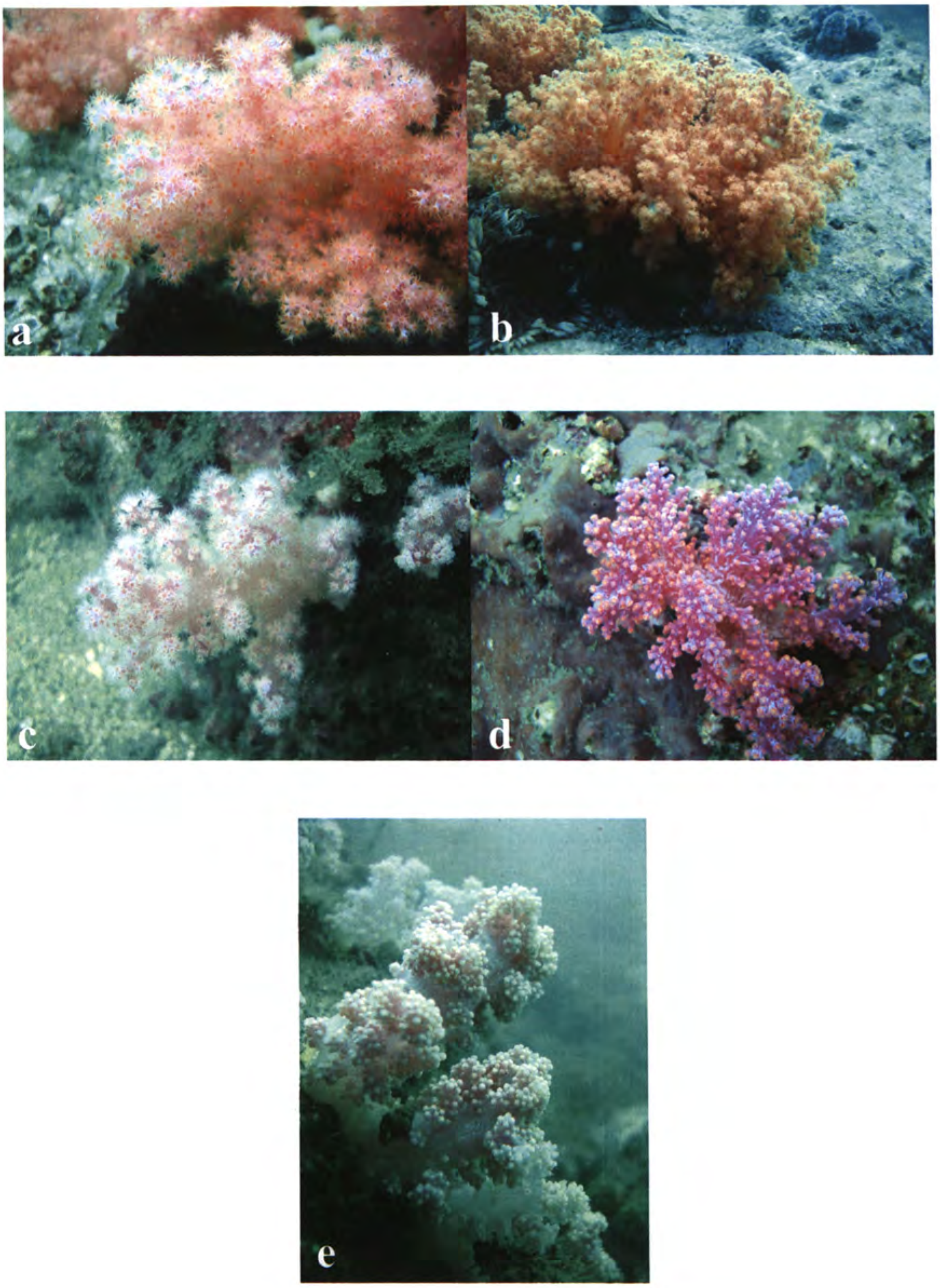


Figure 2.41 Underwater photos of living *Scleronephthya* spp. showing arborescent colonies with subdivided branches. **(a)-(c)** Colonies with extended polyps. **(d)** & **(e)** Colonies with contracted polyps appearing as lumpy crests.

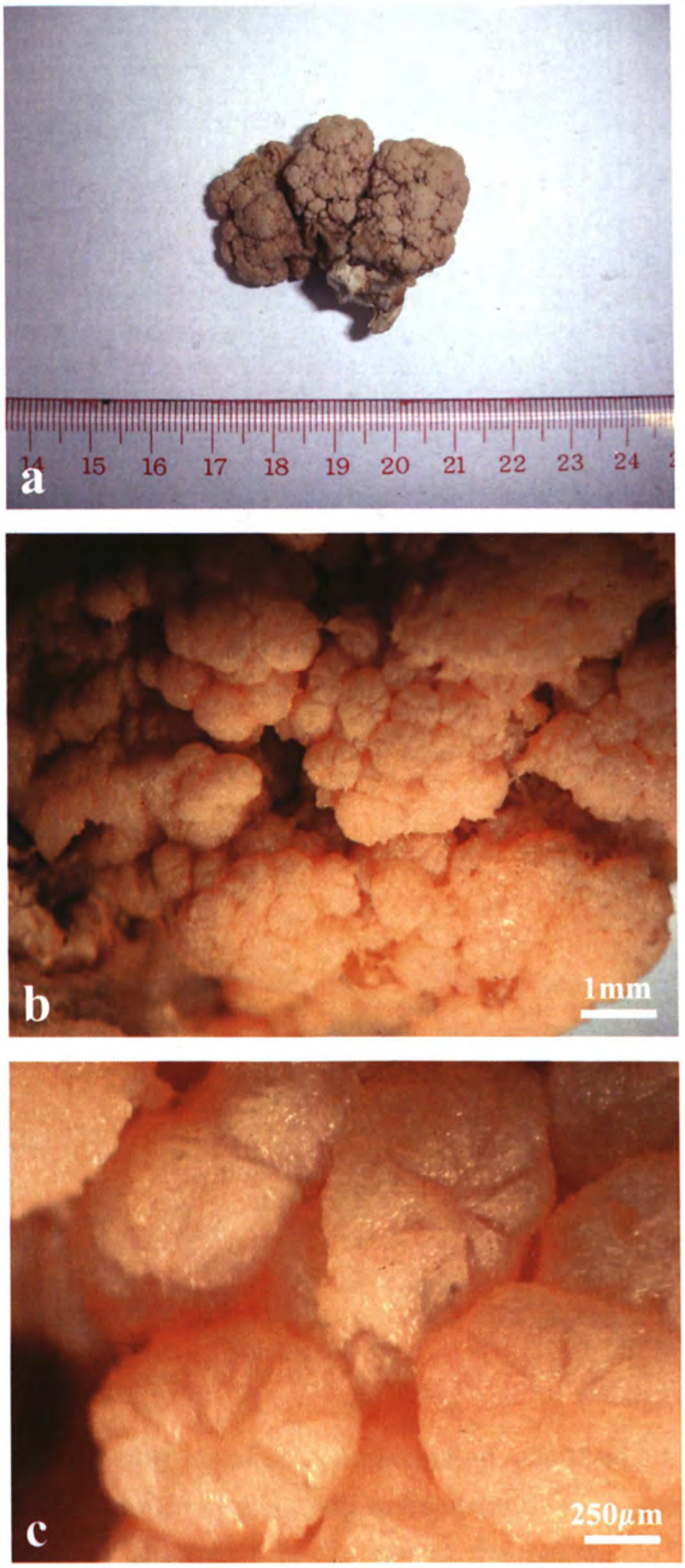


Figure 2.42 Preserved material of *Scleronephthya* sp. **(a)** Colony shrinks after the preservation. **(b)** Polyps appear to be grouped on small lobes observed under the dissecting microscope (10.5x). **(c)** Close-up of the highly contractile polyps (40x).

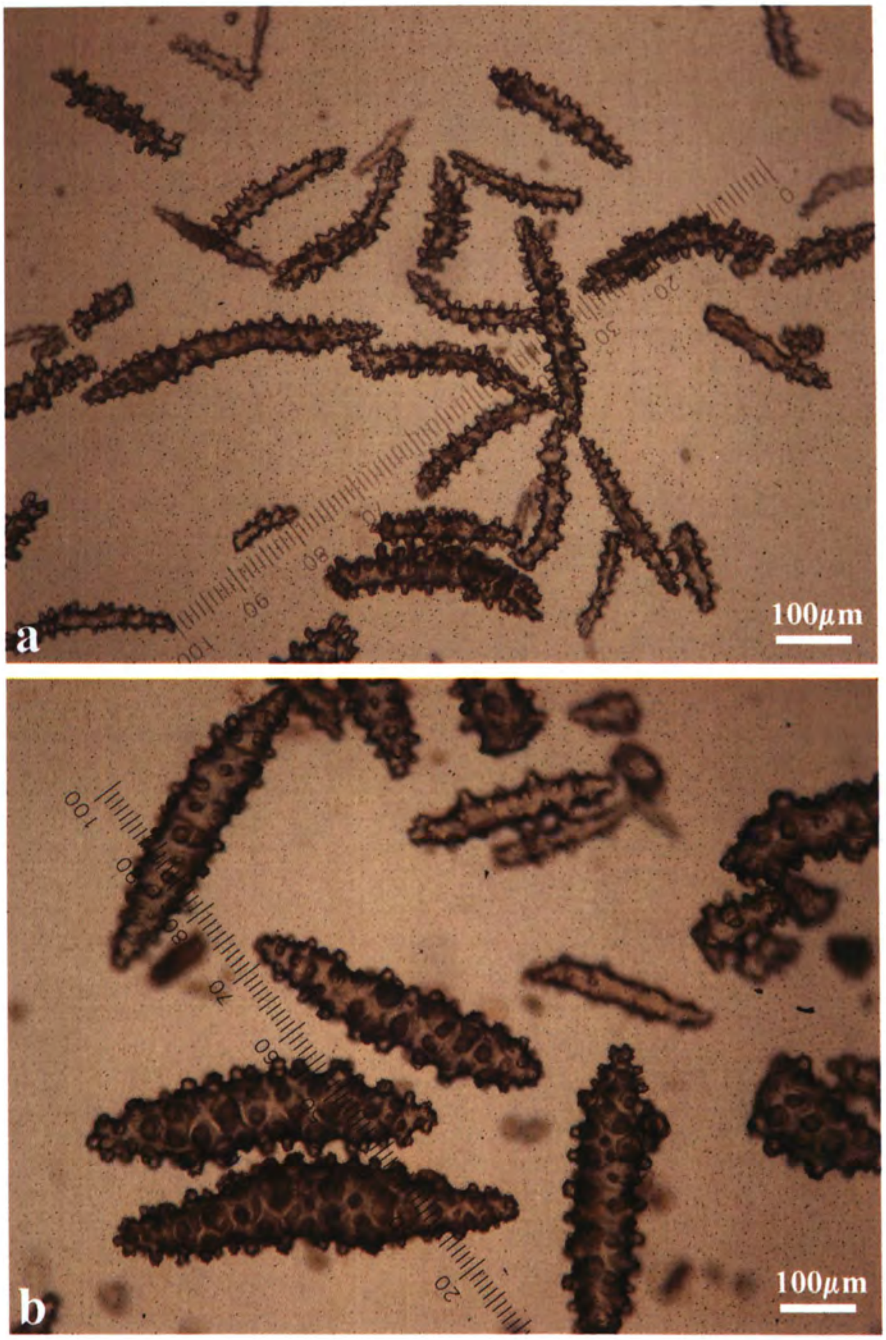


Figure 2.43 Colorless sclerites of *Scleronephthya* sp. observed under the compound microscope (100x). **(a)** Long and spindle-liked sclerites from the polyp. Some are a bit bent to fit around the polyp. **(b)** Large and warty spindles from interior and basal parts of the colony.

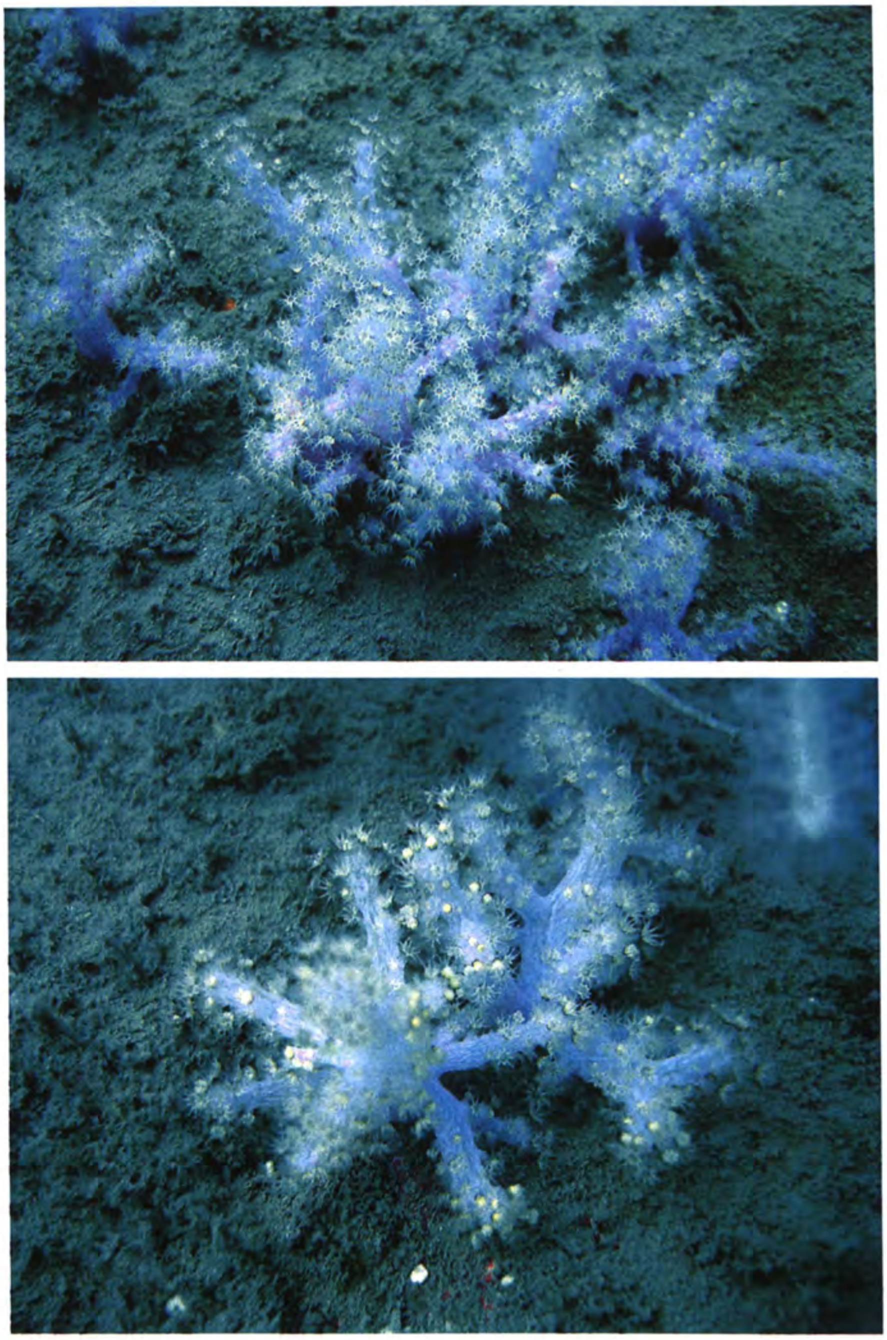


Figure 2.44 Underwater photos of living *Chironephthya* sp. in Tung Ping Chau Marine Park showing colonies which are usually profusely branched. They are pink in color with yellow polyps on the branchlets.

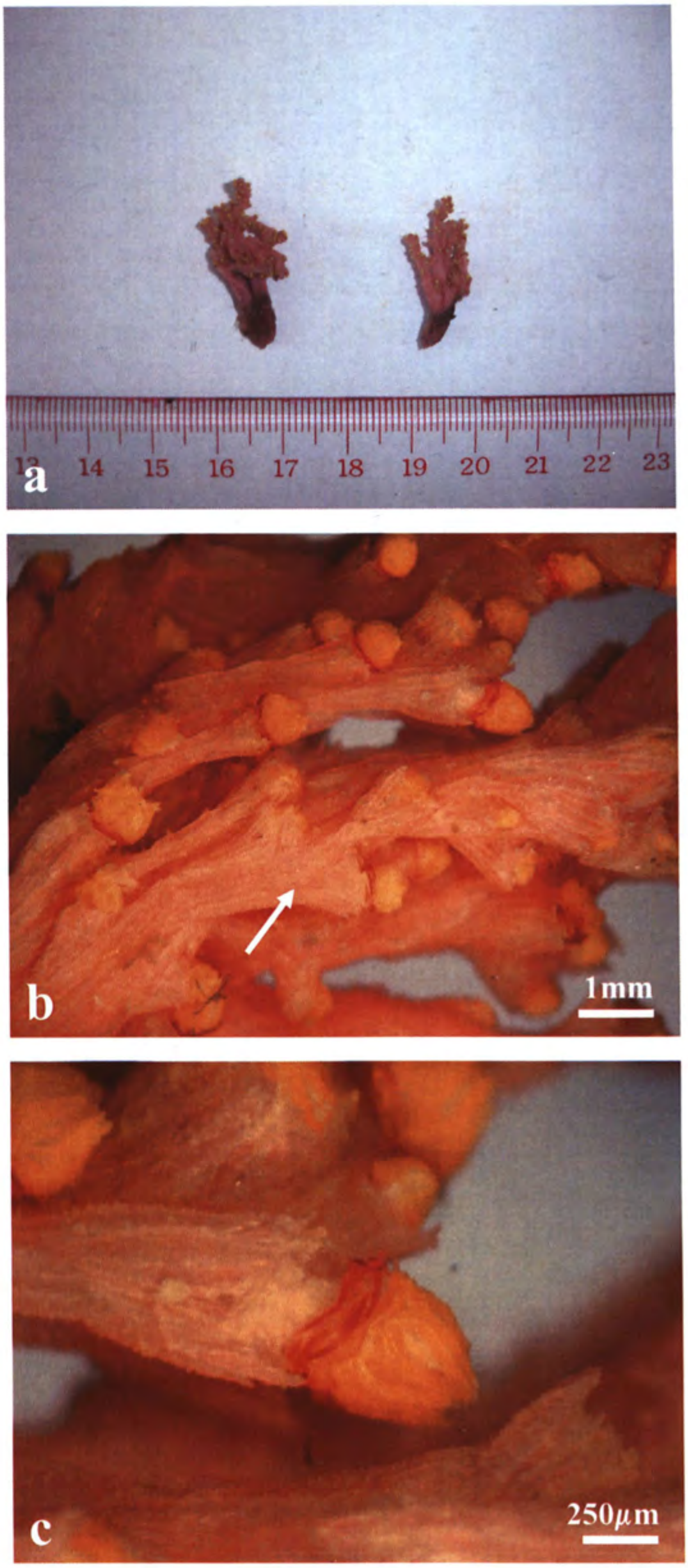


Figure 2.45 Preserved material of *Chironephthya* sp. **(a)** Colonies are a bit rigid after preservation. **(b)** Calyces on three sides of the polyp only. The surface layer of the colony is arranged with large and long spindles (arrow) observable under the dissecting microscope. **(c)** Polyp head composed of spindles in a strong crown and points arrangement (40x).

Figure 2.46 Colored sclerites of *Chironephthya* sp. observed under the compound microscope (100x). **(a)** Yellow spindles are the sclerites in crown and points arrangement around the polyp heads. Broad and flattened rods are from the tentacles. The spindles from collaret are red in color. **(b)** Large, robust and complexly warted spindles from the surface of stem.

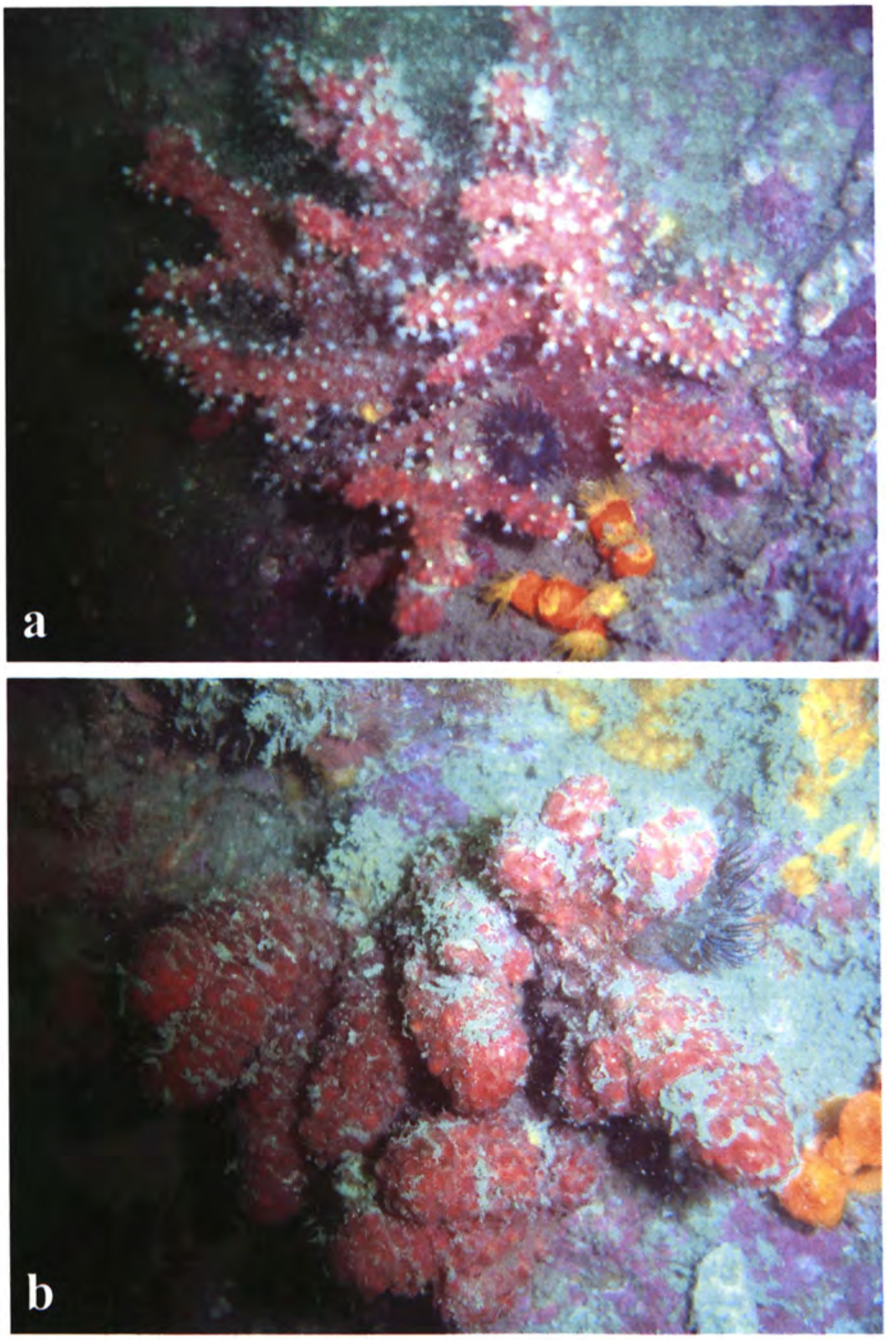


Figure 2.47 Underwater photos of living *Nephthyigorgia* spp. **(a)** Branching colony of *Nephthyigorgia* sp. A. **(b)** Digitate colony of *Nephthyigorgia* sp. B usually covered with detritus.

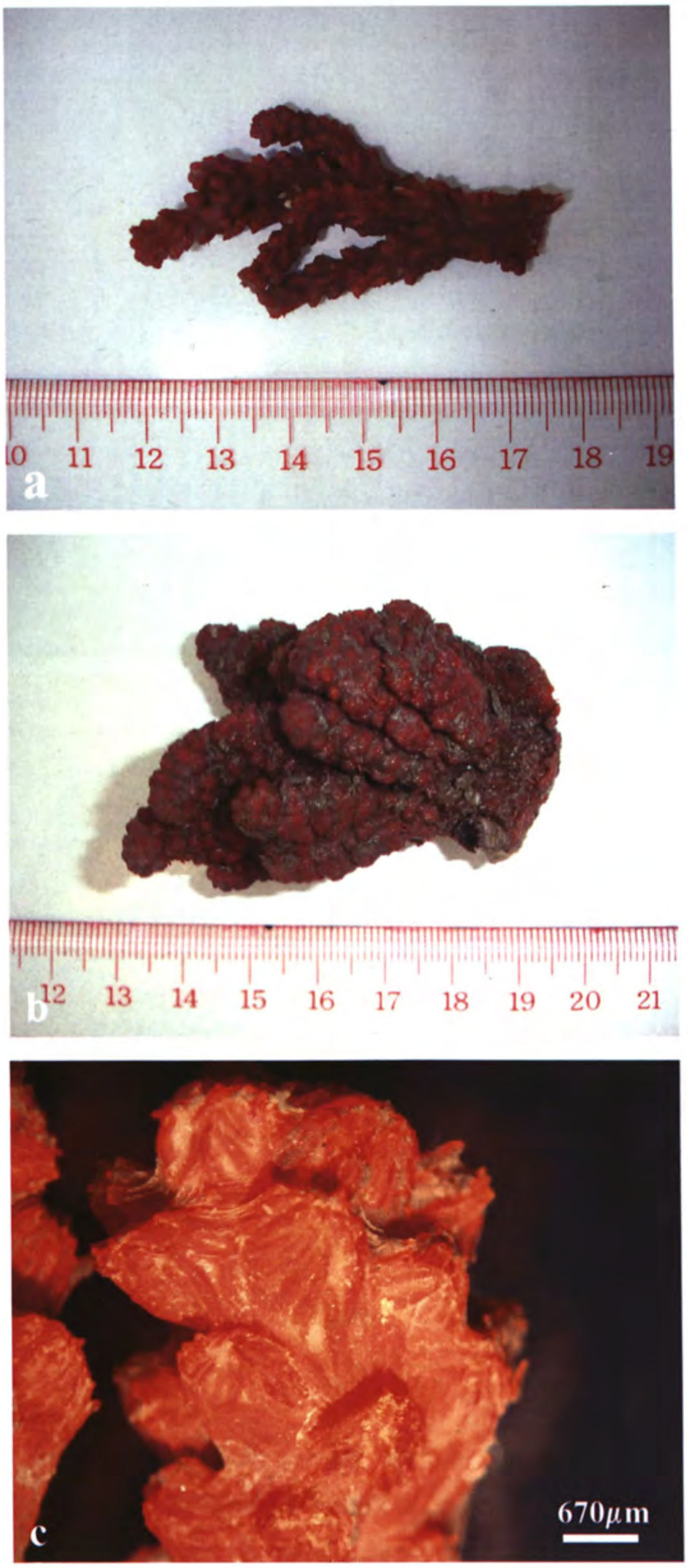


Figure 2.48 Preserved material of *Nephthyigoria* sp. **(a)** Branched colony of *Nephthyigorgia* sp. A. **(b)** Digitate colony of *Nephthyigorgia* sp. B. **(c)** Calyces are volcano-shaped, observed under the dissecting microscope (15x).

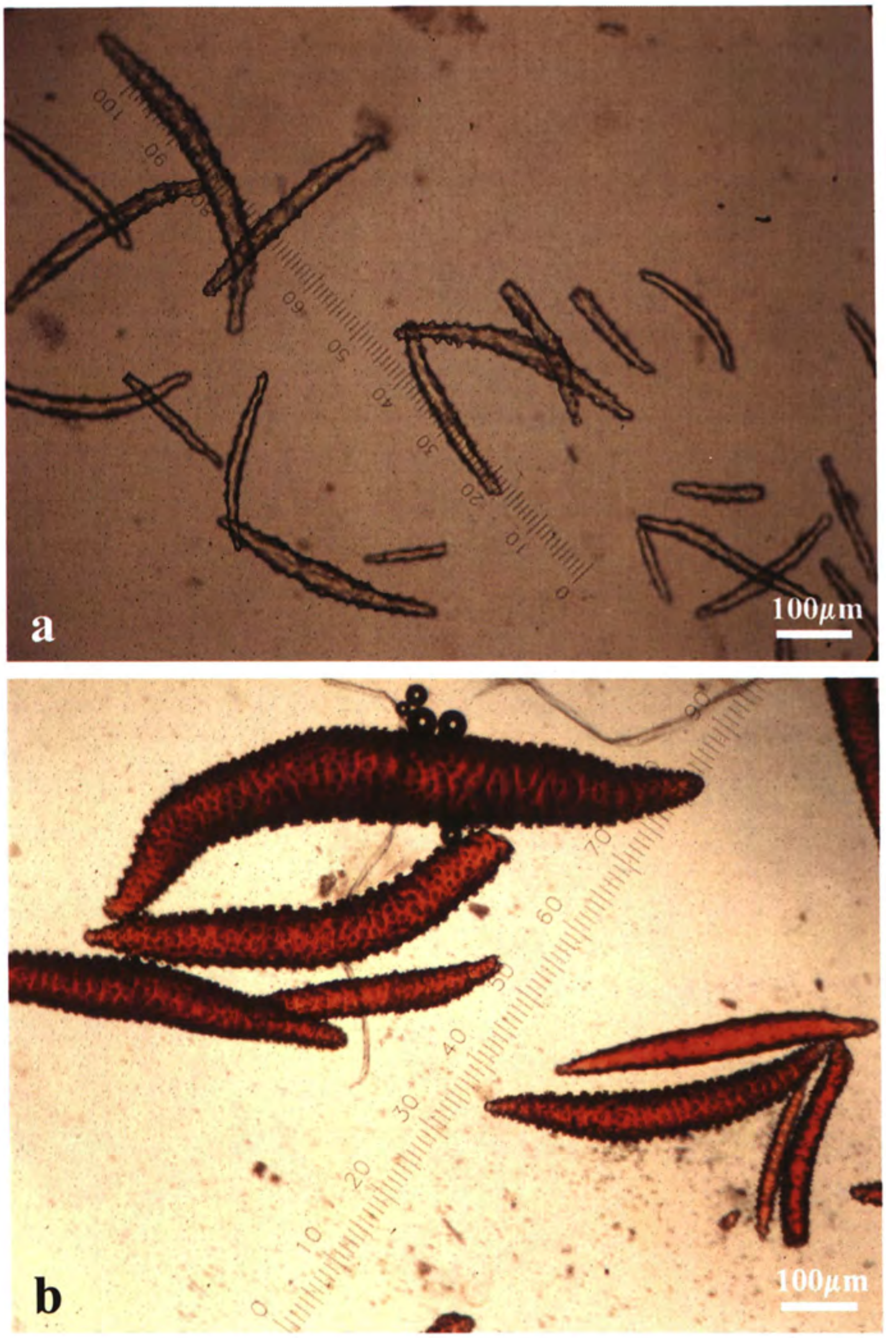


Figure 2.49 Sclerites of *Nephthyigorgia* sp. A observed under the compound microscope (100x). **(a)** Spindles from the polyp part, some of them have spiny heads. **(b)** Red sclerites in the surface and interior parts of the colony are large and warty.

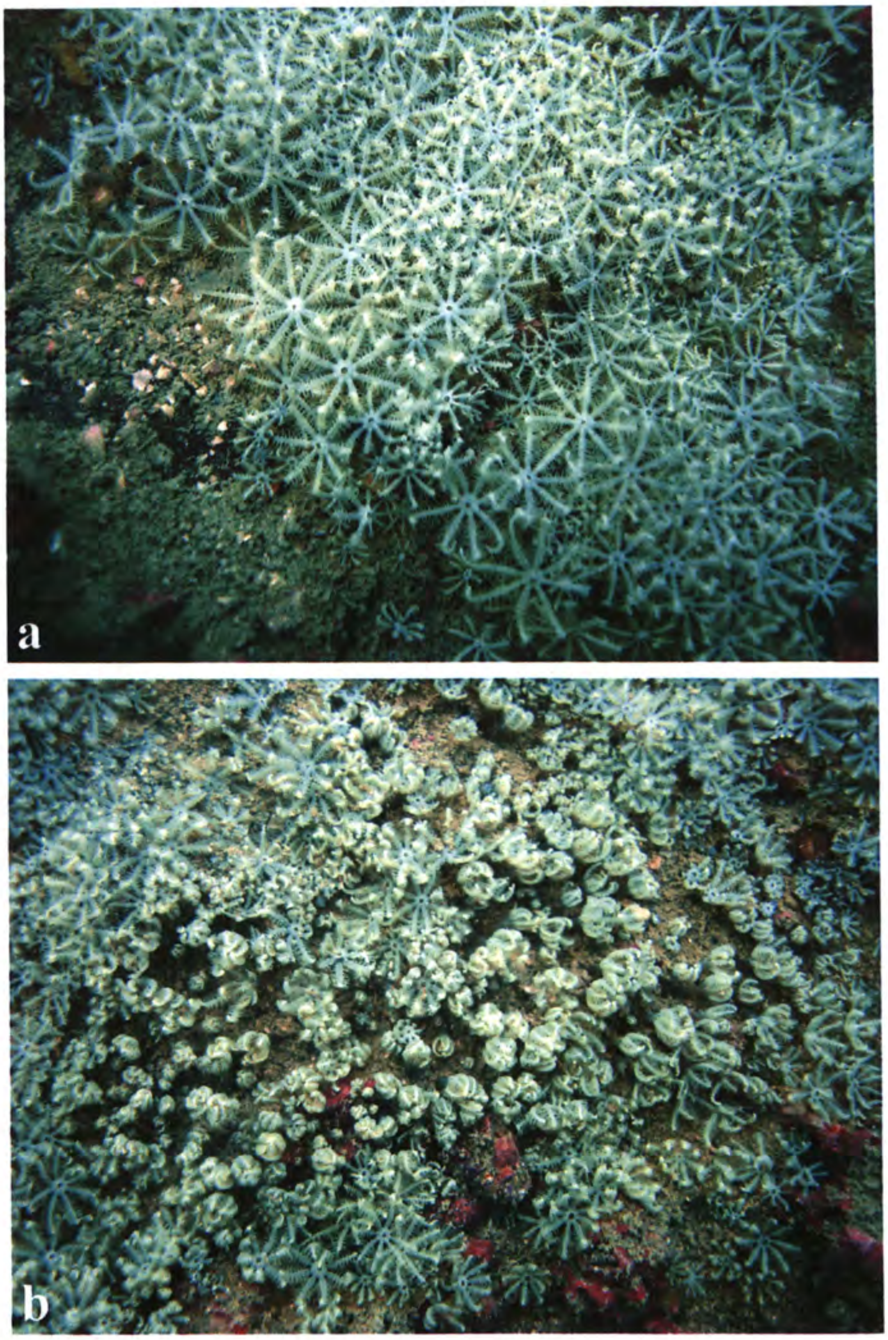


Figure 2.50 Underwater photos of living *Sansibia* sp. in Tung Ping Chau Marine Park. **(a)** Polyps are small and soft, each tentacle fringes with a conspicuous row of pinnules on both edges. **(b)** Polyps are slightly contractile but not retractile.

Figure 2.51 Preserved material of *Sansibia* sp. **(a)** Clusters of polyps encrusted on the shell of bivalves (left) and barnacles (right). **(b)** Close-up of the slightly contracted polyps with tentacles (Ten) observed under the dissecting microscope (40x).

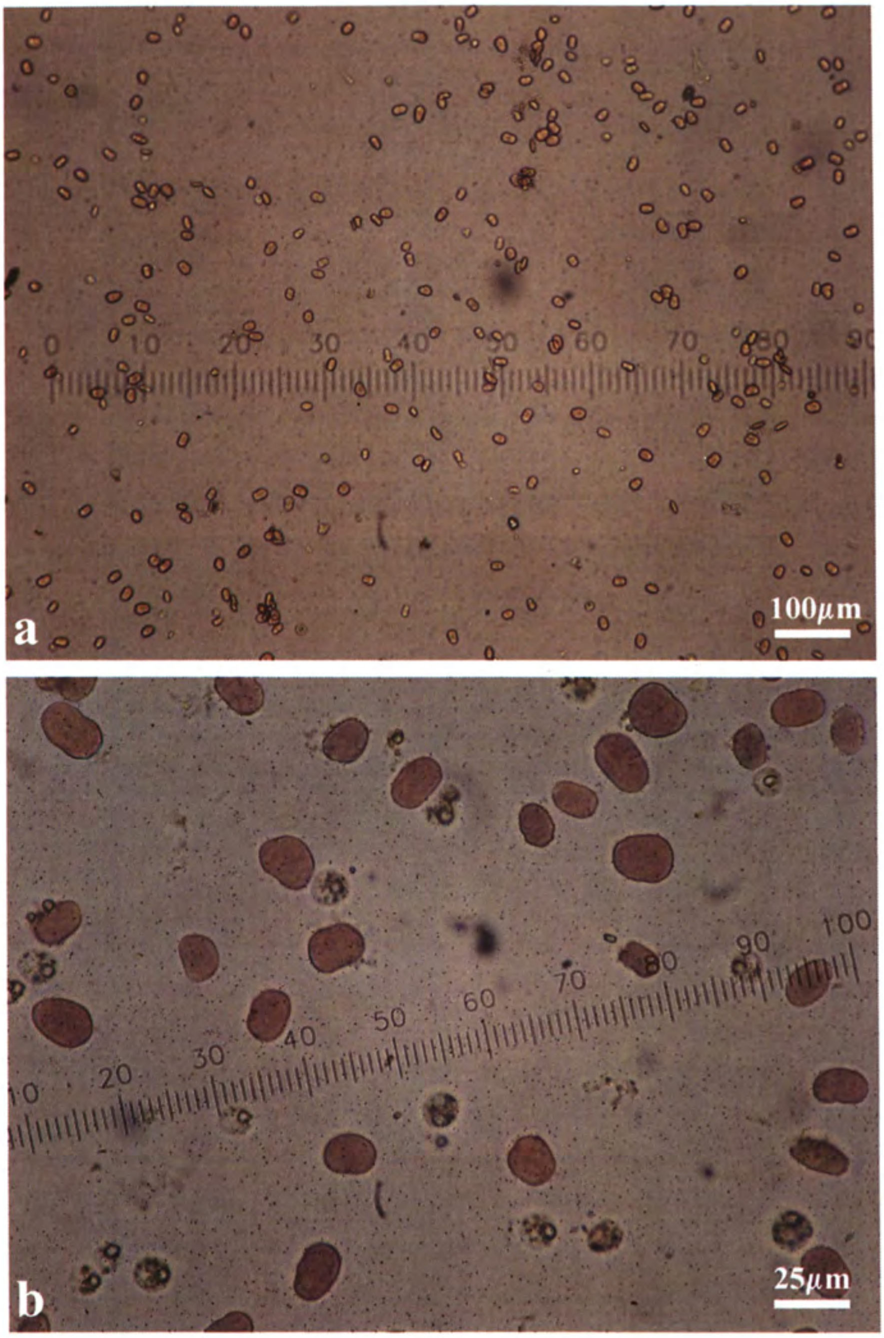


Figure 2.52 Sclerites of *Sansibia* sp. observed under the compound microscope. **(a)** Minute platelets or spheroids (100x). **(b)** Sclerites have a fine granular surface, white in color but iridescent (400x).

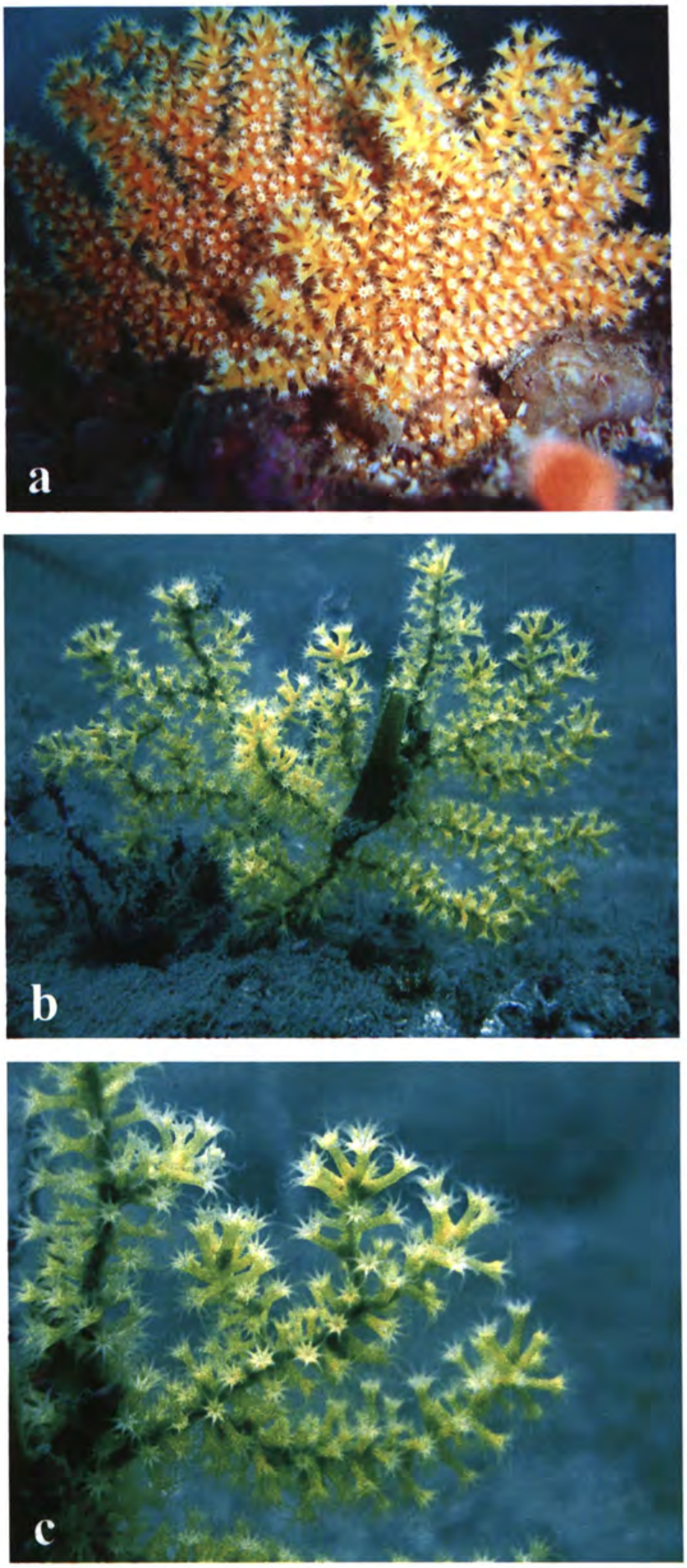


Figure 2.53 Underwater photos of living *Acanthogorgia* sp. showing **(a)** planar, sparsely branched colony; **(b)** thin coenenchyme layer on the stem and branches with black axis easily seen through; **(c)** tall and expanded polyps.

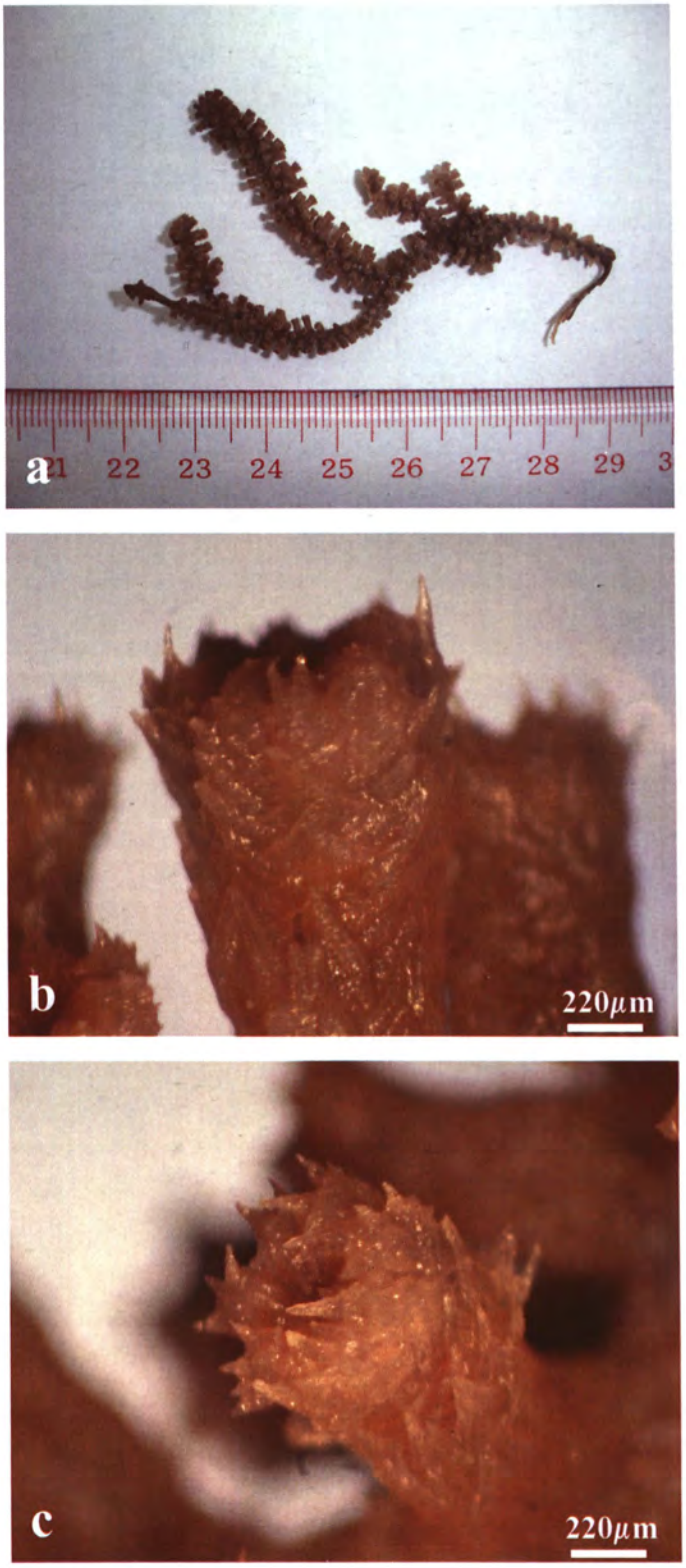


Figure 2.54 Preserved material of *Acanthogorgia* sp. **(a)** Colony tightly contracted after preservation. Polyps non-retractile and without calyces, remain tall after contraction. **(b)** Spindles arranged along the body wall in 8 double rows when observed under the dissecting microscope (45x). **(c)** Spiny crown formed by the protrusion of pointed end of sclerites (45x).

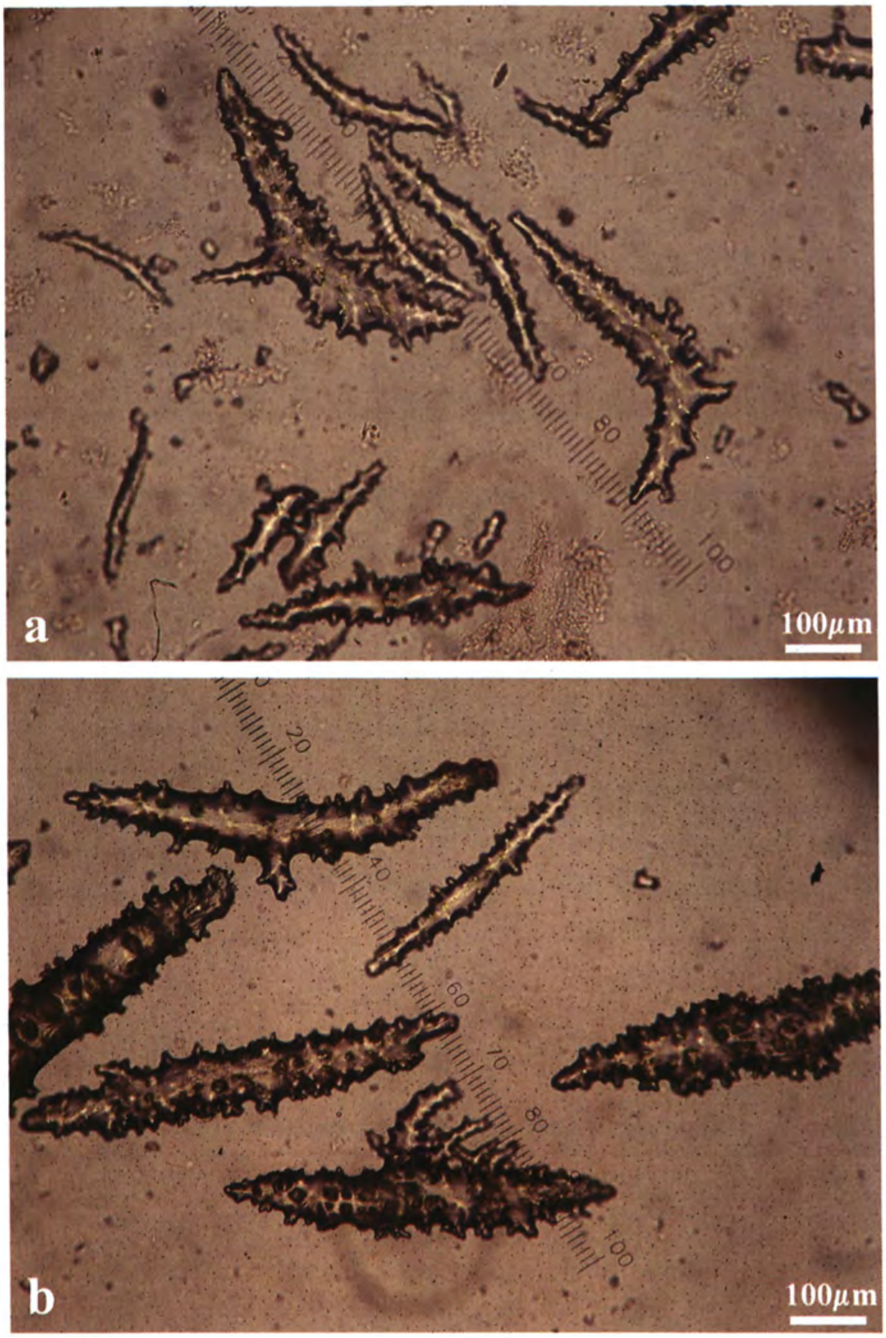


Figure 2.55 Colorless sclerites of *Acanthogorgia* sp. under the compound microscope. **(a)** Boomerang-shaped spindles in polyp heads (100x). **(b)** More warty sclerites found in the surface layer of the colony (100x).

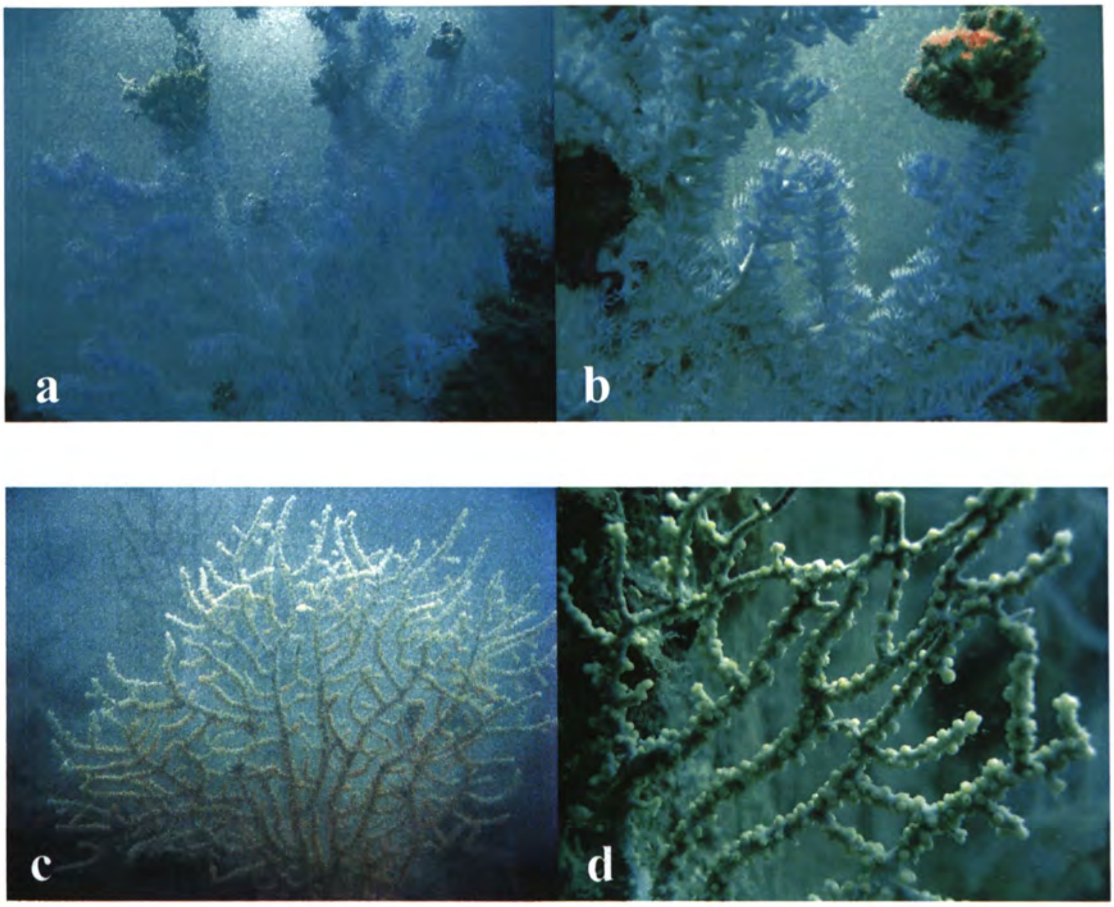


Figure 2.56 Underwater photos of living *Anthogorgia* spp. showing colonies in two color morphs: blue and white. **(a)** & **(c)** Fan-like colony, with free branches and few net-like branch fusions. **(b)** Blue colony with cylindrical polyps. **(d)** Contracted polyps on the white colony.

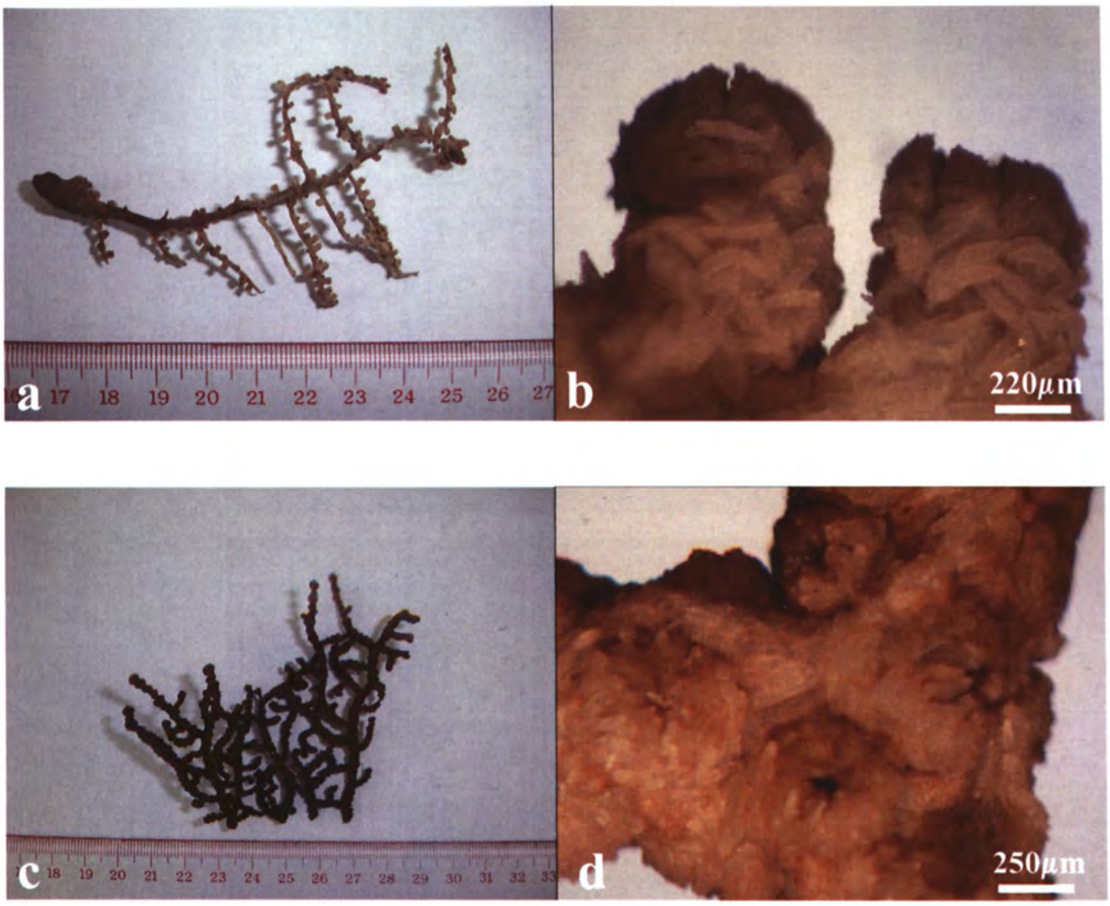


Figure 2.57 Preserved materials of **(a)** & **(b)** *Anthogorgia* sp. A (blue colony) and **(c)** & **(d)** *Anthogorgia* sp. B (white colony). **(a)** Free branches of the blue colony with **(b)** blunt spindles covering the body wall in angled double rows arrangement (45x). **(c)** White colony with **(d)** close-up of the sclerite arrangement on the polyp heads and surface of branches observed under the dissecting microscope (40x).

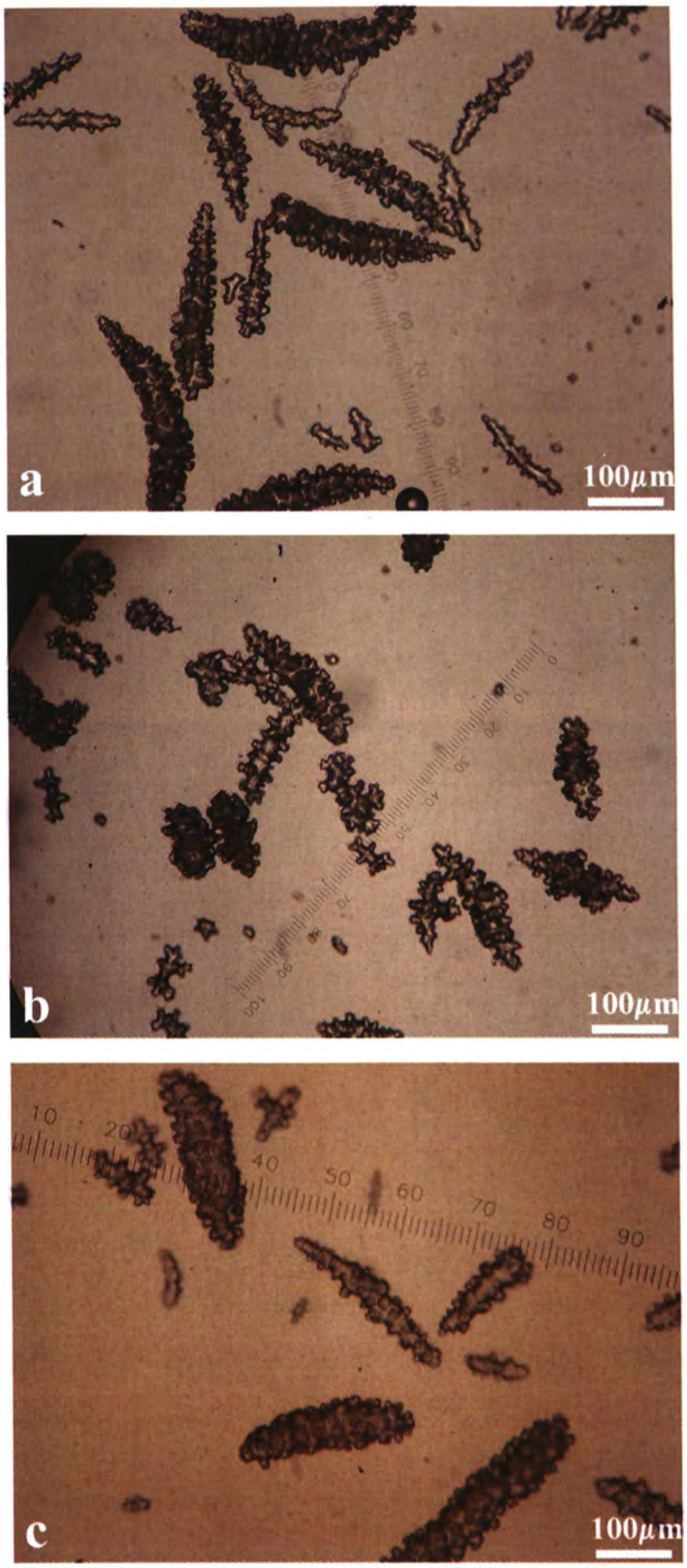


Figure 2.58 Colorless sclerites from **(a)** & **(b)** *Anthogorgia* sp. A and **(c)** *Anthogorgia* sp. B colonies observed under the compound microscope (100x). **(a)** Complexly warted spindles with sharper ends in the polyps. **(b)** Spindles in the surface part of the colony, together with some small capstans. **(c)** **B**lunt and plump spindles from the white colony.

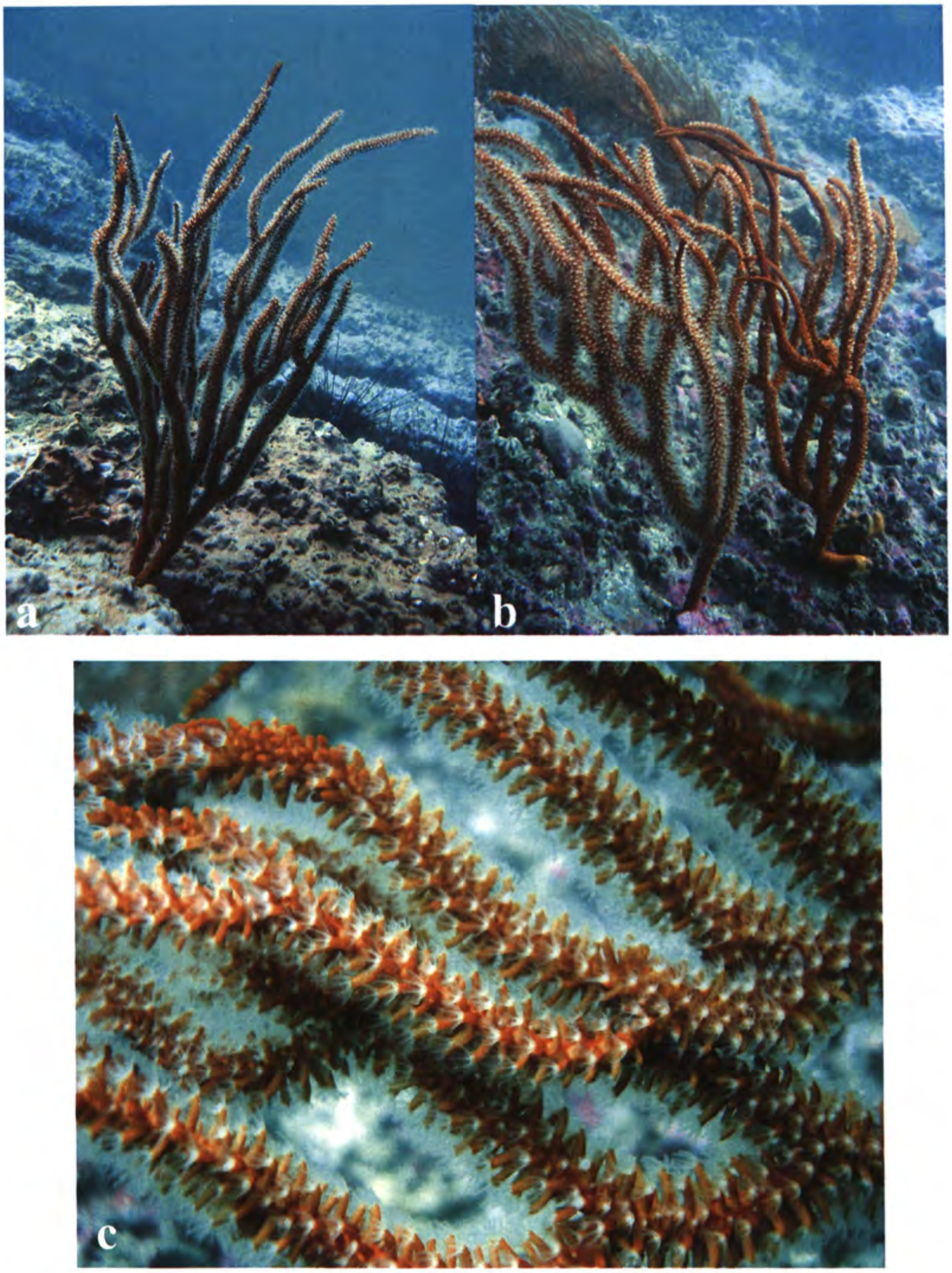


Figure 2.59 Underwater photos of living *Dichotella* sp. **(a)** & **(b)** Colonies are richly branched, they are bushy and have repeated dichotomous upright branching. **(c)** Orange branches with white polyps.

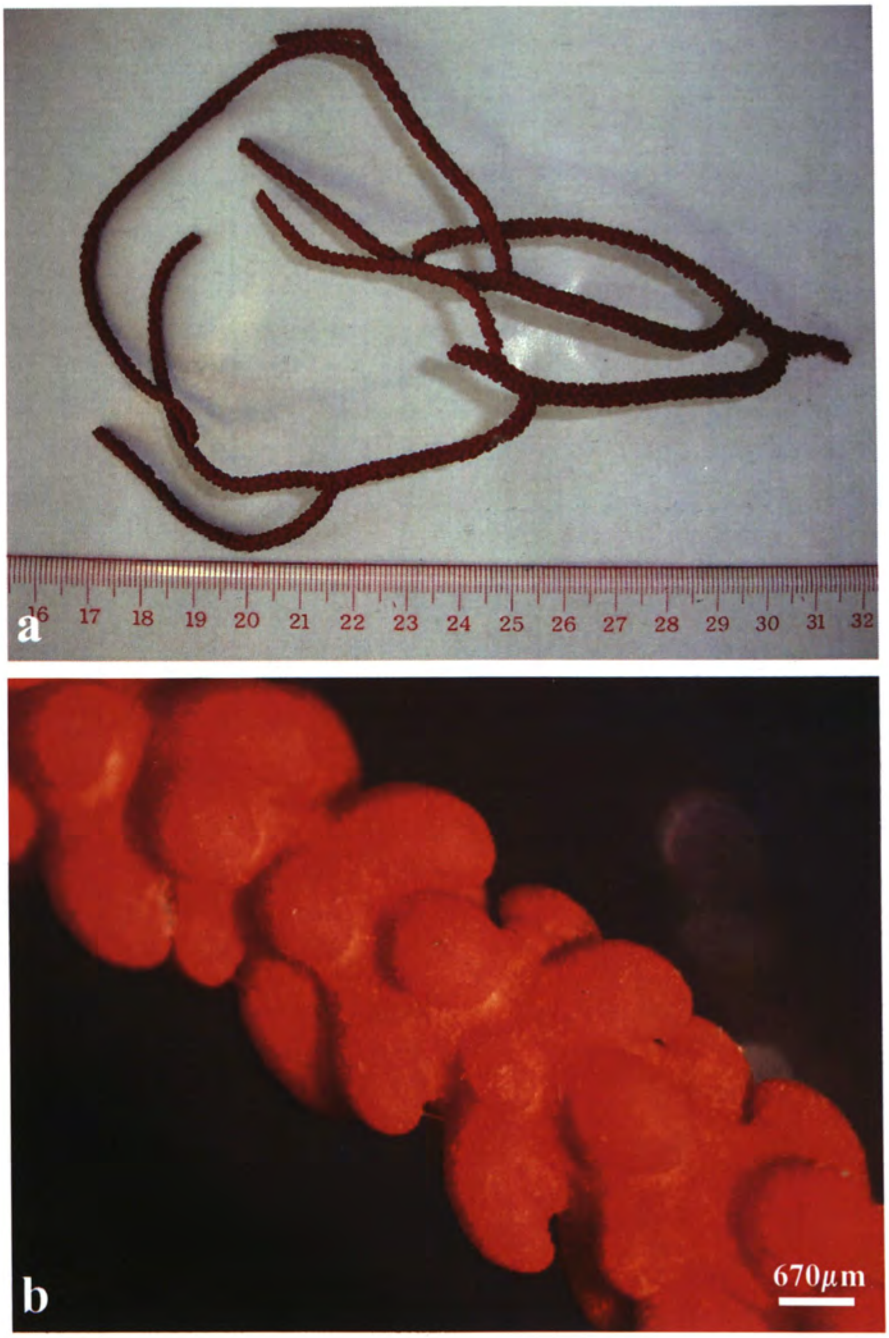


Figure 2.60 Preserved material of *Dichotella* sp. **(a)** Colony is dichotomously branched. **(b)** Contracted polyps appear as small scales pressed against the surface of the branches, observed under the dissecting microscope (15x).

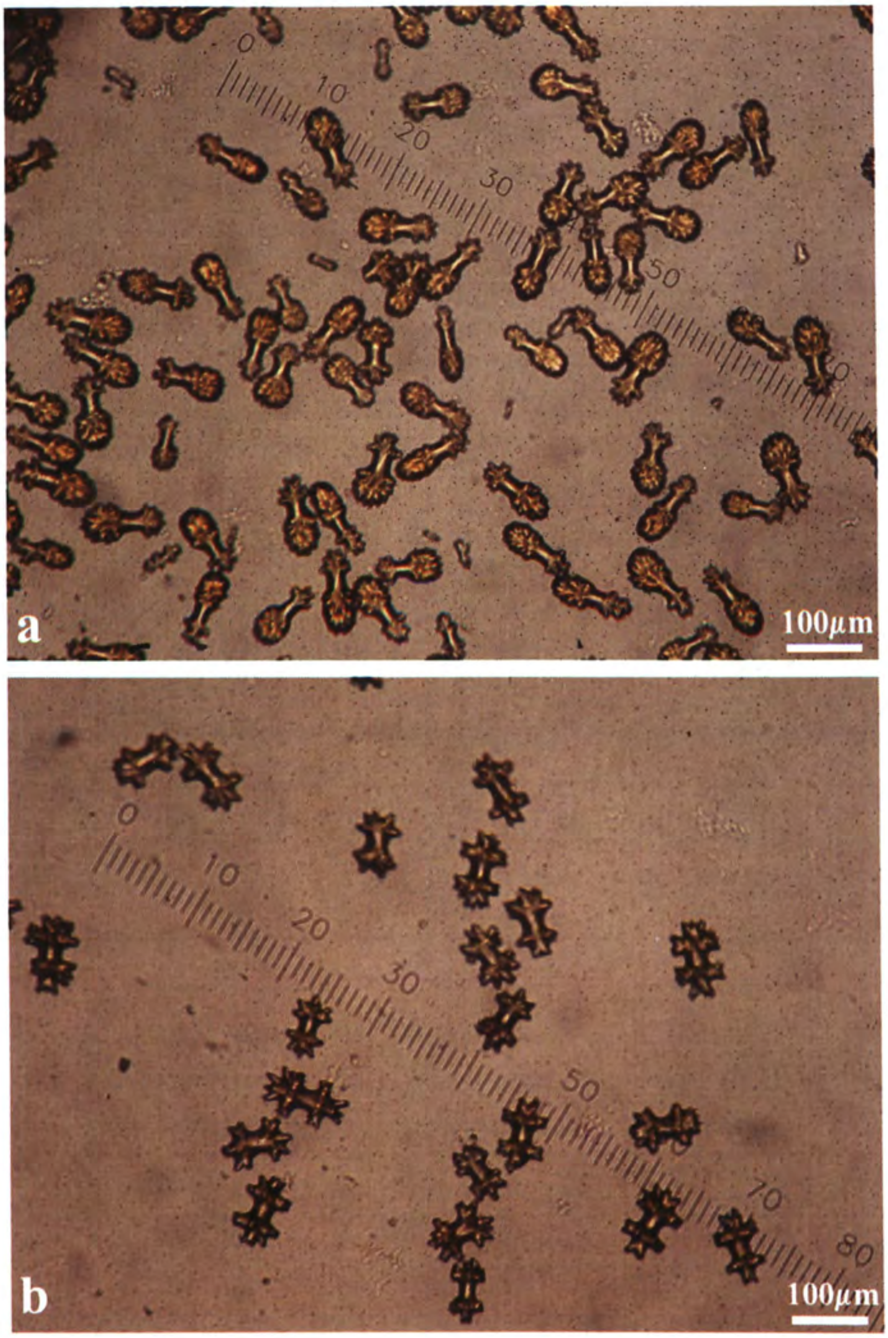


Figure 2.61 Colored sclerites of *Dichotella* sp. under the compound microscope (100x). **(a)** "Pineapple-liked" clubs from the surface. The club heads are formed from a cluster of distally pointed tubercles. **(b)** Symmetrical capstans from the subsurface layer of the colony.

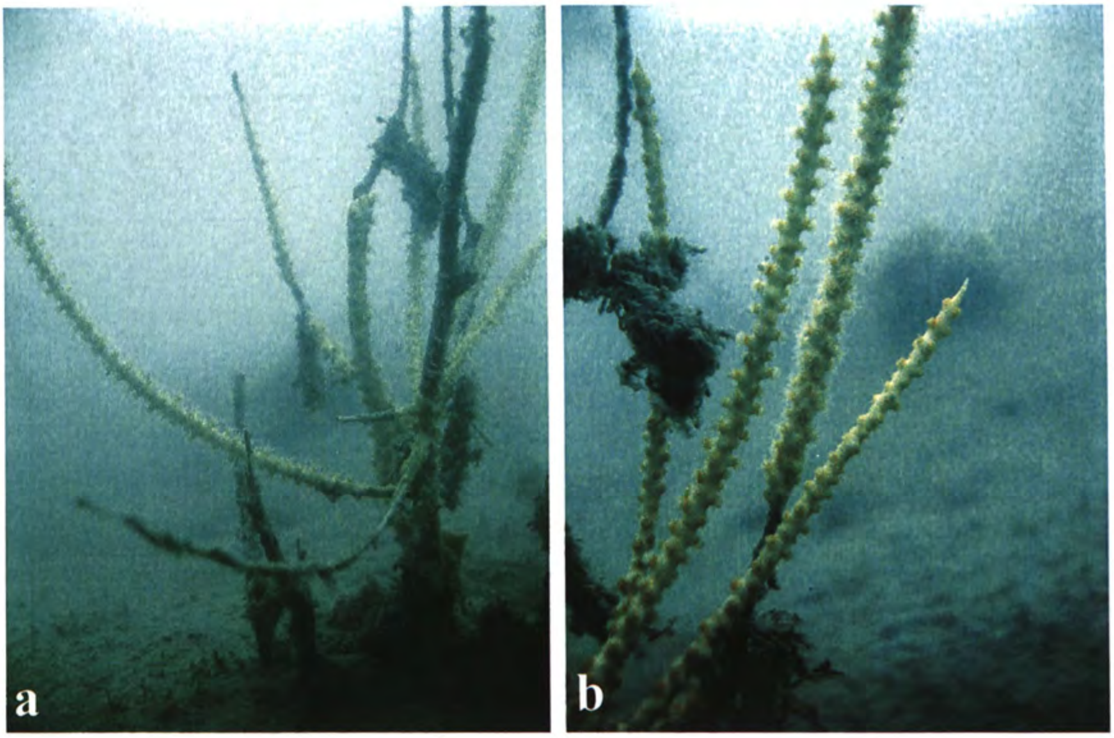


Figure 2.62 Underwater photos of living *Ellisella* sp. in Port Island. **(a)** Colony is sparsely branched with dichotomous branches. **(b)** Colony is yellow with orange polyps which are contractile, forming mounds when contracted.

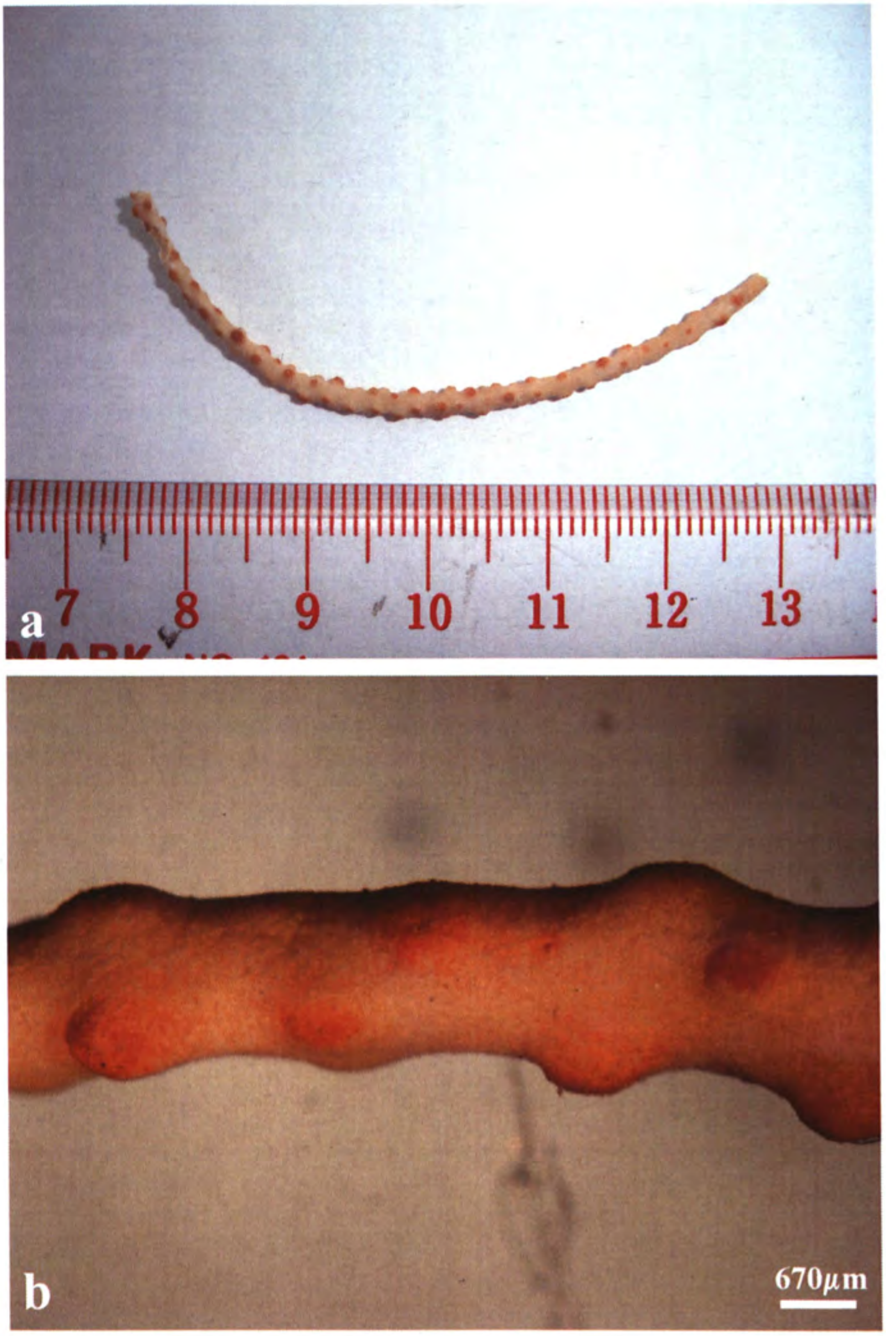


Figure 2.63 Preserved materials of *Ellisella* sp. showing **(a)** long and whip-like branch, **(b)** contracted polyps forming pronounced lobe-like mounds on the branches observed under the dissecting microscope (15x). The smooth surface appearance is due to the presence of tiny sclerites.

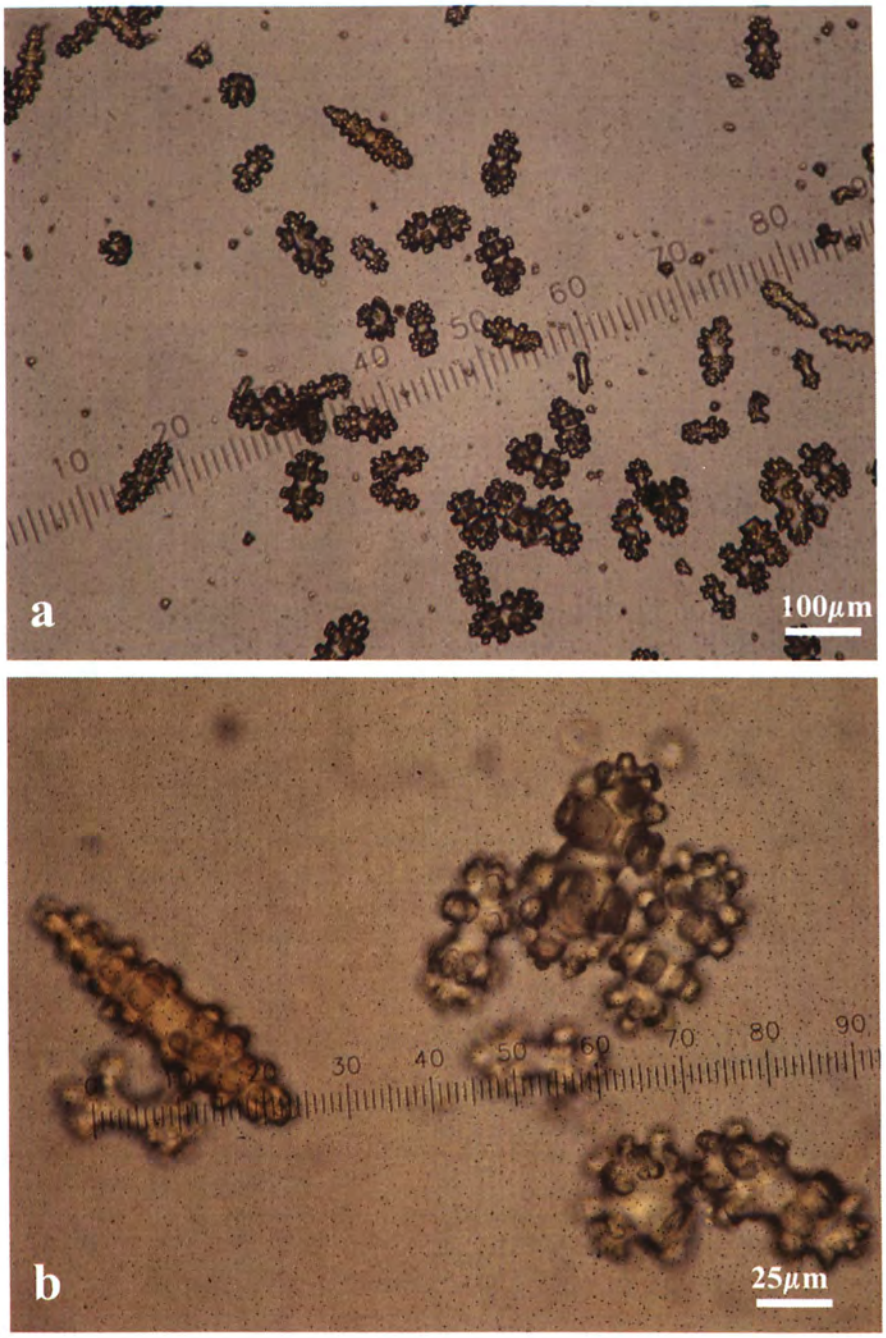


Figure 2.64 Colored sclerites of *Ellisella* sp. under the compound microscope. There are two types of sclerites: double heads (colorless) and spindles (orange), some of which have a waist. **(a)** 100x, **(b)** 400x.

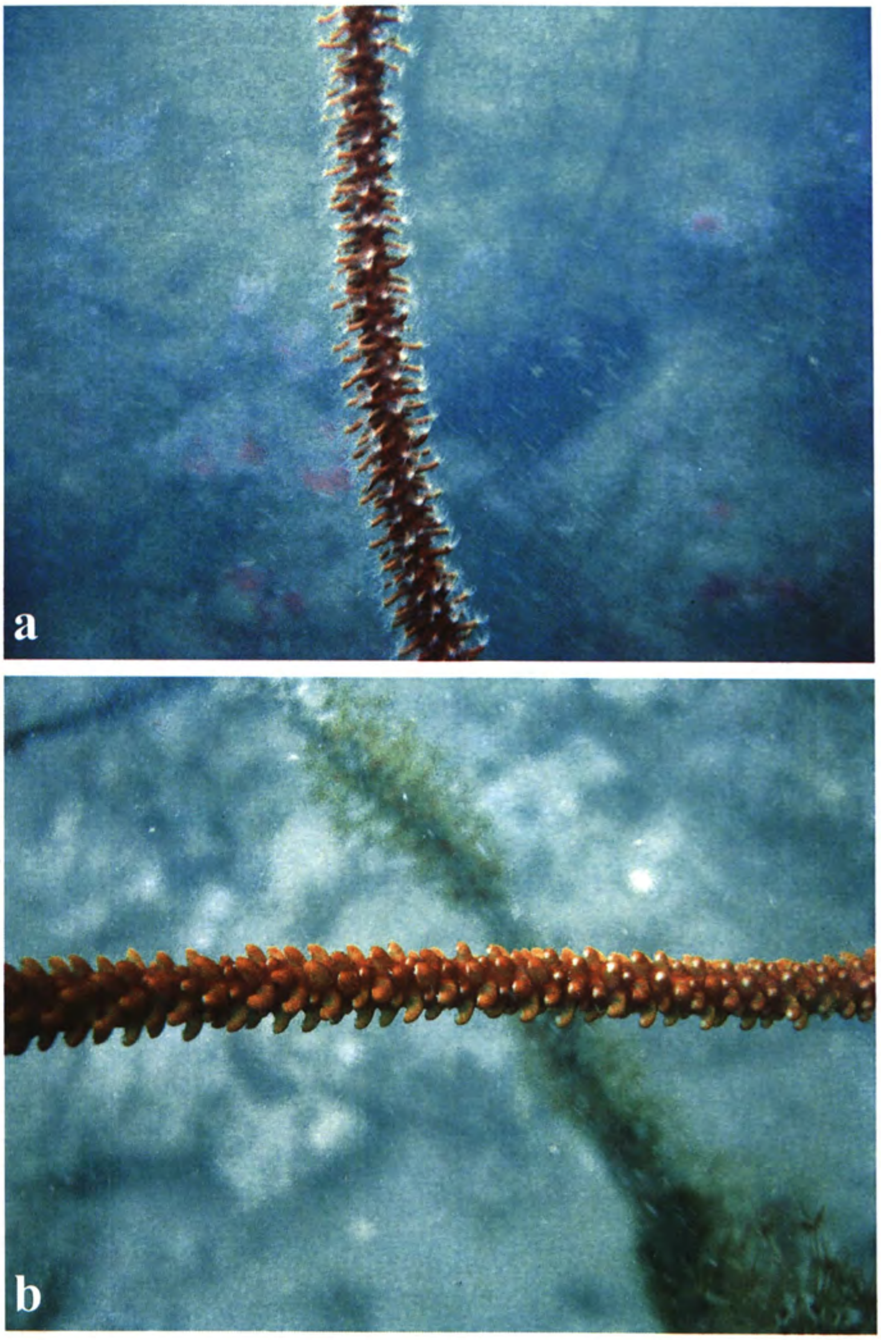


Figure 2.65 Underwater photos of living *Junceella* sp. **(a)** Colony is whip-like and tall. **(b)** Semi-contracted polyps.

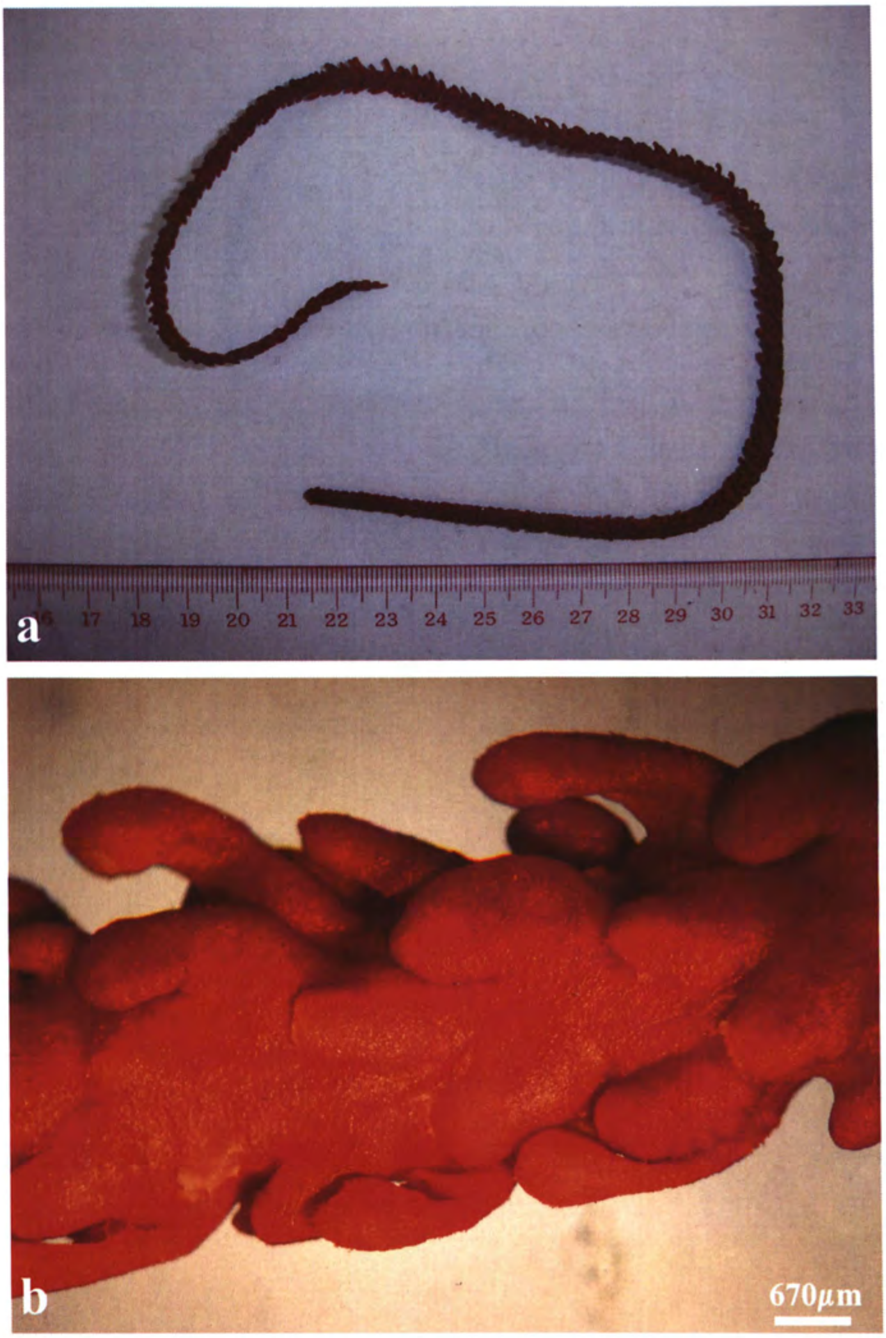


Figure 2.66 Preserved material of *Juncella* sp. **(a)** Colony is whip-like without any branches. **(b)** Contracted polyps appear as small scales pressed against the surface of the branches, observed under the dissecting microscope (15x).

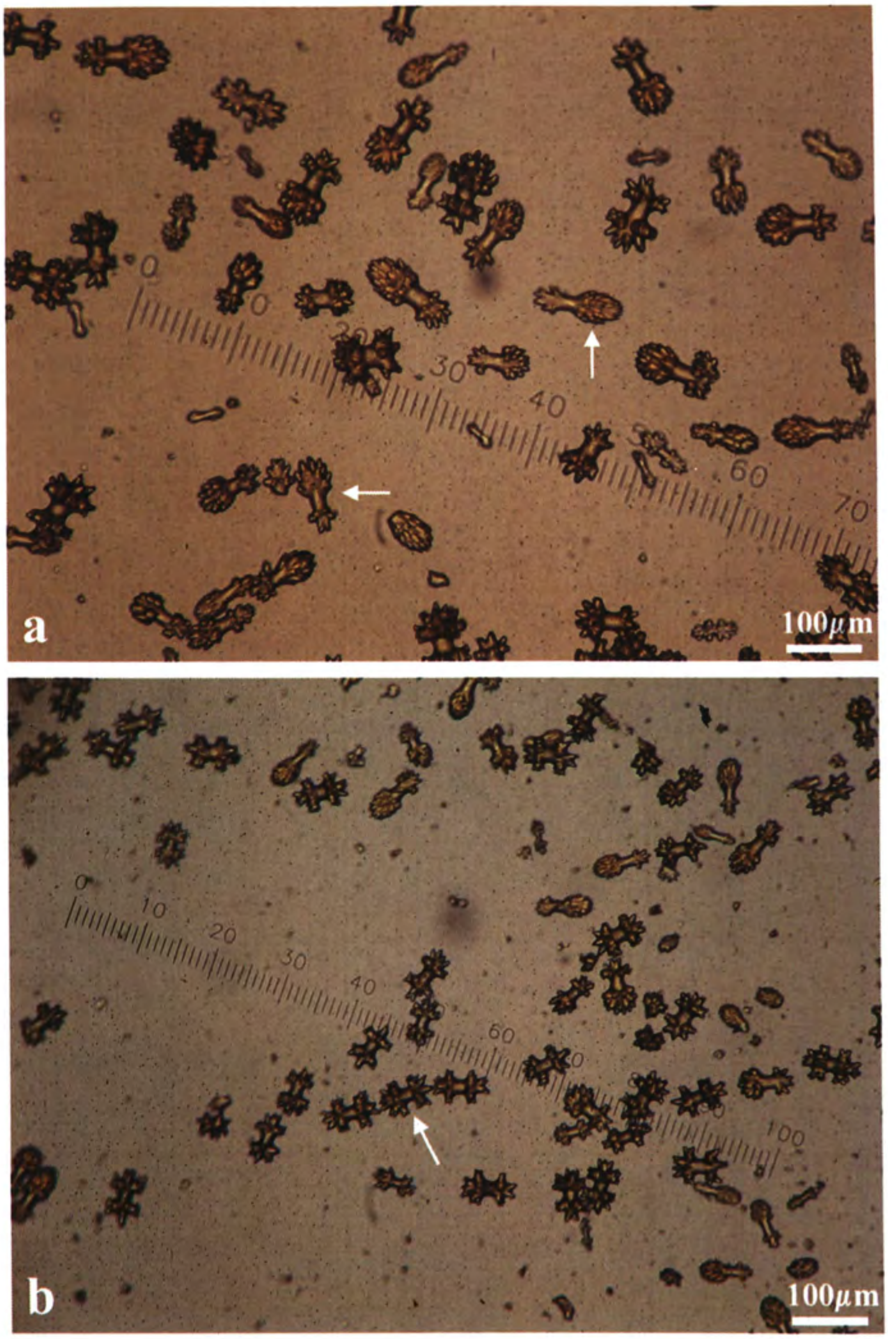


Figure 2.67 Colored sclerites of *Junceella* sp. under the compound microscope (100x). (a) Surface part of the colony contains "pineapple-liked" clubs. The club heads are formed from a cluster of distally pointed tubercles. (b) Symmetrical capstans in the subsurface area of the colony.

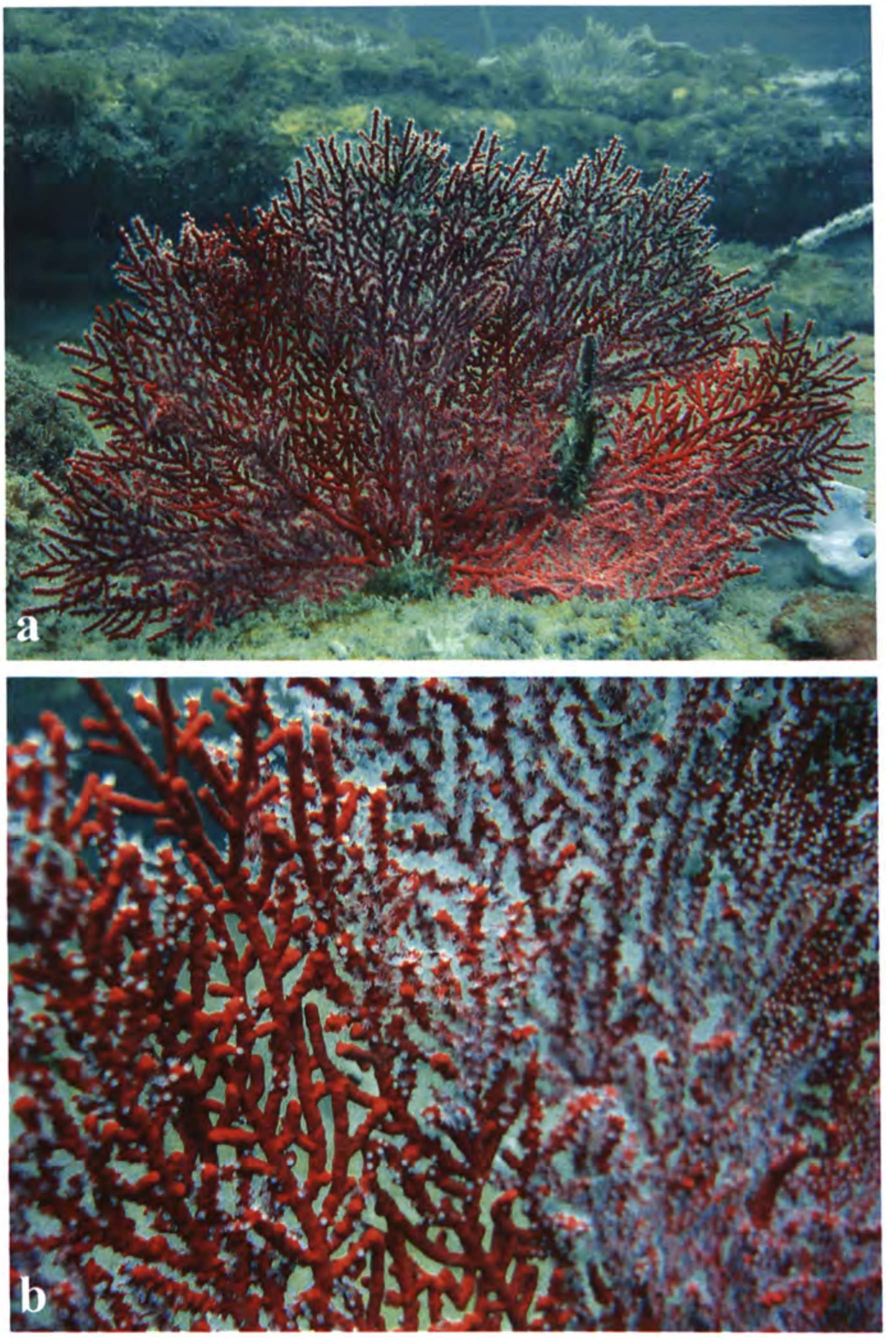


Figure 2.68 Underwater photos of living *Verrucella* sp. **(a)** Colony is richly branched in one plane, the branches join together and form a net-like fan. **(b)** Appearance of the colony when polyps are contracted (left part), while the right part shows the red branches with extended white polyps.

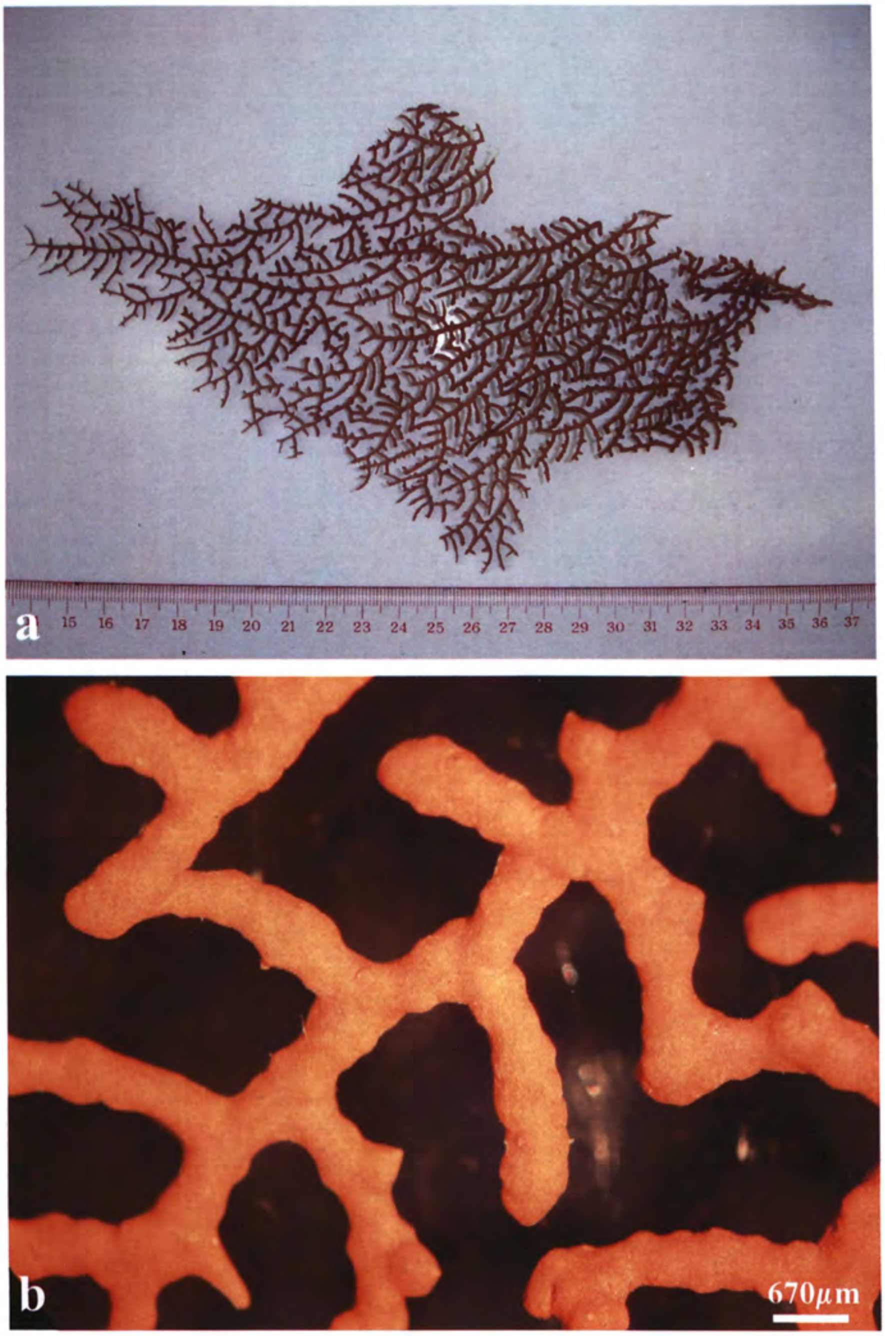


Figure 2.69 Preserved materials of *Verrucella* sp. **(a)** Net-like colony. **(b)** Smooth surface observed under the dissecting microscope (15x) is due to the presence of tiny sclerites.

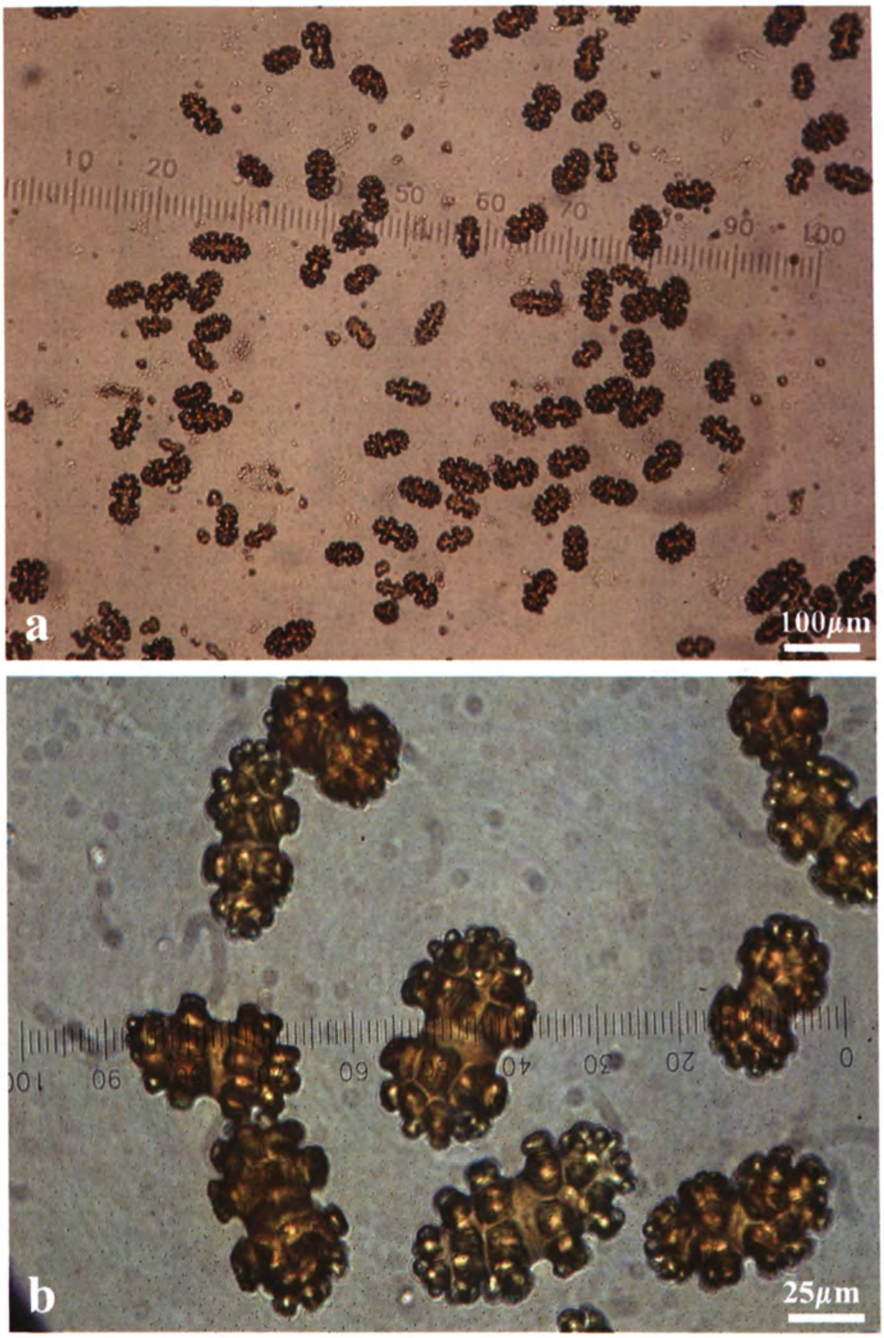


Figure 2.70 Colored sclerites of *Verrucella* sp. under the compound microscope. Spindles are plump and short with double heads, some of them have a waist. **(a)** 100x. **(b)** 400x.

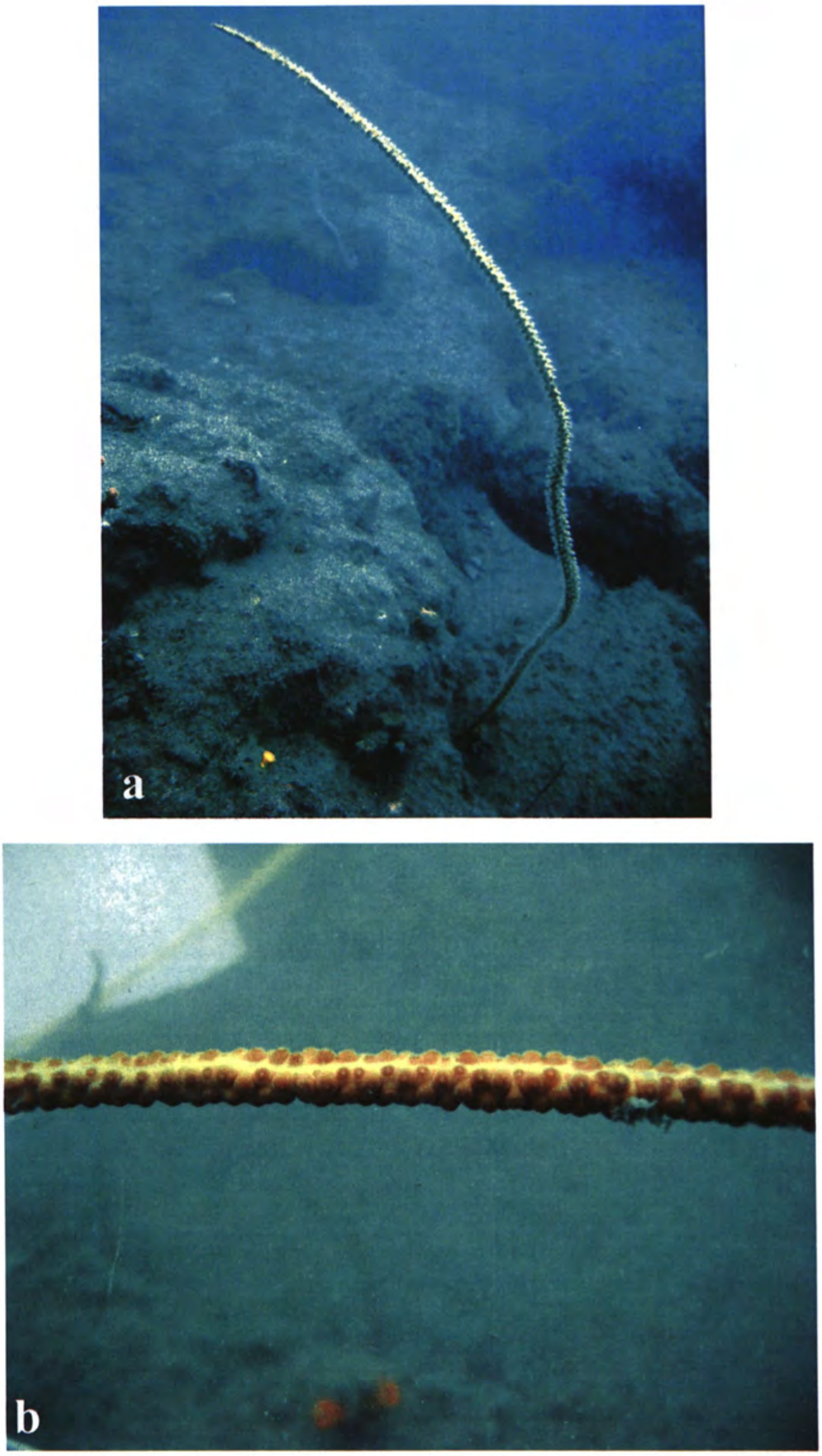


Figure 2.71 Underwater photos of living *Viminella* sp. Colony is whip-like (**a**), with one or a few side branches. Polyps can contract and bend over to form mounds on the surface of the branches, which are small and lobe-like (**b**).

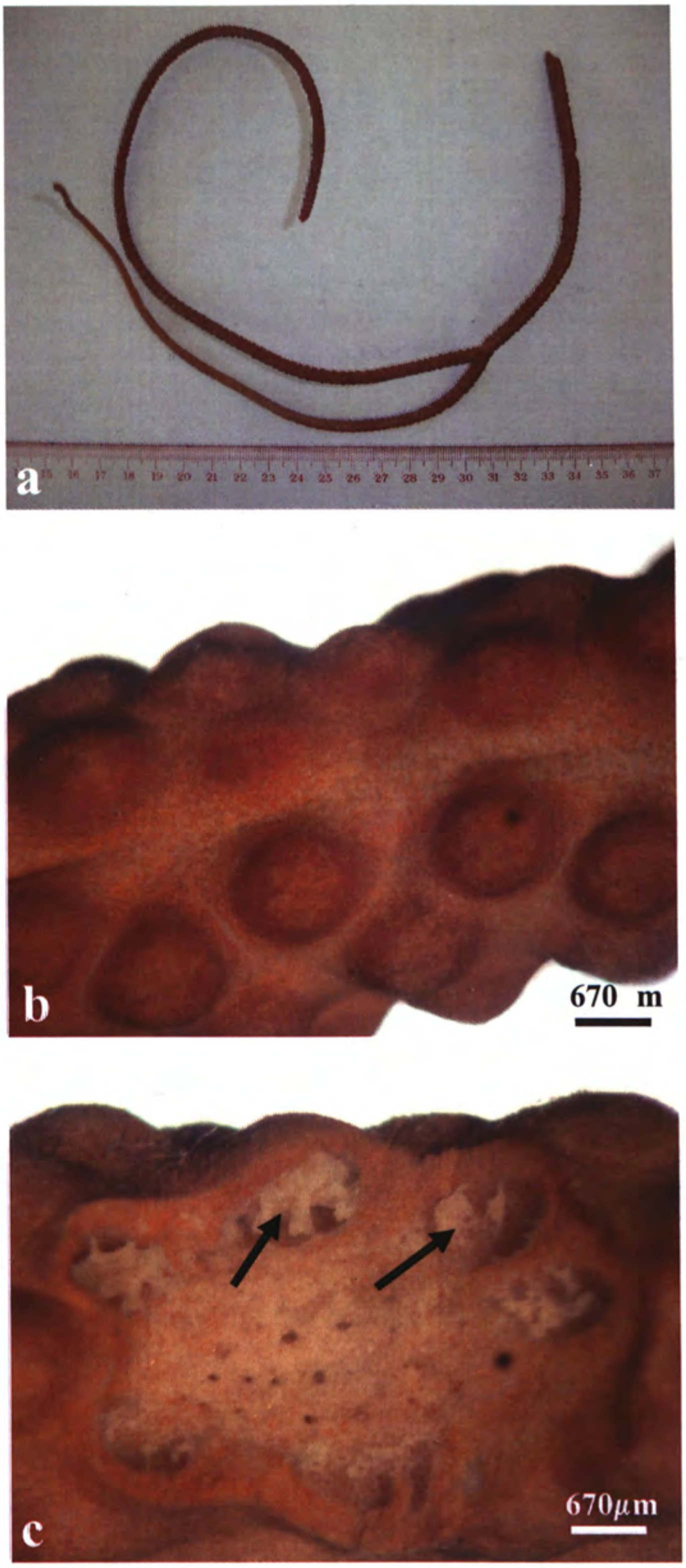


Figure 2.72 Preserved material of *Viminella* sp. (20x) showing **(a)** colony with dichotomous branches, **(b)** mound-like structure formed by the contraction of polyps observed under the dissecting microscope (15x). **(c)** Cross section of the surface of branches, with the contracted polyps clearly shown (arrows) (15x).

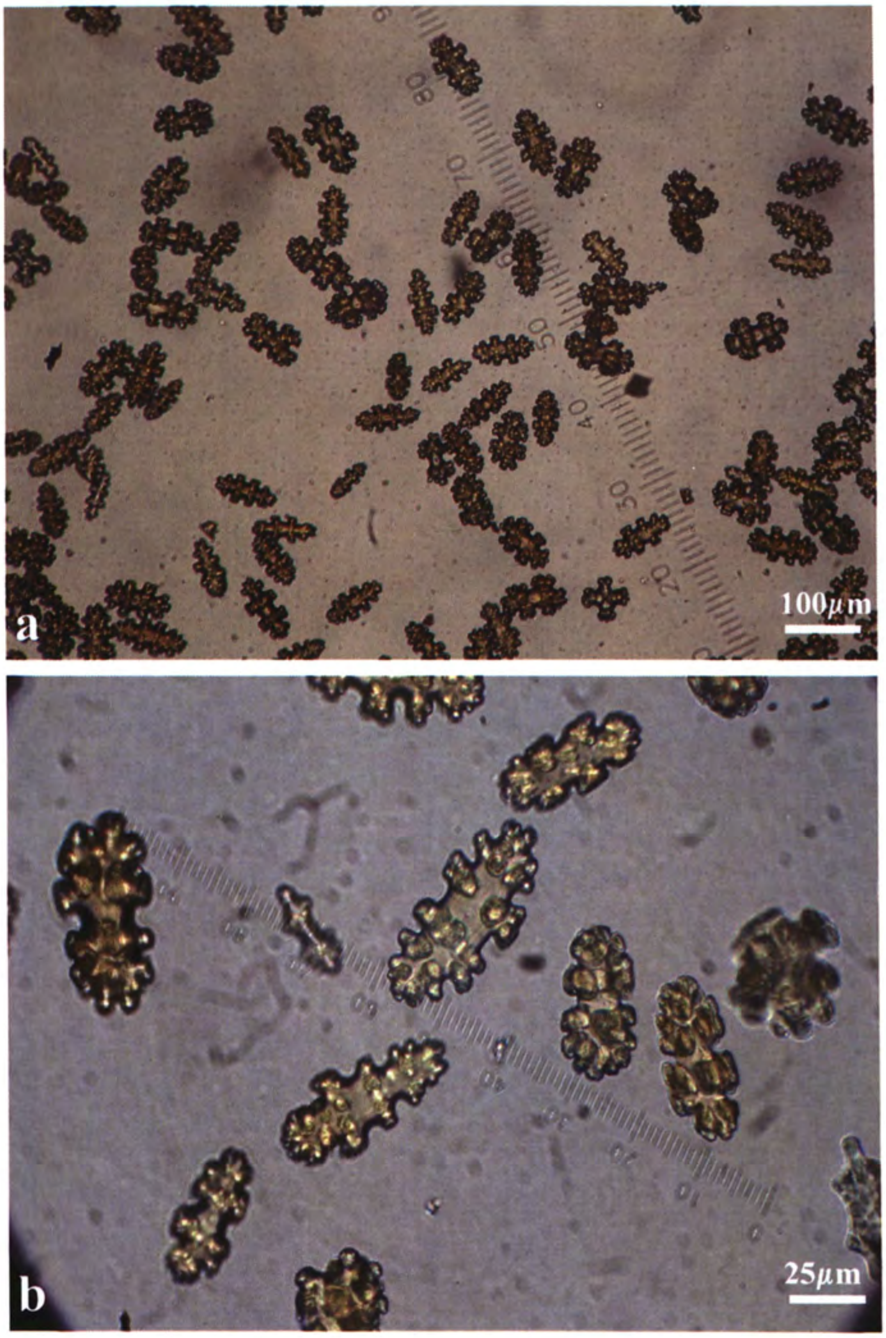


Figure 2.73 Colored sclerites of *Viminella* sp. under the compound microscope. Double heads and waisted spindles are present in the surface layer of the colony. **(a)**100x. **(b)** 400x.

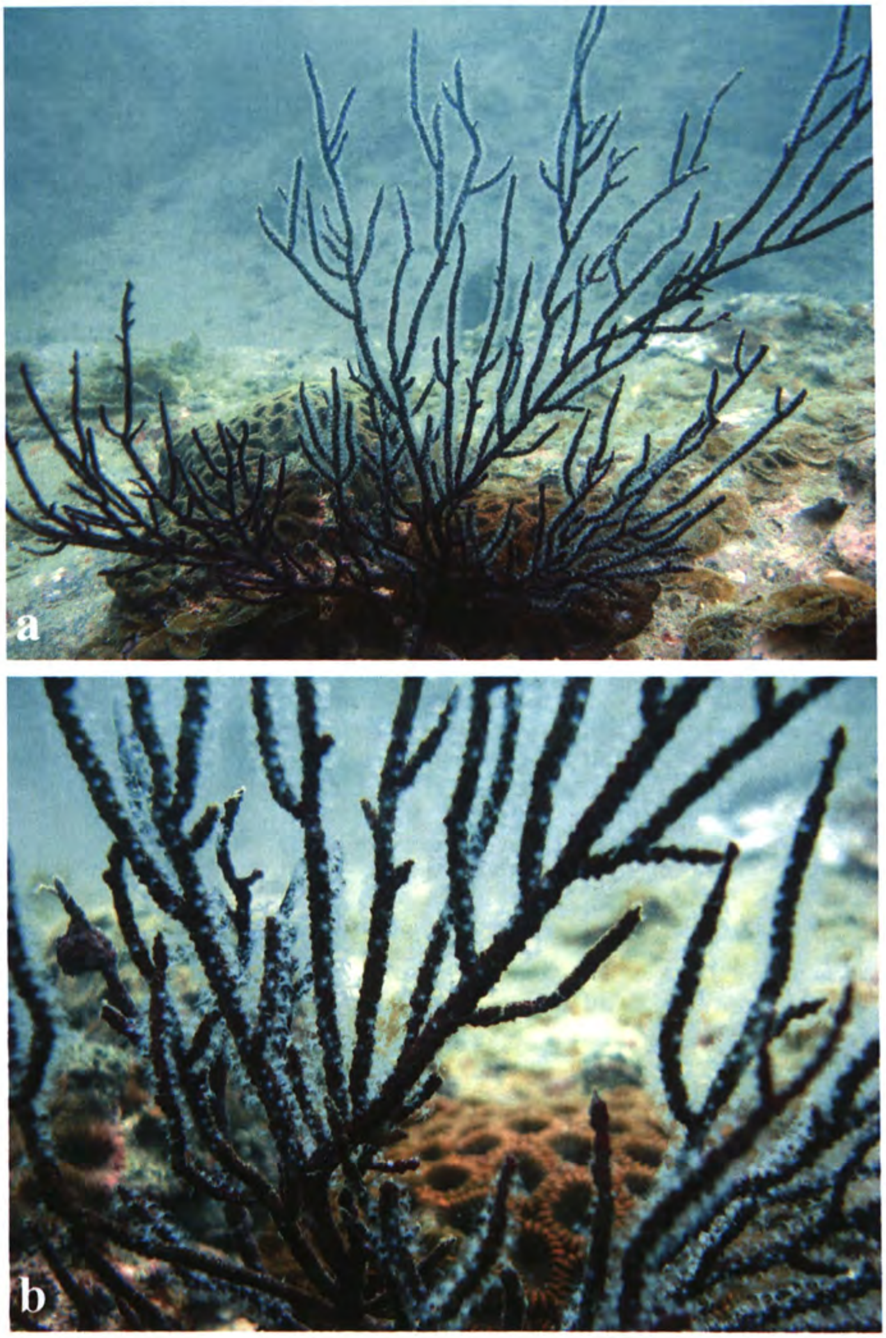


Figure 2.74 Underwater photos of living *Leptogorgia* sp. **(a)** Colonies are composed of one or more pinnately branched plumes. **(b)** Ends of the branches are pointed and tip-liked.

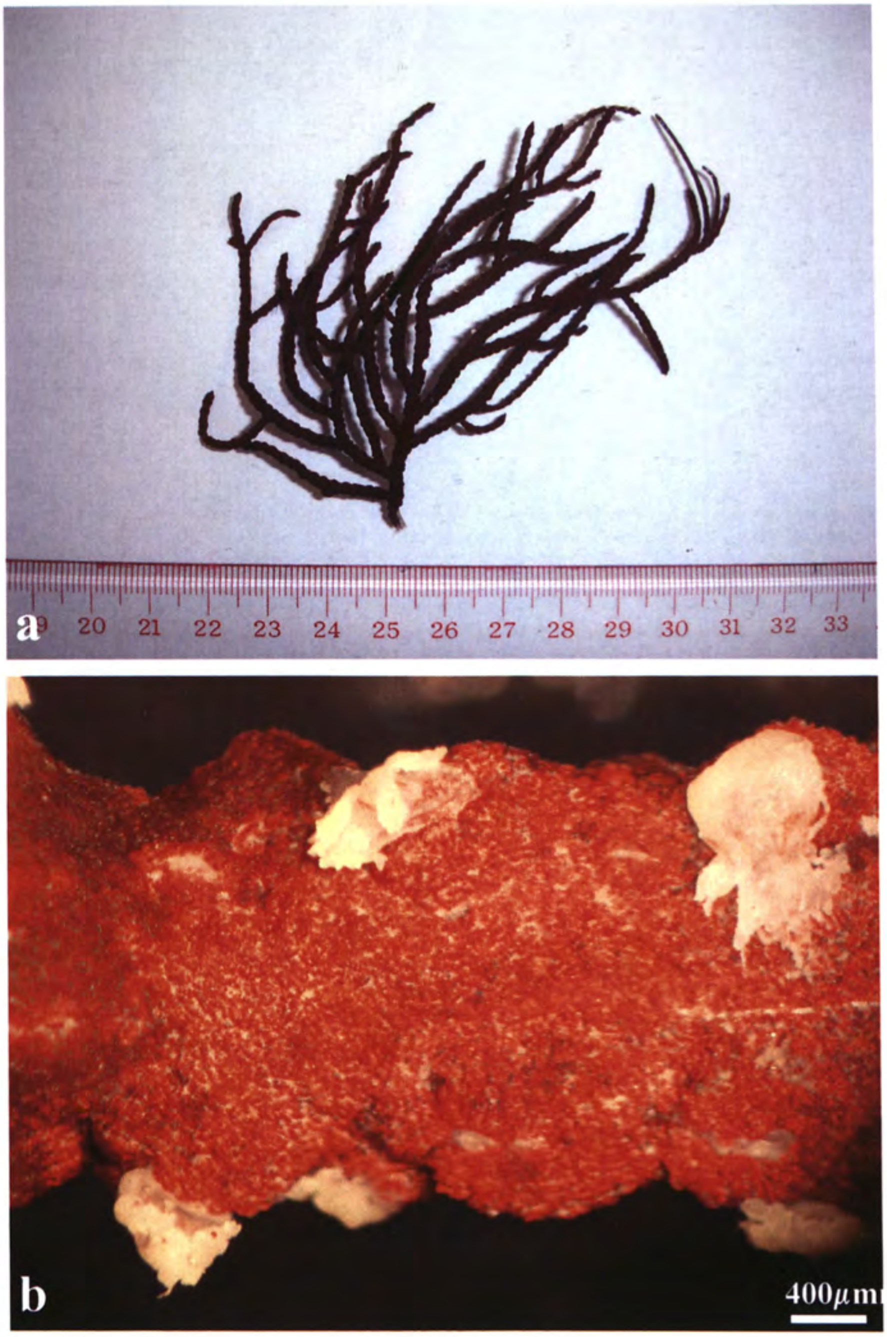


Figure 2.75 Preserved materials of *Leptogorgia* sp. **(a)** Colony grows in one plane. **(b)** Close-up of the stalk surface observed under the dissecting microscope. Polyps are white in color and retractile (25x).

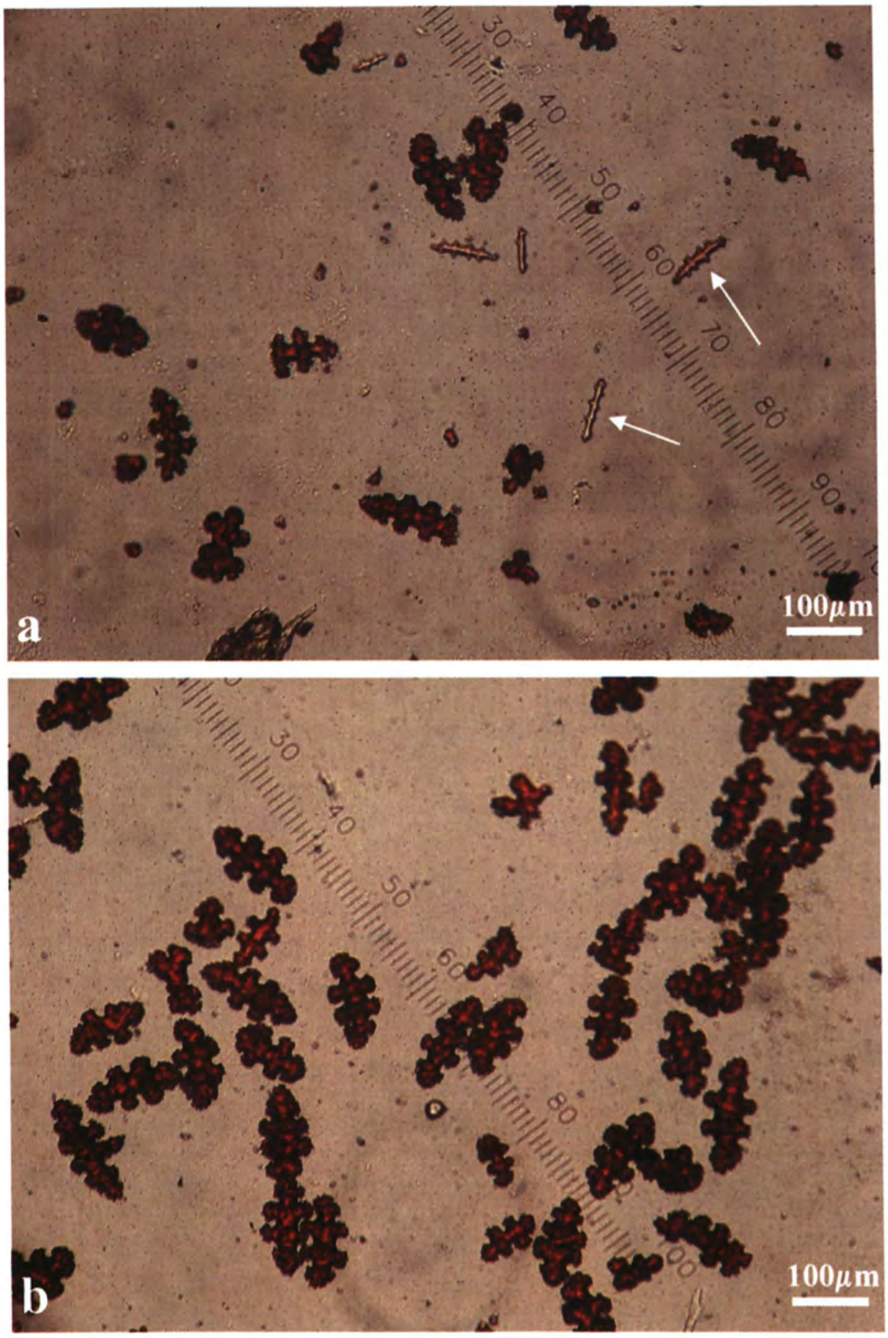


Figure 2.76 Colored sclerites of *Leptogorgia* sp. under the compound microscope (100x). **(a)** Small and flattened rod-shaped sclerites (arrows) from the tentacle. **(b)** Sclerites from the polyp heads are bigger in size.

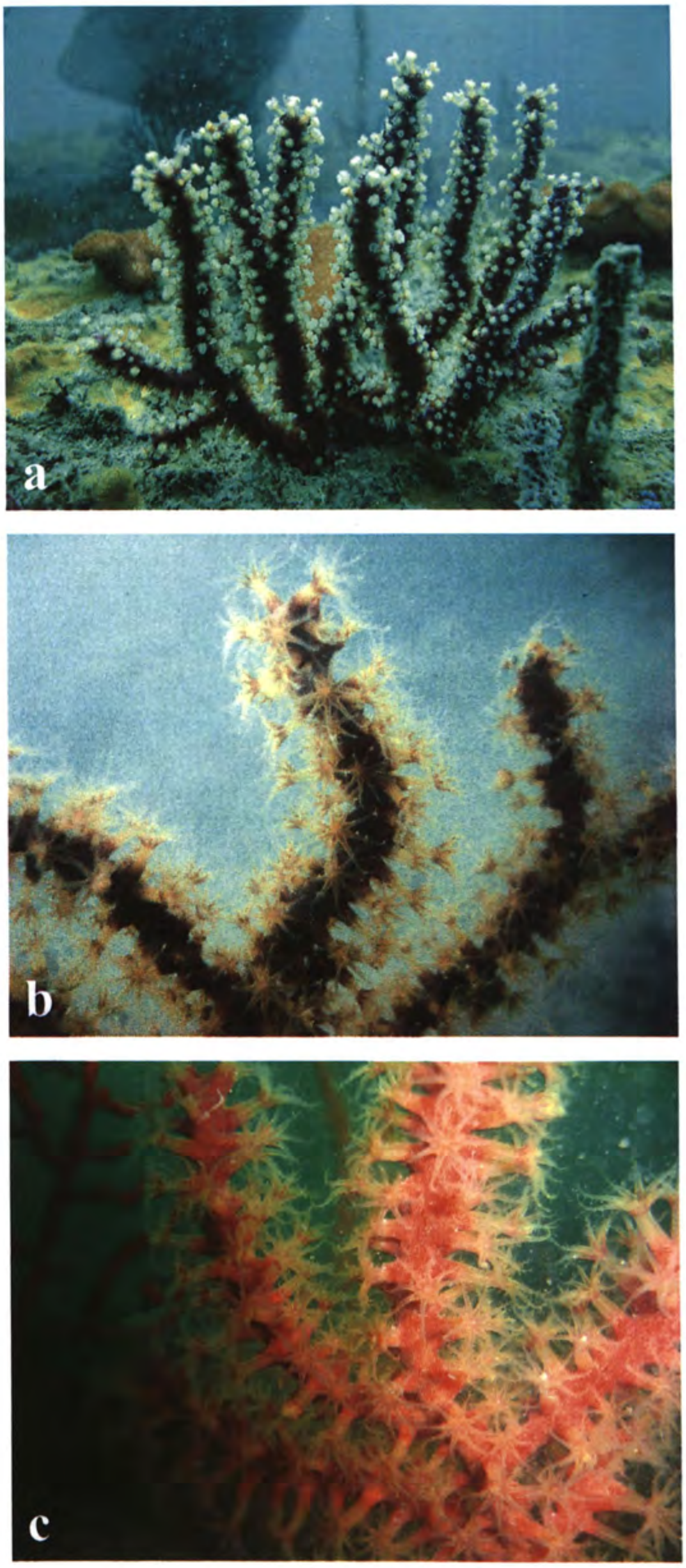


Figure 2.77 Underwater photos of living *Astrogorgia* sp. **(a)** Colony grows in one plane and is sparsely branched. **(b)** & **(c)** Extended polyps with prominent calyces in two rows down the edges of the branches.

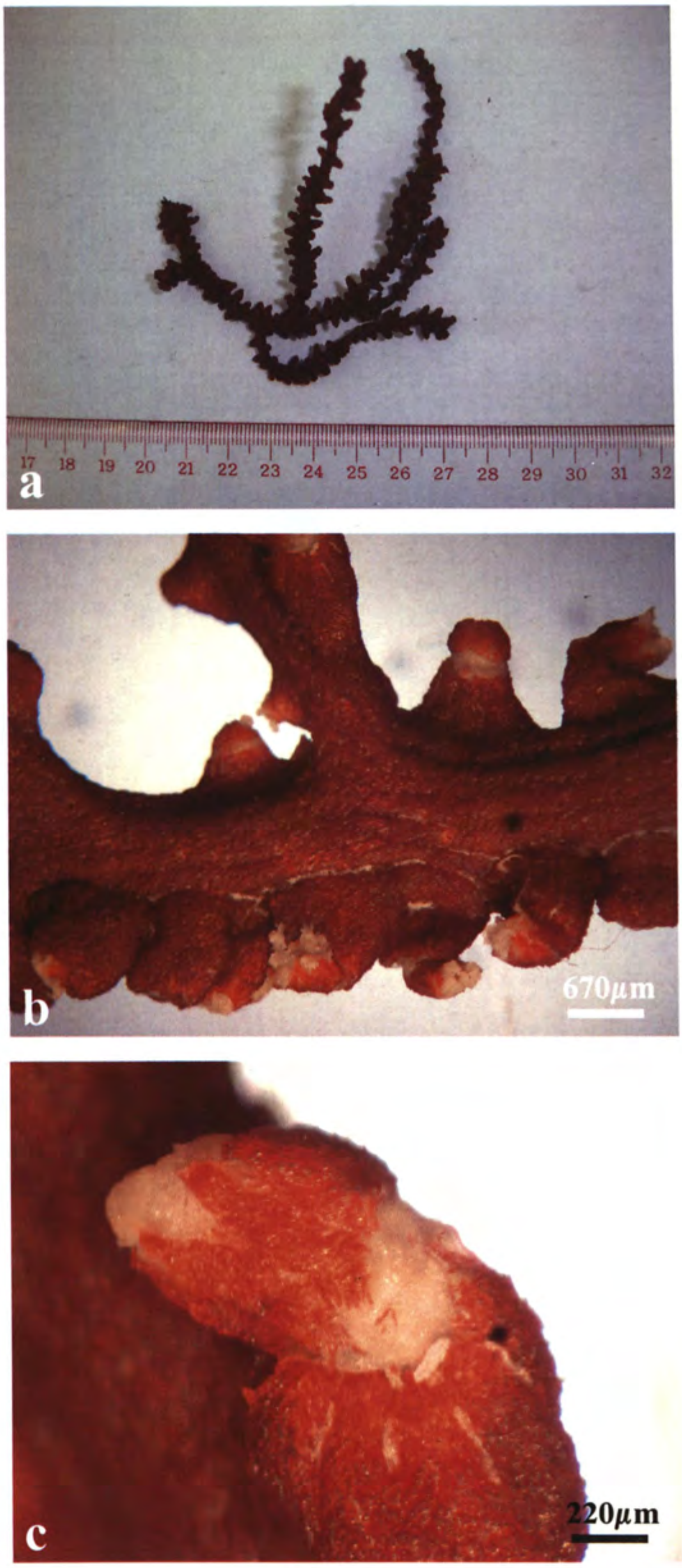


Figure 2.78 Preserved material of *Astrogorgia* sp. **(a)** Calyces are arranged in two rows down each edge of the branches. **(b)** Close-up of the branch, with polyps and calyces clearly shown under the dissecting microscope (15x). **(c)** Polyp head is covered with numerous short spindles arranged in eight longitudinal groups (45x).

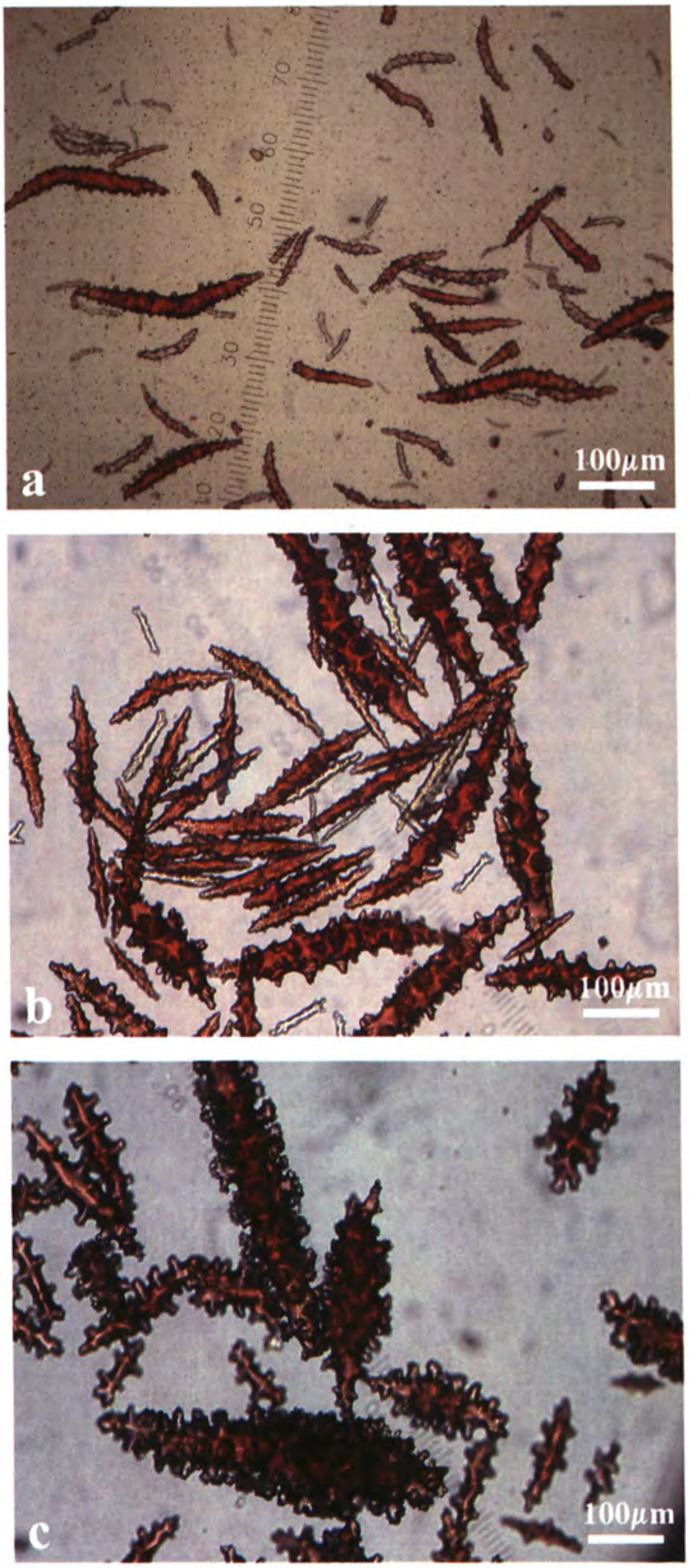


Figure 2.79 Colored sclerites of *Astrogorgia* sp. under the compound microscope (100x). **(a)** Sclerites from the tentacles are colorless, small and flattened. **(b)** Spindles from the wall of calyces. **(c)** Larger and more complexly warted spindles are found in the surface layer of branches.

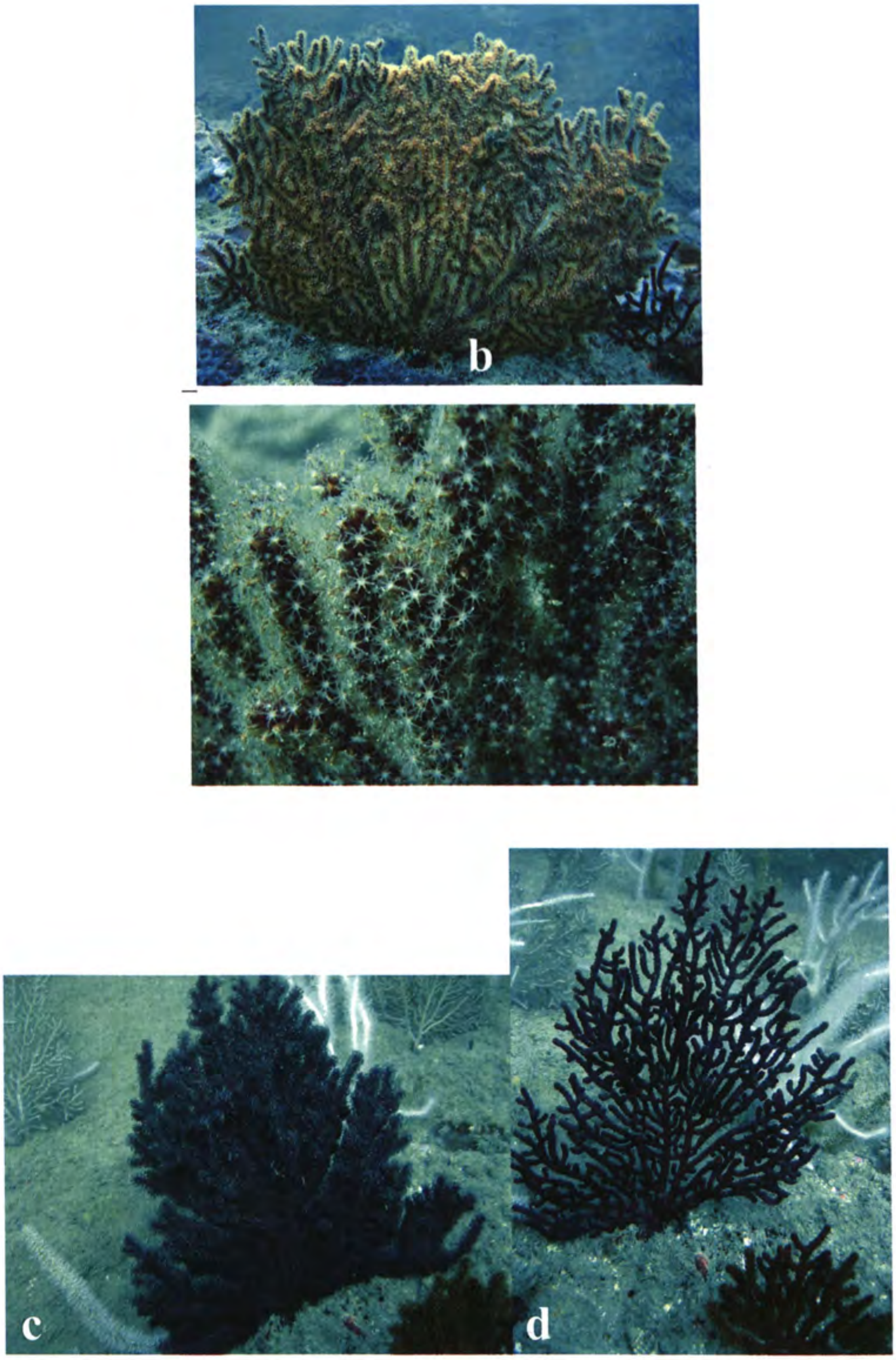


Figure 2.80 Underwater photos of living *Echinogorgia* spp. **(a)** & **(b)** *Echinogorgia* sp. A colony is in brick red color with yellow polyp. **(c)** & **(d)** Colony of *Echinogorgia* sp. B is grey purple in color. Both colonies grow in one plane and in fan shape.

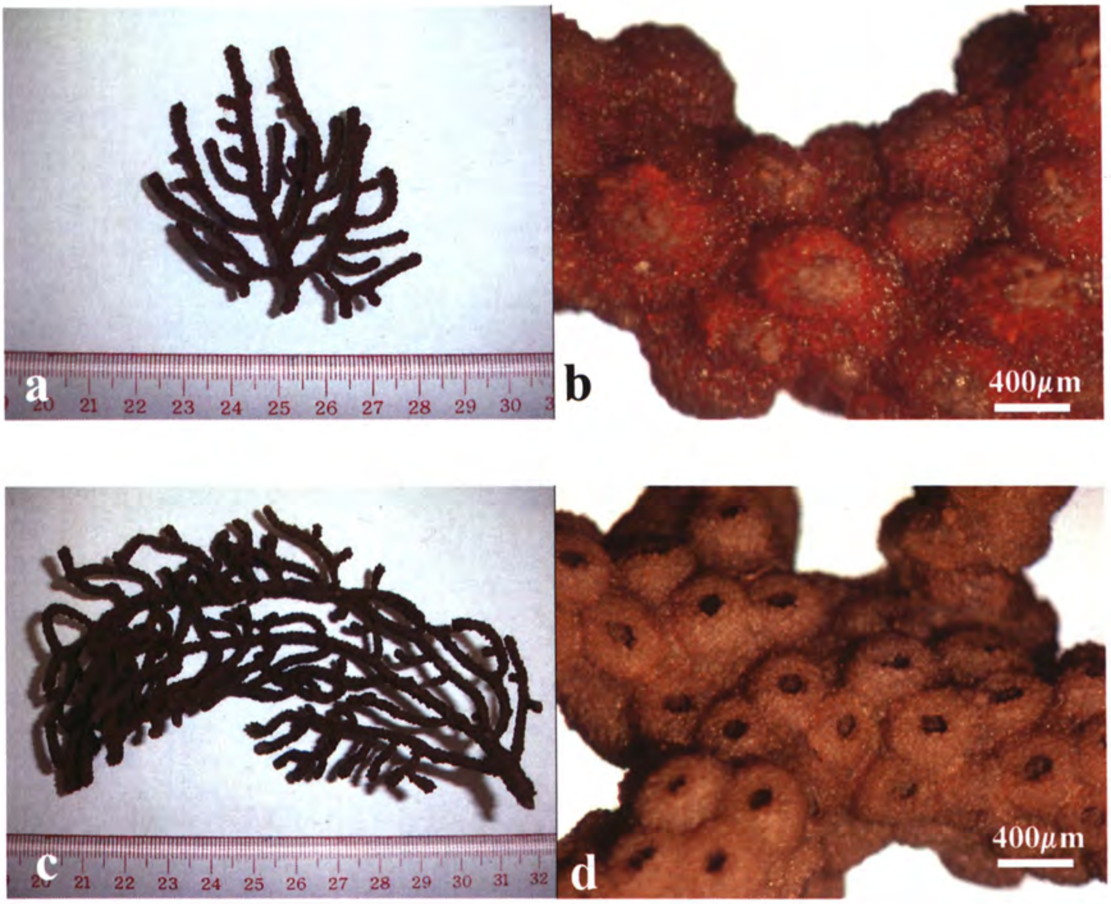


Figure 2.81 Preserved materials of **(a)** & **(b)** *Echinogorgia* sp. A and **(c)** & **(d)** *Echinogorgia* sp. B colonies. Both of them lost their original colors after preservation. Close-up of the branches **(b)** & **(d)** observed under the dissecting microscope shows the prominent calyces as the polyps completely retracted into them (25x).

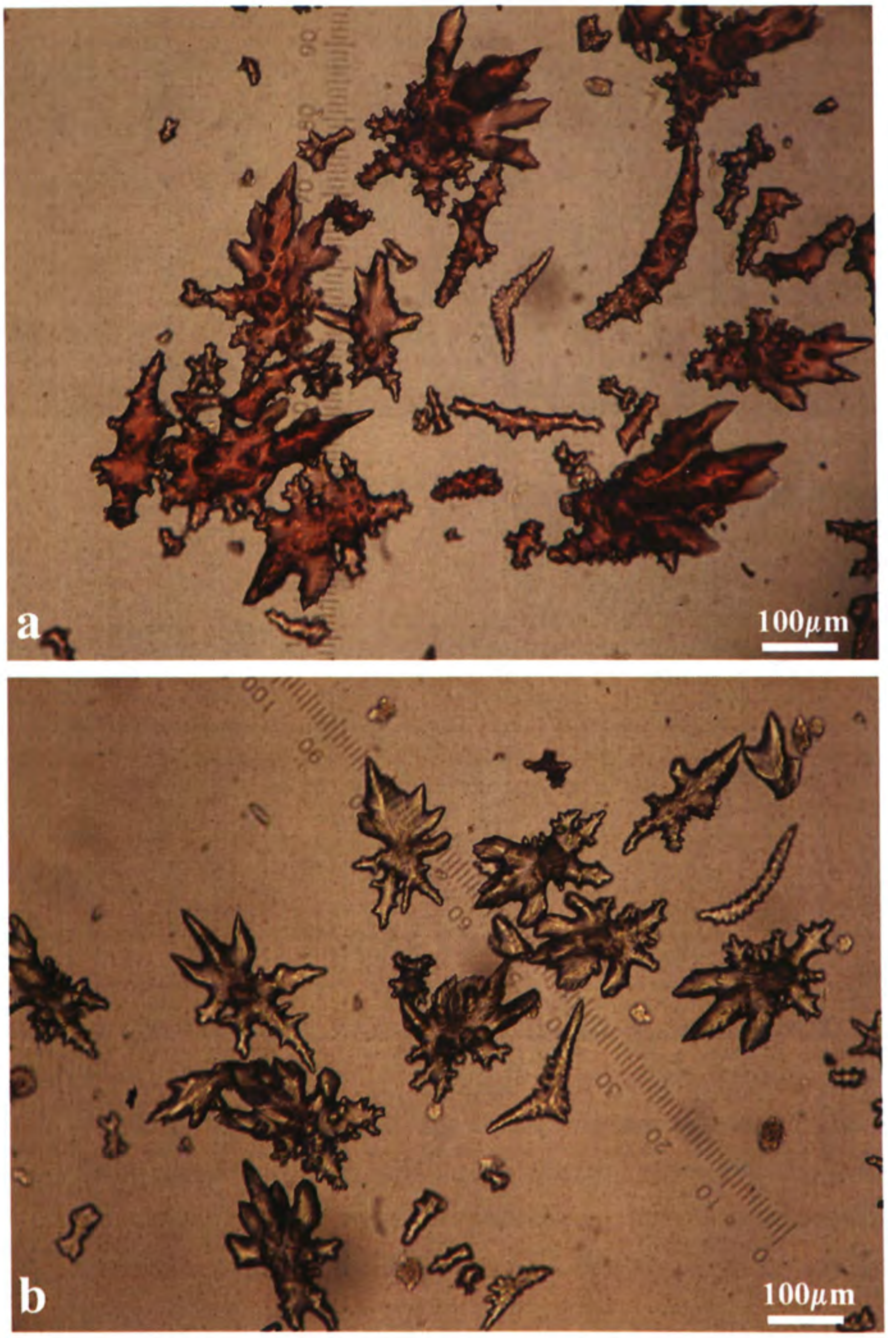


Figure 2.82 Colored sclerites from **(a)** *Echinogorgia* sp. A and **(b)** *Echinogorgia* sp. B observed under the compound microscope (100x). Well-formed thornscales are present in the calyx and surface layer. They are thorn-like or blade-like projections bearing a tuberculate root structure. The root structure of sclerites from sp. B is more complex than that of sp. A. Hockey stick-shaped or bow-shaped spindles are formed in the polyp heads.

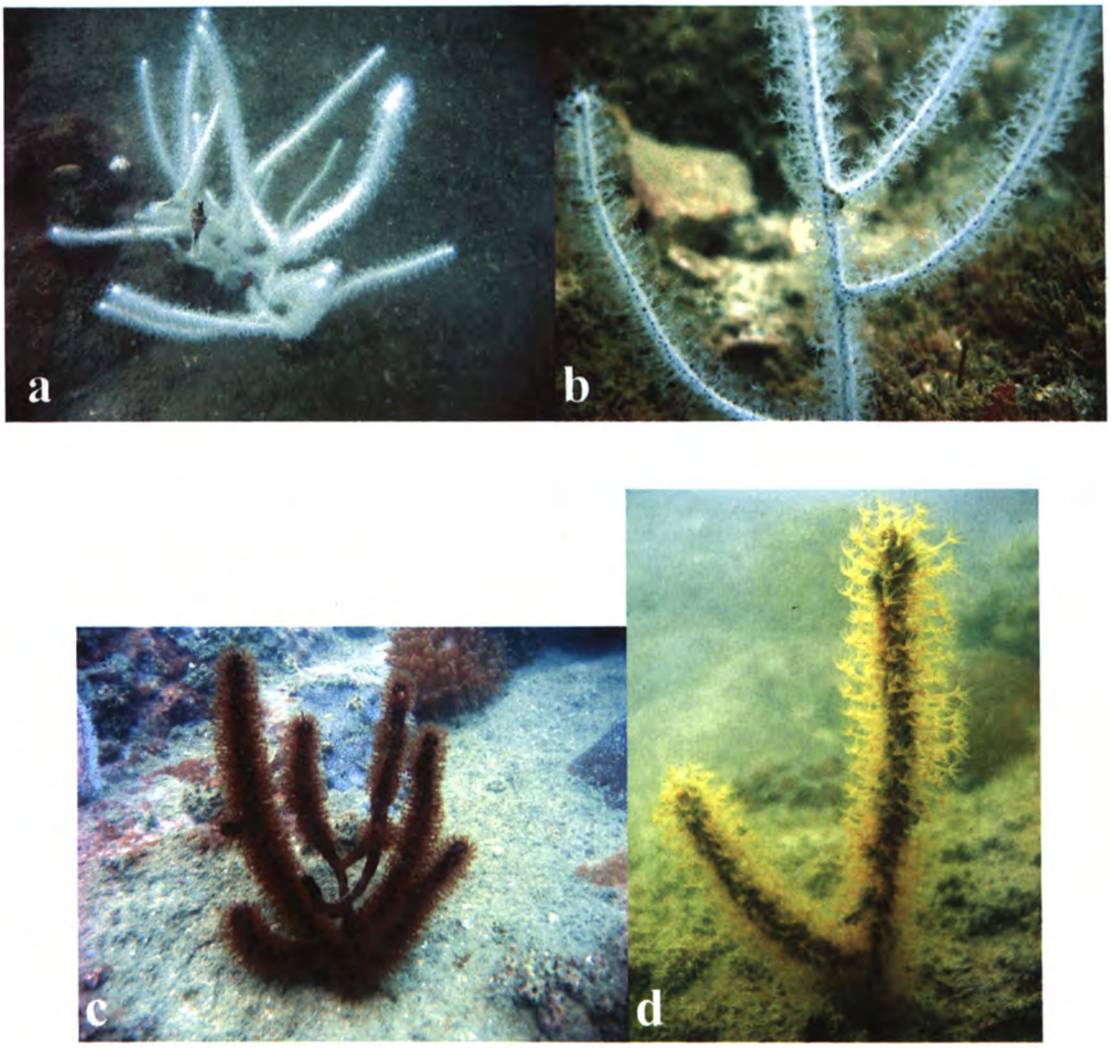


Figure 2.83 Underwater photos of living *Echinomuricea* spp. **(a)** & **(b)** Colony of *Echinomuricea* sp. A is white in color and sparsely branched, with few, long and slender branches. **(c)** & **(d)** Colony of *Echinomuricea* sp. B is brown in color, with thicker branches that appear as loose bushes.

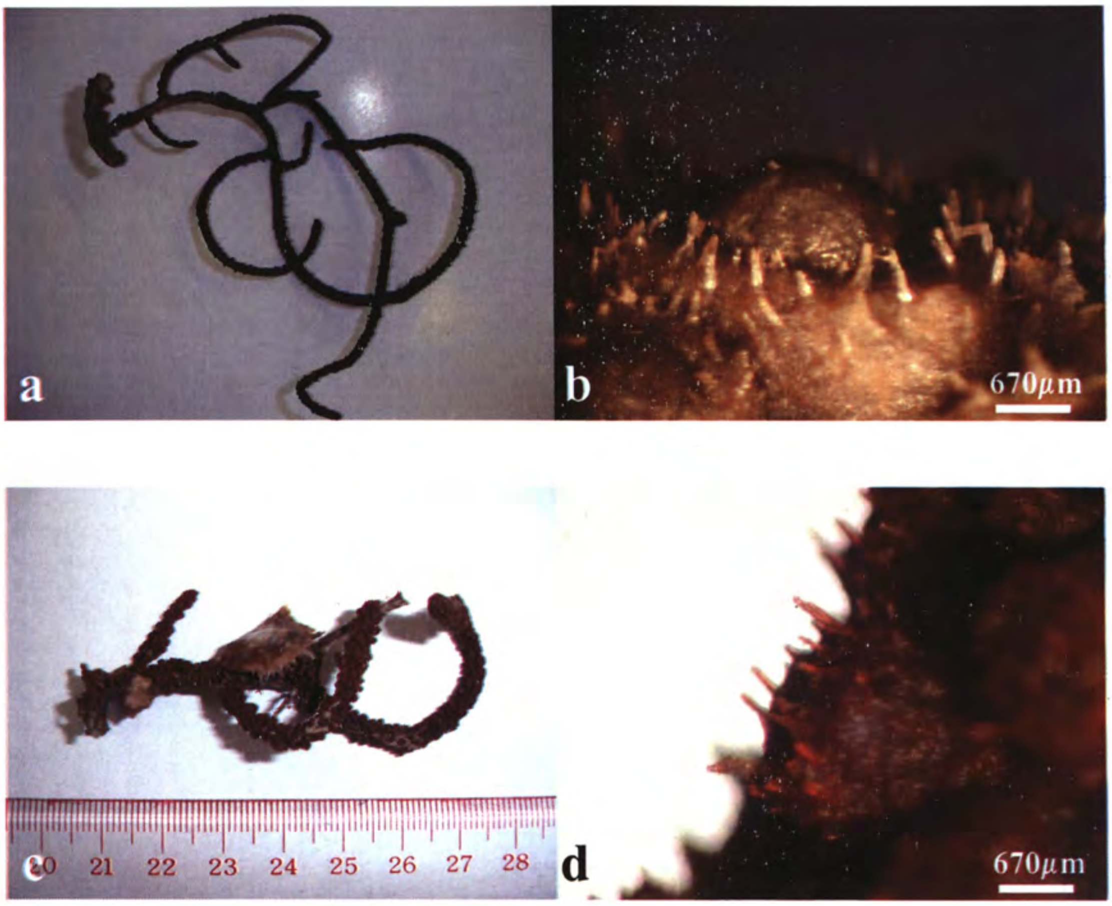


Figure 2.84 Preserved materials of **(a)** & **(b)** *Echinomuricea* sp. A, **(c)** & **(d)** *Echinomuricea* sp. B. Colonies lost their original colors after preservation. **(b)** & **(d)** Close-up of the polyps observed under the dissecting microscope showing the protrusion of long pointed ends of the thornscales of the calyces, giving the colony a spiny appearance (15x).

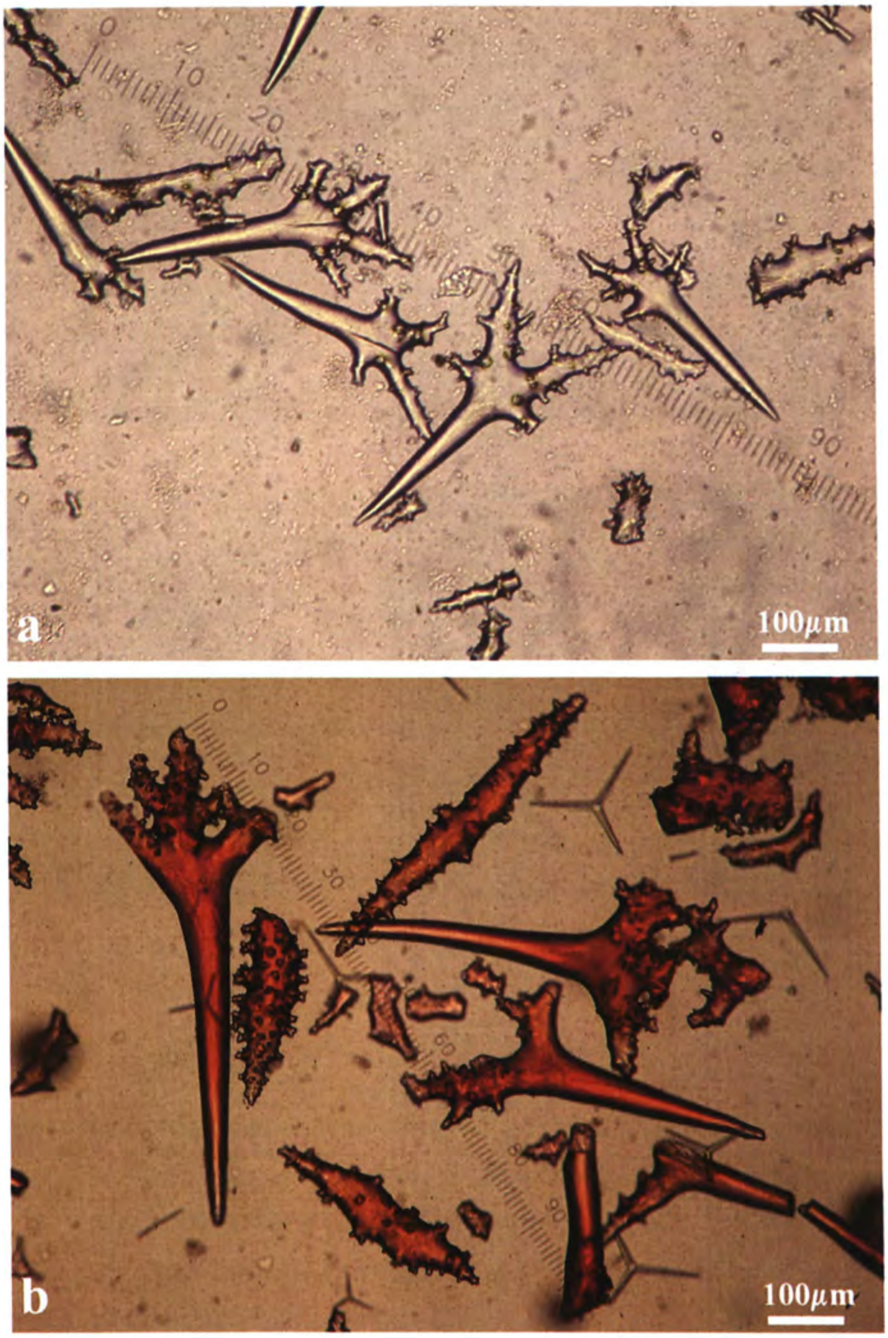


Figure 2.85 Sclerites of **(a)** *Echinomuricea* sp. A and **(b)** *Echinomuricea* sp. B (100x). Thornscales are present in the calyx and surface parts of the colony. They have a long and smooth spine with a spreading and warty base. Bases of thornscales in **(a)** are in 4-radiate associated with lesser warts. Bases of thornscales in **(b)** are more complex and warty.

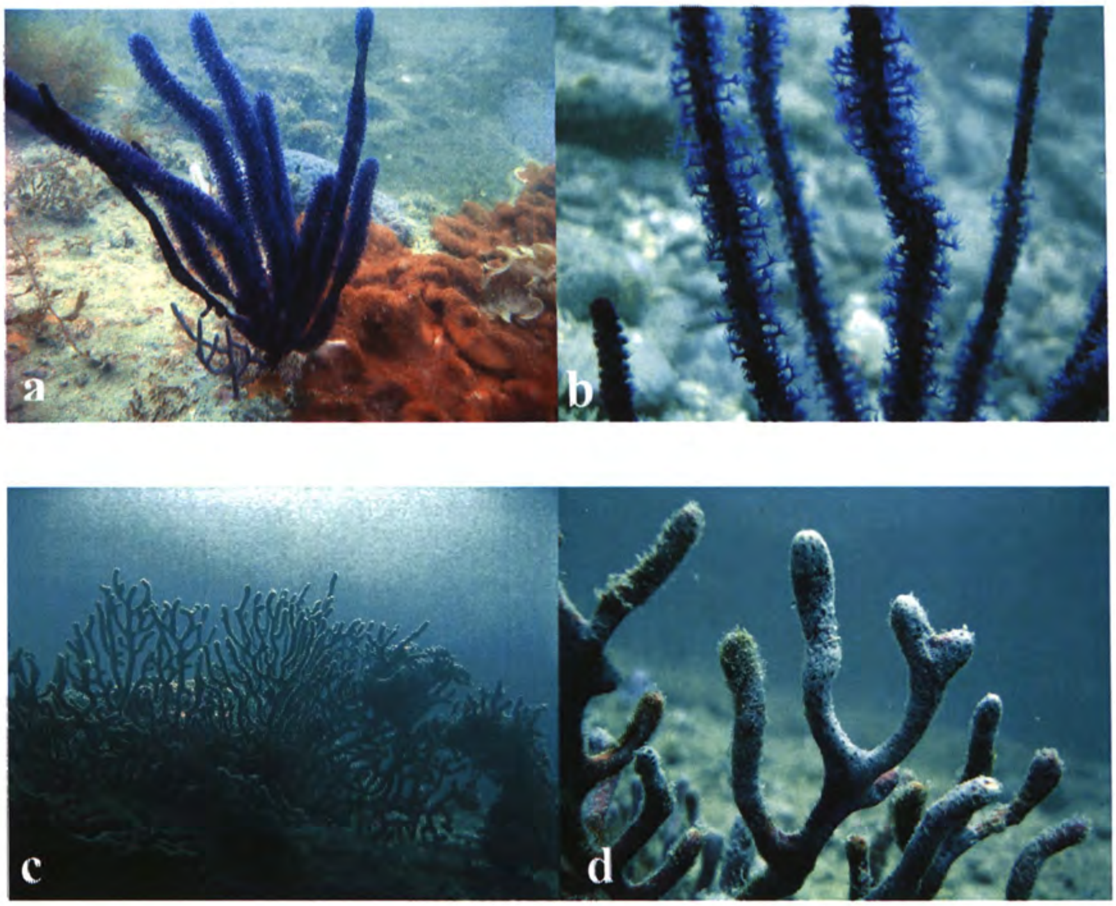


Figure 2.86 Underwater photos of living *Euplexaura* spp. in two growth forms. **(a)** & **(b)** Colony is sparsely branched. **(c)** & **(d)** Colony is richly branched and grows in one plane. The coenenchymes in the stem and branches are thick and the branchlets are short that arise more or less at right angles from the base and curve upwards.

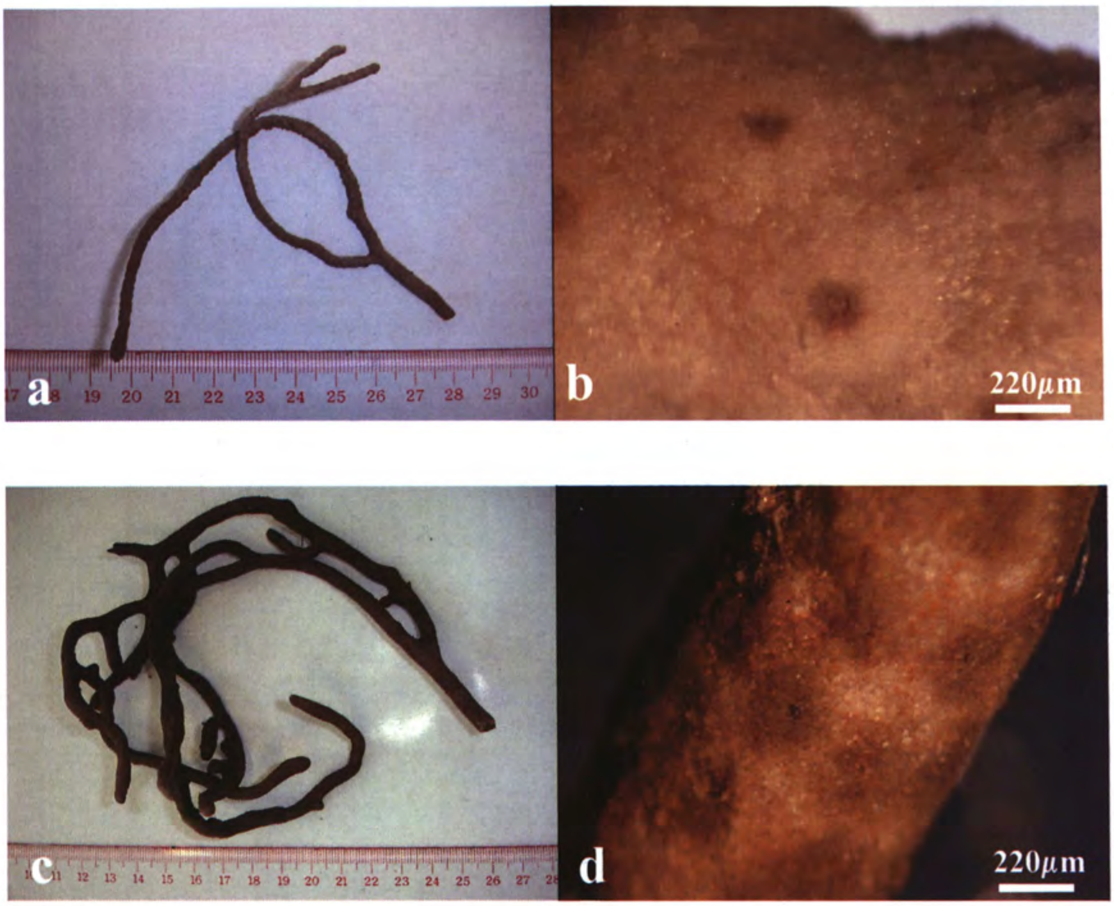


Figure 2.87 Preserved materials of **(a)** & **(b)** sparsely branched colony and **(c)** & **(d)** richly branched colony of *Euplexaura* spp. The coenenchyme layer of the richly branched colony is thicker than that of the other one. **(b)** & **(d)** Close-up of the calyces showing large apertures resulted from the retraction of polyps from the branch surface as observed under the dissecting microscope (45x).

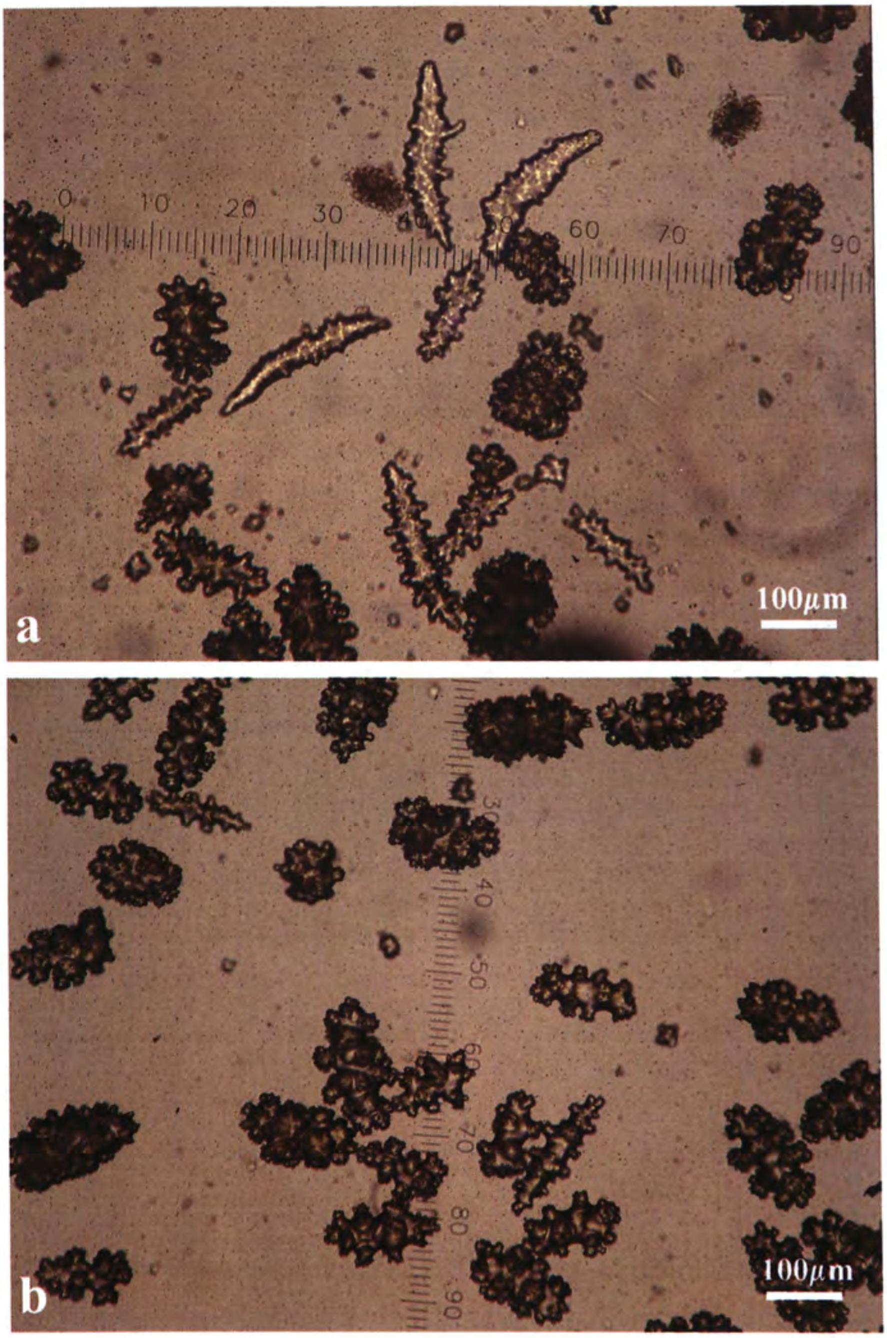


Figure 2.88 Colorless sclerites of the sparsely branched *Euplexaura* sp. under the compound microscope (100x). **(a)** Large spindles in the polyp heads; **(b)** Plump spindles associated with large complex warts from the surface. Some of them are oval shape.

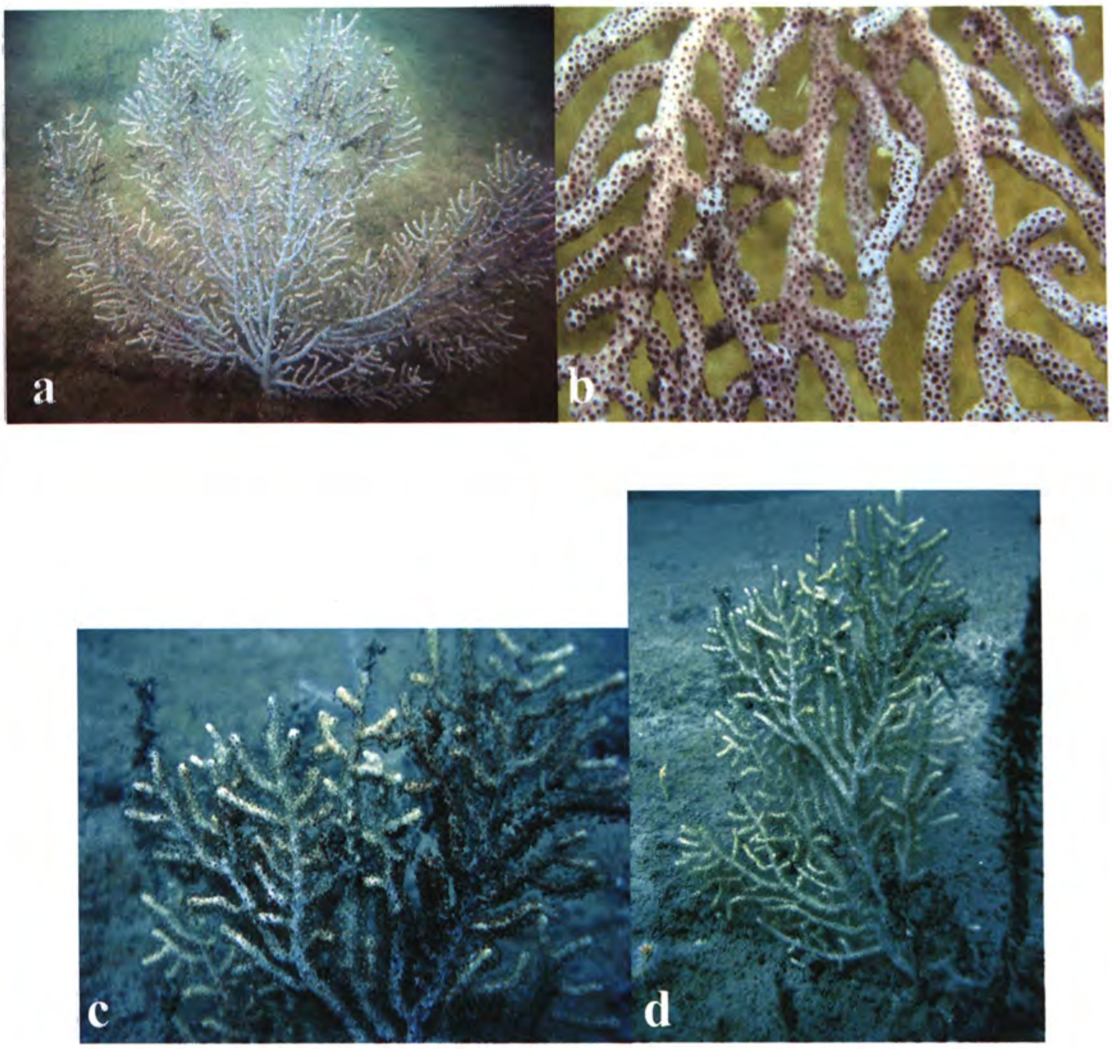


Figure 2.89 Underwater photos of living *Menella* spp. Colonies grow on a plane and are richly branched. **(a)** & **(b)** Branches of *Menella* sp. A are white in color with red polyps. **(c)** & **(d)** Branches of *Menella* sp. B are white in color with yellow polyps. Some darker pits on the stem surface can easily be observed after the polyps completely retracted.

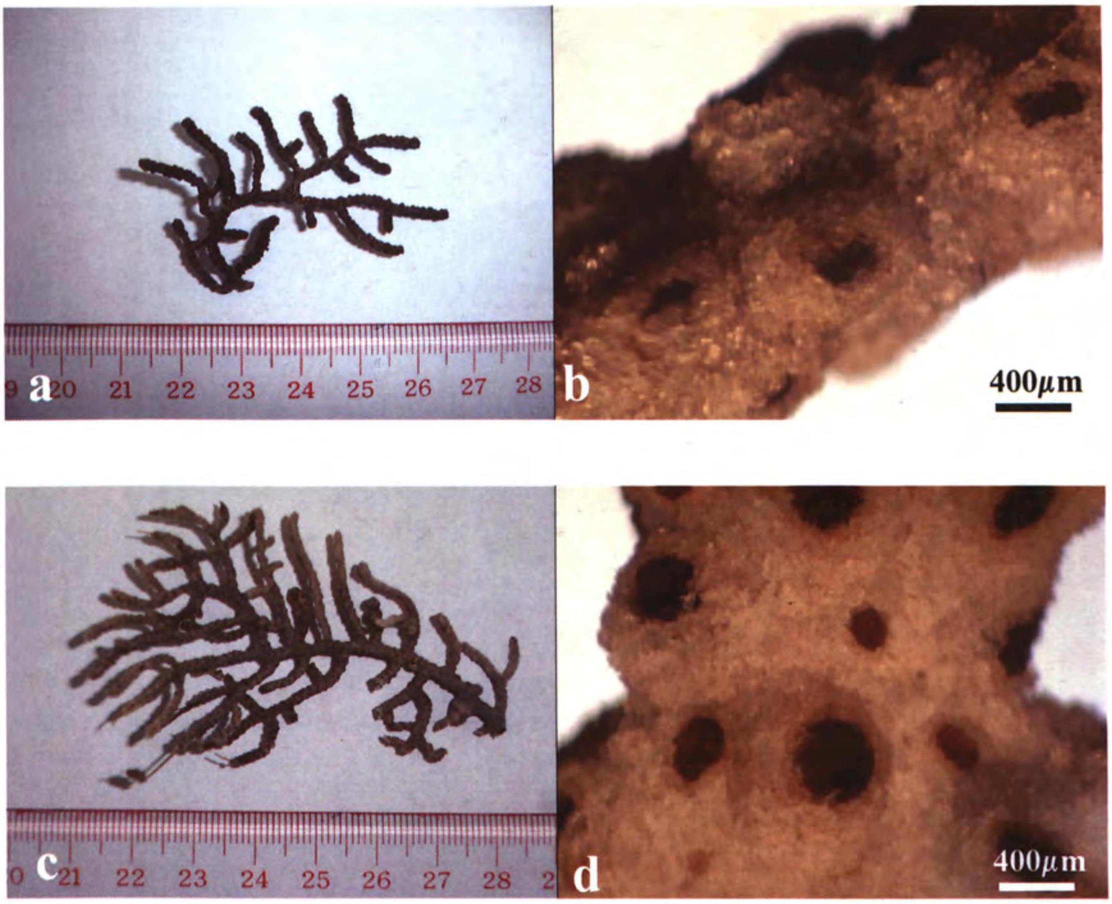


Figure 2.90 Preserved materials of **(a)** & **(b)** *Menella* sp. A and **(c)** & **(d)** *Menella* sp. B. Colonies lost their original white color after preservation. Close-up of the stalk surface are shown in **(b)** & **(d)** under the dissecting microscope (25x). Some darker pits on the stem surface can easily be observed after the polyps completely retracted into the hemispherical calyces.

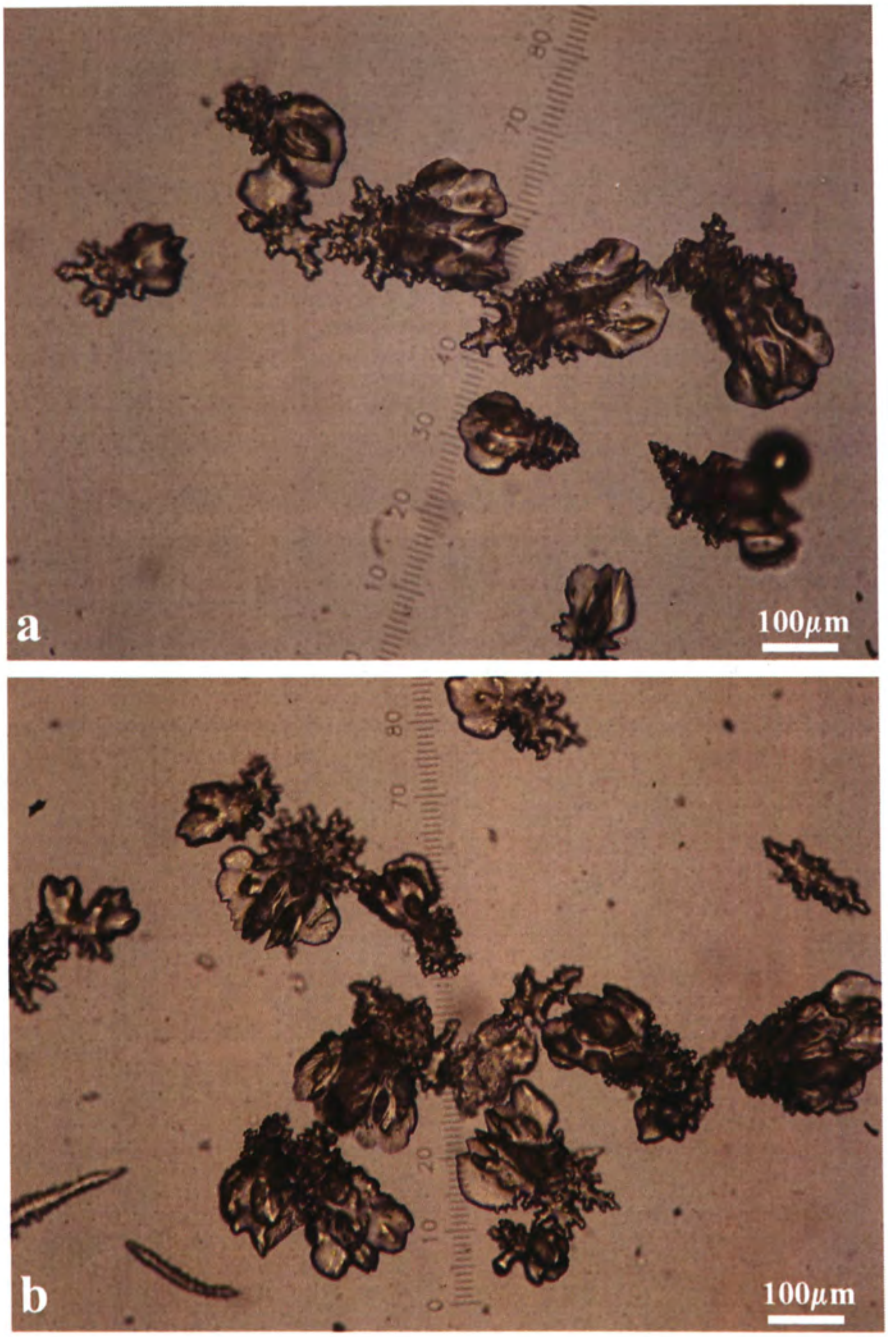


Figure 2.91 Colorless sclerites from **(a)** *Menella* sp. A and **(b)** *Menella* sp. B, observed under the compound microscope (100x). The characteristic sclerite of this genus is the leaf-scale, which is associated with a tuberculate and bifurcate "root" structure. The blade portion is thickened and has irregular ribs down the side.

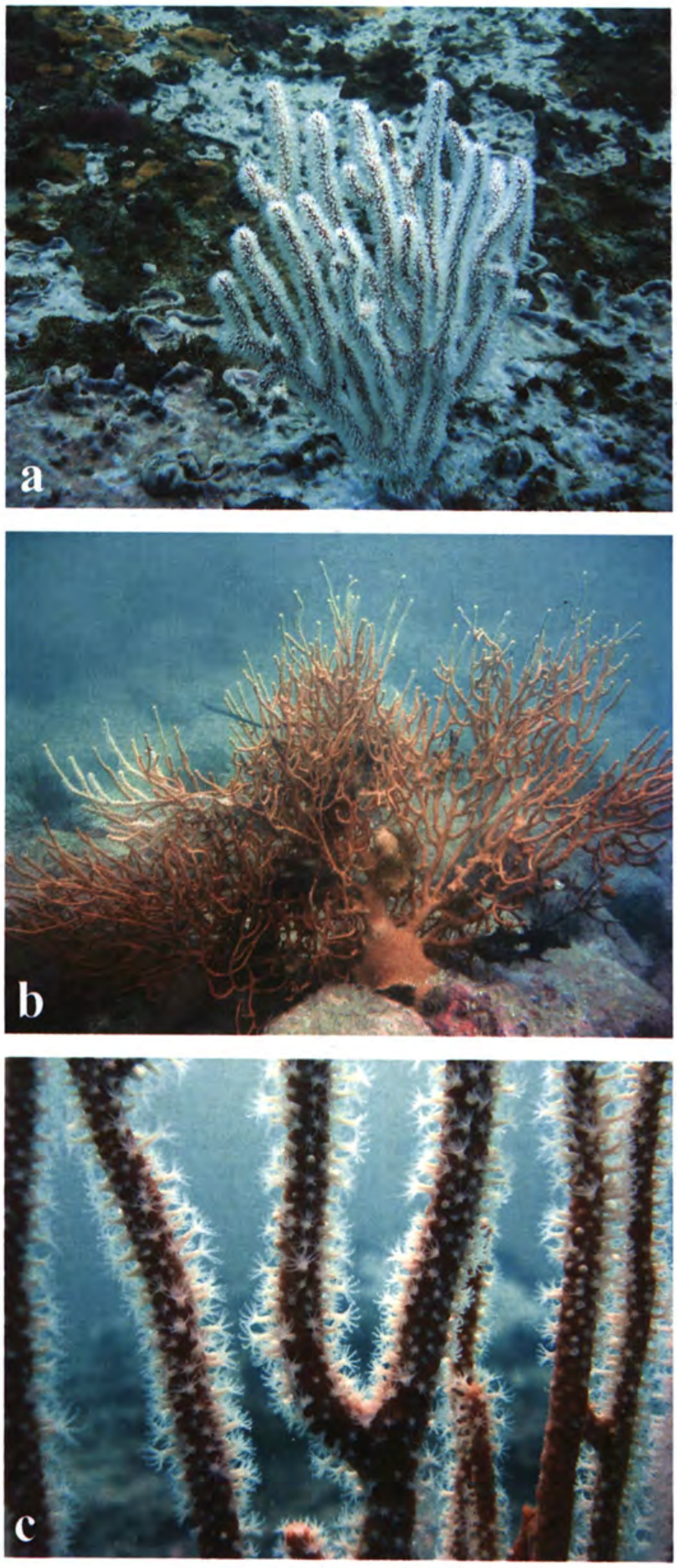


Figure 2.92 Underwater photos of living *Paraplexaura* sp. **(a)** Sparingly branched colony. **(b)** A richly branched colony. **(c)** Orange branches with white polyps.

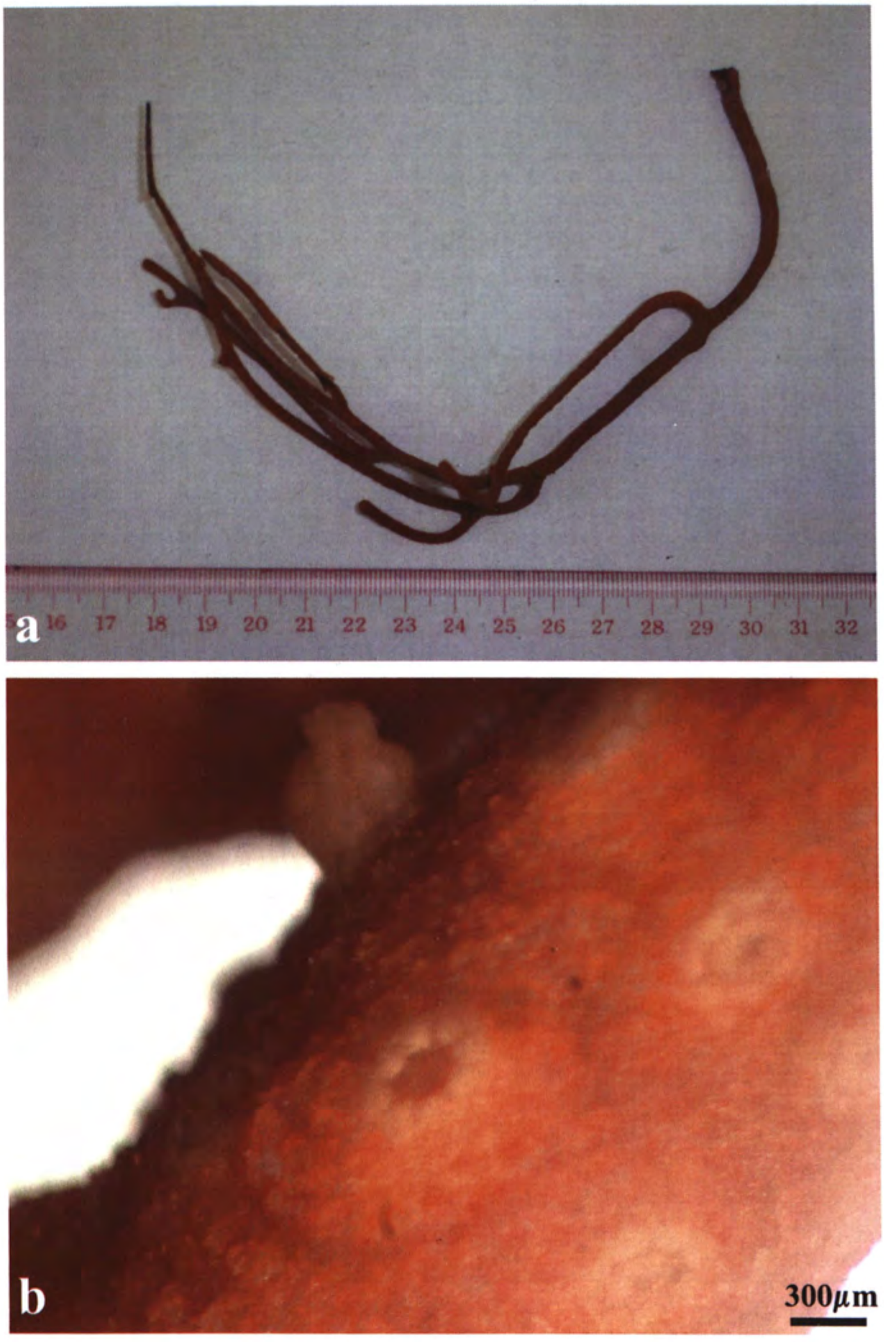


Figure 2.93 Preserved material of *Paraplexaura* sp. **(a)** Side branches arise at nearly right angle from the base and curving upwards. **(b)** Close-up of the branch surface under dissecting microscope, with retracted polyp surrounded by a calyx (35x).

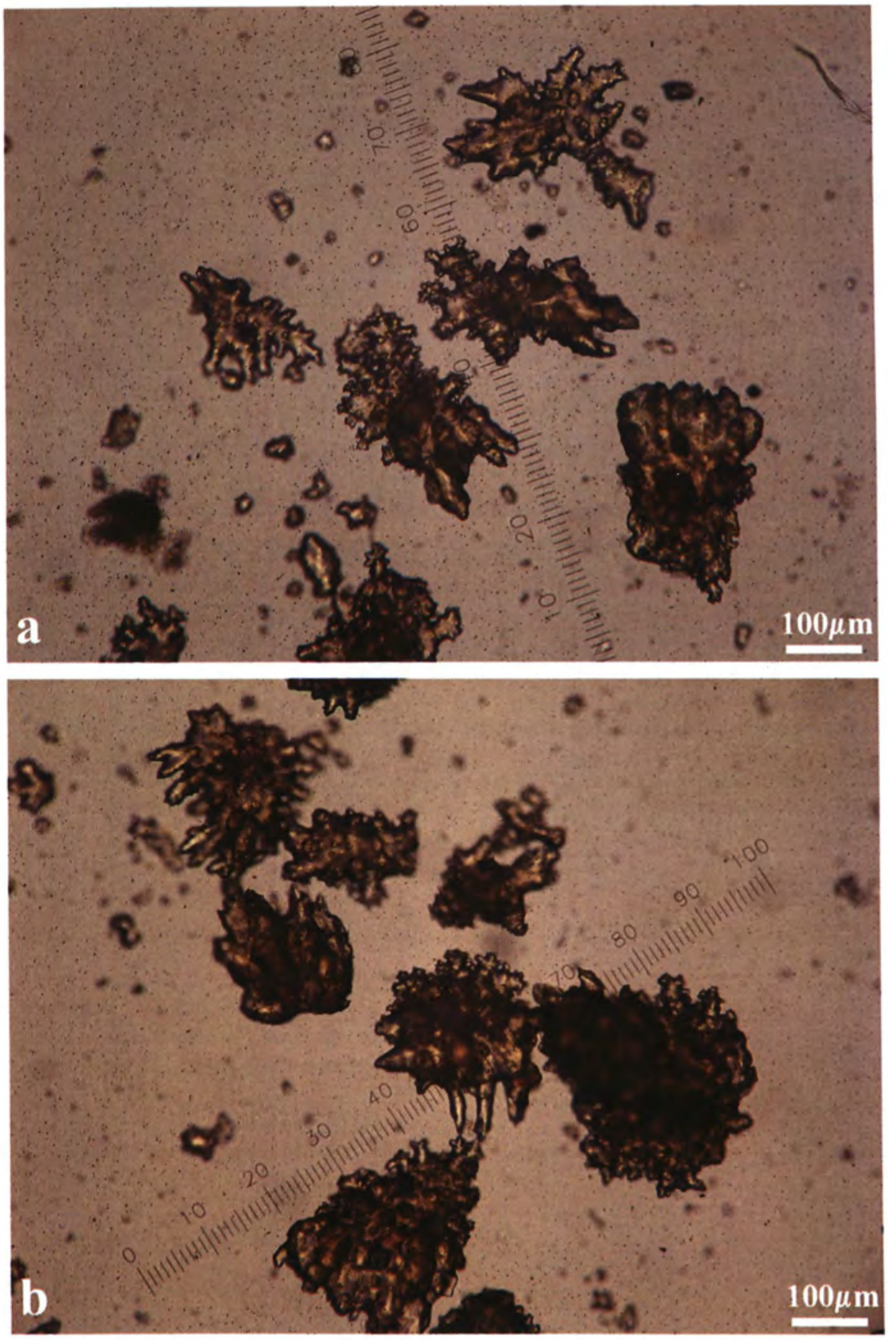


Figure 2.94 Colored sclerites of *Paraplexaura* sp. under the compound microscope (100x). **(a)** Thick thornscales with thorny projections on the top from the calyces of polyps. **(b)** Massive sclerites with huge thorns on the top and complex tubercles on the base from the surface layer of branches.

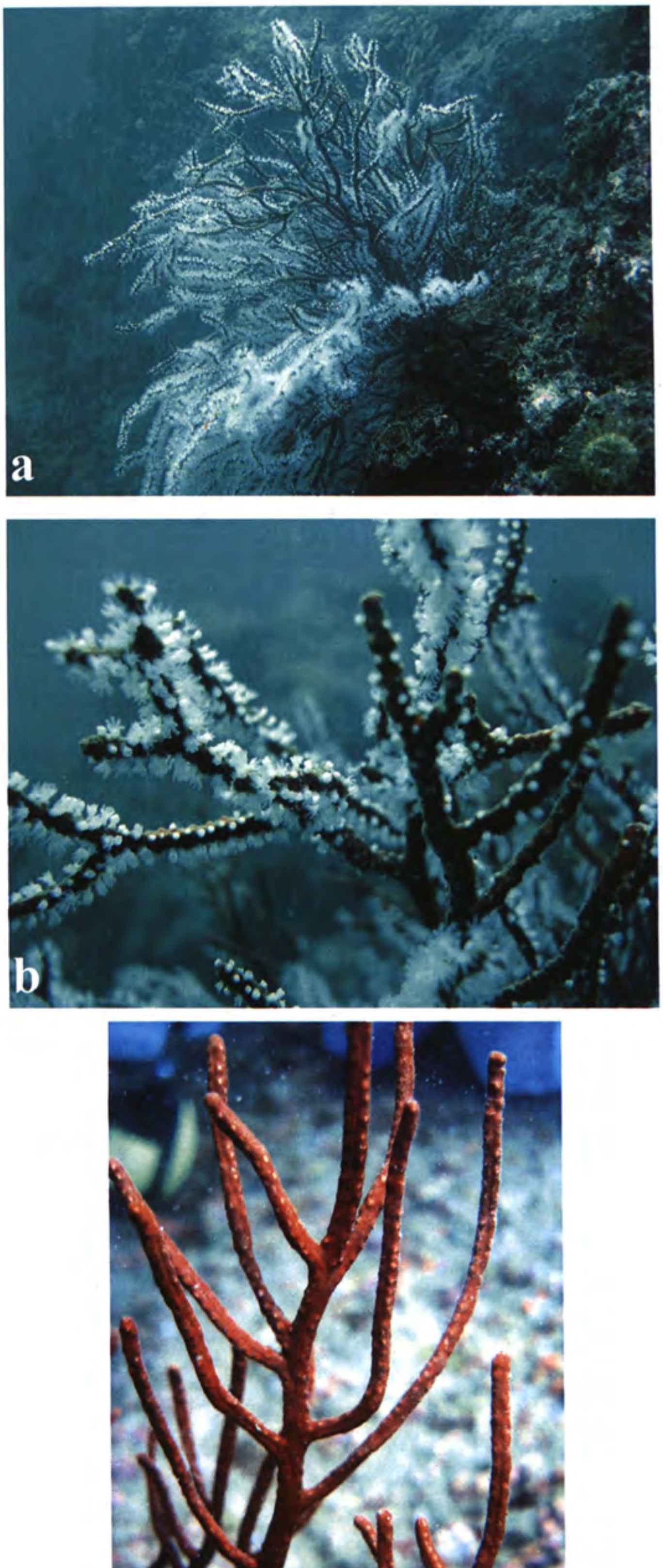


Figure 2.95 Underwater photos of living *Subergorgia* sp. (a) Large colony found in Tung Ping Chau Marine Park. (b) White polyps along two sides of branches. (c) Dichotomously branched colony.

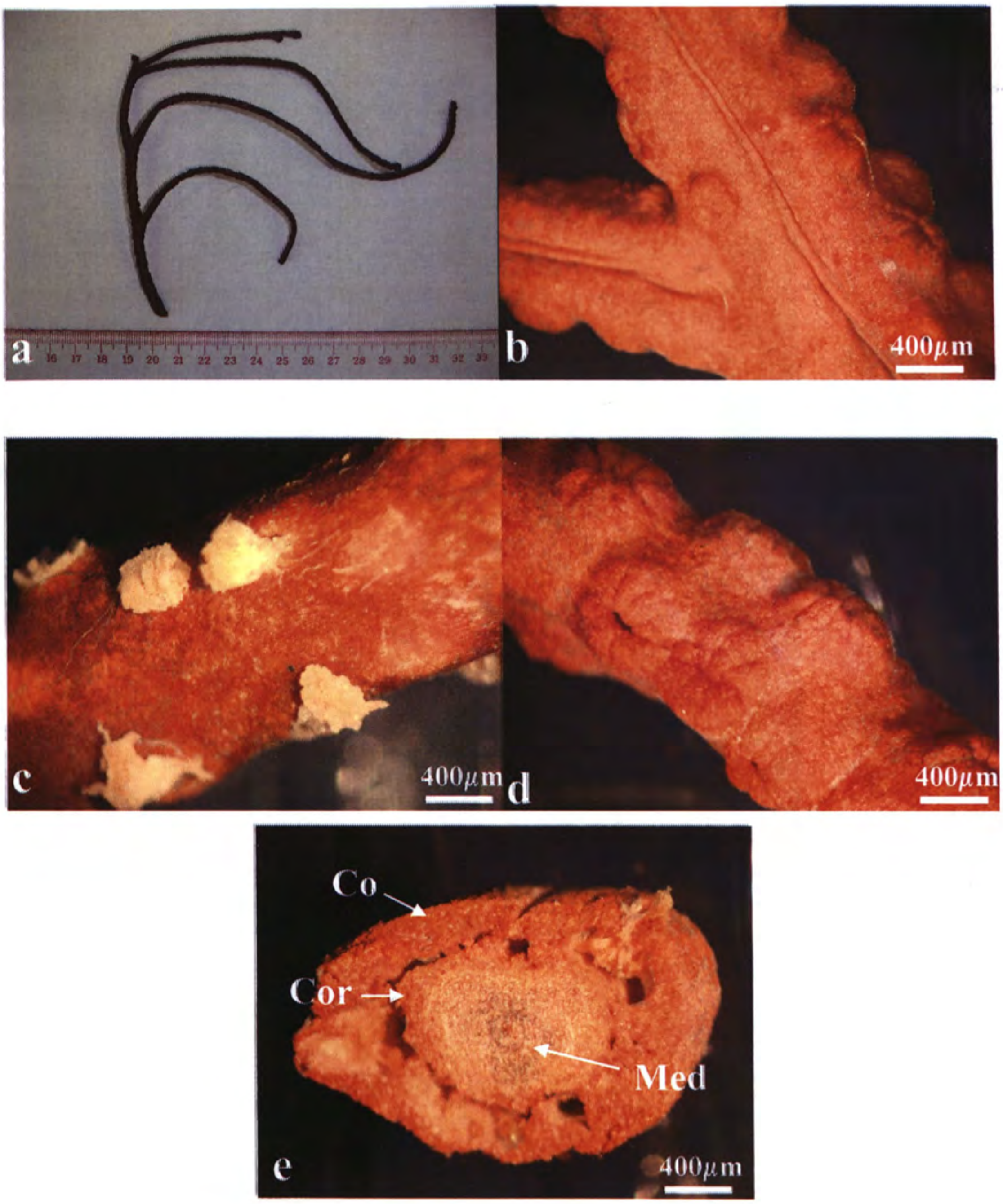


Figure 2.96 Preserved material of *Subergorgia* sp. showing **(a)** dichotomous branches, **(b)** narrow groove running along the branch (25x), **(c)** white polyps laying on the branch surface (25x) and, **(d)** polyps retracted into dome-shaped mounds (25x). **(e)** Cross-section of the stem showing the coenenchyme (Co), the cortex (Cor) and the horny axial medulla (Med) under the coenenchyme (35x).

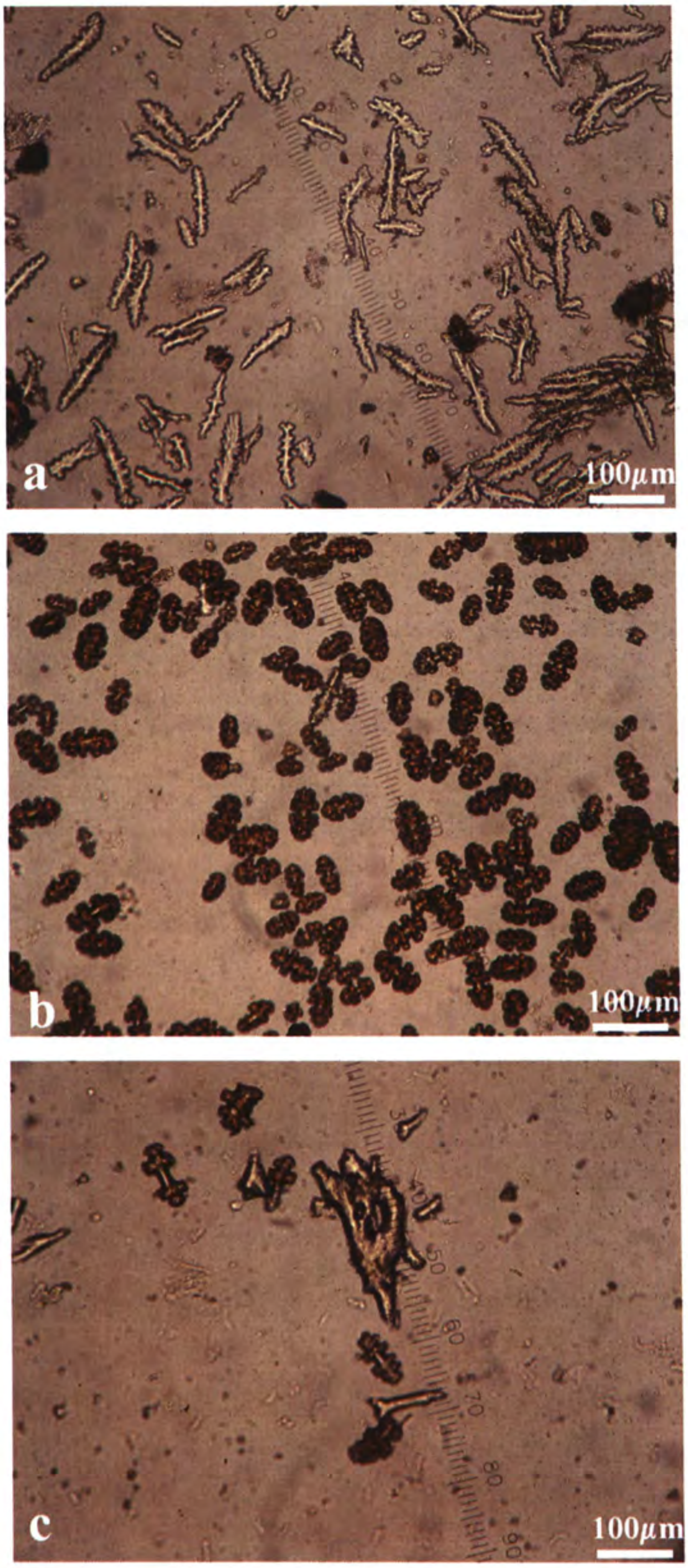


Figure 2.97 Colorless sclerites of *Subergorgia* sp. observed under the compound microscope (100x). **(a)** Flattened spindles in polyp heads. **(b)** Cortex sclerites are warty ovals, with girdles of warts, **(c)** Sclerites in the medulla are branched and fused together.

Chapter 3 Spatial Comparison of Octocoral Assemblages in Tung Ping Chau Marine Park (TPCMP)

3.1 Introduction

Spatial patterning of marine benthic organisms is an important feature that reflects the habitat complexity and the structuring effects of both biotic (e.g. intra- and inter-specific competition, mode of nutrition and reproduction) and abiotic (e.g. temperature, light intensity, salinity, nutrient concentration and water movement etc.) factors. The spatial distribution of organisms may be a result of functional relationships among multi-species populations and the interactions of these organisms with the environment (Buss, 1986).

Octocorals are one of the most important faunistic compositions in the marine environment. They achieve high abundance in many coral reefs (Benayahu & Loya 1981; Tursch & Tursch 1982; Dinesen 1983). In early 1970s, Carpine & Grasshoff (1975) suggested three possible factors that influence the settling, growth and distribution of octocorals. These include 1. depth: which is related to the irradiance and temperature (e.g. thermocline); 2. hydrodynamics: which are important for the food intake; and 3. substratum type: which includes soft and hard substrata. Allelopathy and the mode of reproduction are also important factors affecting species composition, distribution, abundance and growth forms of octocorals in a particular locality. Subsequently, more and more researches have focused on the relationships between the octocoral community structure and environmental variables, and showed that depth and availability of hard substratum were also significant factors that influenced the spatial compositions of octocorals (Kinzie 1973, Benayahu 1985, Goh & Chou 1994, Clark 1997, Fabricius & McCorry 2006).

Depth is an important factor in structuring and limiting the growth of soft corals and gorgonians. In the preliminary surveys of the gorgonian fauna of Singapore (Goh & Chou 1994), a total of 715 specimens were recorded and 86% of the colonies were found at the bottom (<22.2 m), 11% on the slope (4.5-10.9 m) and only 3% on the crest (1.5-4.2 m) of the reef. Clark (1997) suggested the preference of gorgonians for deeper water as she observed a general trend for the species richness and abundance to increase steadily from -1 to -22 m CD (Chart Datum) in an ahermatypic coral assemblage at Cape D' Aguilar, Hong Kong. A more up-to-date study (Fabricius & McCorry 2006) in Hong Kong added more evidence to support Clark's statement. In this latter study, the octocoral cover was found to be lowest in shallow and wave-exposed waters, while the highest (5%) cover was recorded in Tseung Kwan O at 8-10 m depth. Overall data showed that the richness of zooxanthellae-free taxa increased with depth.

Hydrodynamics is crucial for the growth and distribution of octocorals. As these corals are passive suspension feeders, they reply on the water current for food delivery and waste disposal. However, different flow velocities will result in different food capture efficiency of the coral polyps. Dai & Lin (1993) conducted a study on the effects of water flow rate on the feeding activities of three different gorgonian species from southern Taiwan. They showed that these gorgonians fed most effectively under the moderate flow velocities (~8 cm/s), while the polyp feeding effectiveness declined under water motion condition that was too slow (<4 cm/s) or too strong (>15 cm/s).

Apart from depth and hydrodynamics, hard substratum availability is another factor that contributes in shaping the structure of octocoral communities. Kinzie (1973) studied the zonation pattern of West Indian gorgonians and reported that in the surveyed reef areas among the shore, lagoon and rear zones, the common factor controlling the gorgonian distribution was the type of substratum. The presence and abundance of sand limited the growth of gorgonians. Higher assemblage of them could only be found on hard and firm substrata.

The northeastern waters of Hong Kong support diverse and healthy octocoral communities, especially in Tung Ping Chau Marine Park (TPCMP). Comparing the spatial variations in octocoral assemblages between different areas within the park can help to reveal the topographic and environmental factors affecting the octocoral distribution patterns. The objective of this part of the study was therefore to investigate and compare the diversity and community structures of soft coral and gorgonians in three exposed areas of TPCMP, in two different depth zones (shallow and deep). Information examined in this study and reported in this chapter included the abundance, species composition and relative cover of octocorals, their spatial and vertical distribution pattern, and also the size structure of common octocoral species. The relationship between selected environmental factors, i.e. amount of suspended particulates in the water and water motion, and octocoral community structure are provided and discussed in Chapter 4.

3.2 Study Areas

This study was conducted around the island of Tung Ping Chau in TPCMP (N 22°32', E 114°25'), located in the northeastern most region of Hong Kong Special Administrative Region (HKSAR), China (Figs. 2.1-2.2). TPCMP is the fourth marine park in Hong Kong and was designated in November 2001 covering a sea area of about 270 hectares. Two core areas, A Ye Wan (AYW) and A Ma Wan (AMW), were set up on the northeastern side of the island where more extensive coral communities are located in order to protect the corals and other valuable marine lives. All fishing activities are prohibited inside the core areas. The coral cover in AYW was 45.8% and 54.4% in A Ma Wan (Ang *et. al.* 2000). The southern to southeastern sides of the island are much more exposed to strong waves so only layers of sedimentation rock and larger boulders can be found in these areas with very low hard coral cover. However, the octocorals in deeper areas (>-3 m CD) along these shores tend to be more abundant. In this research, a total of three areas were chosen as study sites along these exposed shores, including Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) (Fig. 3.2). These sites are usually exposed to southwestern winds in summer and northeastern winds in winter. More detailed descriptions of each of these sites are provided below.

3.2.1 Kang Lau Shek (KLS)

This is located in the southeastern tip of TPCMP (N 22 ° 32' 446", E 114° 26' 584"). It is renowned for the presence of two unique stacks of sedimentary rocks of about 7-8 m high that sit on the wave-cut platform near the sea. Layers of sedimentation rocks extend all the way underwater, forming a steep slope with high topographic relief. Big boulders and rocks are the most common substratum type. The seaweed *Lobophora variegata* and bryozoans are common flora and fauna found on the rock surface in the shallow water areas. Sedimentation is high beyond -13 m CD.

3.2.2 Lan Guo Shui (LGS)

This is located on the southern coast of TPCMP (N 22 ° 32' 179",E 114° 26' 333"). Long vertical cliff along the coast is the major characteristic of this site. This feature is the result of continuous exposure to wind and wave actions. Layers of sedimentation rocks also extend all the way underwater but only a gentle slope is formed. The deepest depth for this site is -14 m CD, and a sandy flat bottom with heavy sedimentation is found beyond the rock layers. This site is thus characterized as having a moderate topographic relief. *Lobophora variegata*. is one of the dominant seaweeds in the shallow water areas, with various species of *Sargassum* also found especially during winter and spring.

3.2.3 Lung Lok Shui (LLS)

This is located in the southwestern coast of TPCMP (N 22 ° 32' 344", E 114° 25' 631"). This site is characterized by having layers of metamorphic rocks with rugged triangular edges, resembling the backbone of a "dragon", that extend from the coast into the sea. This rock formation is a result of differential erosion of rock layers of different hardness. Sedimentary rock layers are also found extending from the shore to the water depth of about -12 m CD. Comparing with KLS and LGS, the slope in this site is the least steep among the three sites and the topographic relief is moderate-low. The shallow water region of this area supports extensive patches of the brown seaweeds *Sargarssum* spp.

3.3 Methodologies

3.3.1 Sampling and Analysis of Octocoral Assemblages

Each study site (KLS, LGS and LLS) was divided into two depth zones: shallow (< -8 m CD) and deep (> -8 m CD) water regions. Belt quadrat sampling method was employed to sample the marine benthic communities (Sullivan & Chiappone 1992). This method allows the collection of detailed information for the spatial comparison of benthos. A total of 15 transects, each 5 m long, were laid parallel to the shoreline in each depth zone in every study site. Preliminary surveys using species area curves indicated that the number of transects employed was sufficient for the diversity and octocoral cover analyses. Quadrats of 0.25 m^2 in size, each with 10 random points, were placed on both sides of the transect. The two sides of each transect were then surveyed continuously along its whole length of 5 m. A total of 200 points were thus recorded within a 5 m^2 (5 m long x 1 m width) area along each transect. The following 13 types of benthos intercepted under each random point were recorded: soft coral, gorgonian, hard coral, black coral, ahermatypic coral, zoanthids, algae, sea anemone, rock, rubbles, sand, dead coral and dead gorgonian. If octocorals were encountered, they were identified up to the genus level *in situ*. Underwater photos of the living animals were taken. At times, specimens of the organism were also collected and brought back to the laboratory for further confirmation of their identity when necessary. Alcyonaceans like *Lobophytum* and *Sinularia* usually occurred as monospecific carpet, so when a colony was found to grow independently from its neighbors, it was then considered as a separate individual. Other information collected include relative abundance of the benthos (e.g. colony per quadrat), their percentage cover (%) and species composition. Species diversity of the benthos, particularly the octocorals, was then calculated.

3.3.1.1 Diversity Indices

The number of points intercepting each soft coral and gorgonian species (genus) in each transect was converted into relative percentage cover of each species using the following formula:

Relative percentage cover (%) =

No. of points intercepting each octocoral species / 200 x 100

Three common diversity indices were calculated using PRIMER 6 (PRIMER-E Ltd, UK), with the following equations:

1) Margalef's Index (*d*) (Margalef 1958):

$$d = (S-1) / \log_e N$$

where S is the total number of species, N is the relative percentage cover

This index can be used to reflect the species richness of the community. The higher the *d* value, the higher the species richnesss.

2) Shannon-Wiener diversity index (H') (Shannon & Weaver 1948):

$$H' = - \sum P_i \log (P_i)$$

where P_i is the proportion of the relative cover arising from *i*th species

This index is an indicator of the heterogeneity of the species composition and their abundance. The larger the *H'* value the higher the species diversity of the community.

3) Pielou's evenness index (*J'*) (Pielou 1966):

$$J' = H'/\log_e S$$

where H' is the Shannon-Wiener diversity index, S is the total number of species

This index is used to reflect the homogeneity of the distribution pattern of the octocorals. It is a measure of dominance, i.e. the lower the J' value, the higher is the dominance by certain species of octocorals; the higher the J' value, the more even is the abundance of the octocoral species in the community.

3.3.1.2 Spatial Comparison of Octocoral Assemblages

Student *t*-test was first used to compare the octocoral cover between two depth zones in each study site. Spatial variations of the relative coral cover in shallow and deep water octocoral communities among sites were further compared using Two Way ANOVA (treatment factors = depth zones x sites). Tukey-Kramer method was run as a post hoc test for pair-wise comparison of differences in these factors among sites. Assumptions of homogeneity of variance and normality of data were tested. If the assumptions cannot be satisfied (i.e. $p<0.05$, Levene's Test of Equality of Variances), the data sets were transformed and further tested. Non-parametric Kruskal-Wallis test was used instead if attempts at data transformation failed to satisfy the parameteric assumptions.

Multivariate analyses of octocoral community structure in terms of relative cover and species composition of each depth zone among sites were performed using PRIMER 6

(PRIMER-E Ltd, UK). The cover data were first square-root transformed to reduce the effects of dominating species on the similarity matrix. Bray-Curtis coefficient was chosen to measure similarities among samples in different depth zones among sites. Non-metric multi-dimensional scaling (MDS) plots were then generated in order to visualize the samples as points in 2-D dimension. If the sample points were close together, this meant that they were very similar in species composition and coral cover. Dendrogram from cluster analysis was also used to represent the ranks of similarities among depth zones of different sites. An analysis of similarity (ANOSIM) was then applied to test for significant difference in octocoral assemblages among depth zones in different sites. The global R value calculated was used to reflect the degree of differences between groups of samples. If $R > 0.75$, the sample groups are being well separated. The samples are overlapped but clearly different with $0.75 > R > 0.50$, or barely separable at all if $R < 0.25$ (Clarke & Gorley 2006). Finally, typical species in each depth zone and site and differentiating species between zones and sites were detected by the similarity percentage procedure (SIMPER) analysis. Top three typical and differentiating species were identified by this analysis to explain the similarity within sites and the dissimilarity among depth zones and sites.

3.3.2 The Size Structure of Octocorals

In order to collect information on the size structure of the octocorals intercepted by the random points in each quadrat, colony dimensions such as length, width or height (dimensions perpendicular to each other) of the octocorals were recorded. For octocorals growing in a horizontal plane (e.g. *Lobophytum* and *Sinularia*), their maximum length and width were measured. For those growing in a vertical plane (e.g. *Dendronephthya* and gorgonians), only their maximum width and height were recorded.

The planar area (cm^2) of every encrusting soft coral colony encountered by the random points within the belt transects was calculated using the equation of an ellipse: (3.14 x width x length) / 4 (Sullivan & Chiappone 1992). In most cases, the length of the colony was greater than its width, so that an ellipse was the geometric shape that would best approximate its planar area. For those octocorals that assumed a vertical growth form, e.g. *Dendronephthya*, or gorgonians, only the height of the colony was used to represent its size structure. The size structures of the most common gorgonian species, *Paraplexaura* sp. were used as a representative to analyze the spatial variation in the size structures of octocorals in different depth zones among sites.

3.3.3 Vertical Zonation and Distribution Pattern of Octocorals

Vertical zonation pattern of the octocorals was recorded by SCUBA divers swimming perpendicularly from the shallow towards the deeper zone ($\leq$ -15m CD) in the study site in a constant speed for five times [=five transects]. In each swim, stops were made at every 30 sec interval. A 5 m long transect was laid parallel to the shore at each stop. Soft corals and gorgonians encountered by the transect were identified and recorded, the depth of the transect and the abundance of each octocoral species were also noted.

Data from the five transects in each site were pooled in order to have a more general picture of how the octocorals were distributed. Profiles of vertical zonation pattern of every soft coral and gorgonian species were plotted using number of coral colonies encountered against depth. Maps showing the zonation pattern of octocoral species in each of the three study sites were then constructed.

3.4 Results

A total of 23 genera of octocorals (10 soft corals and 13 gorgonians) were recorded in the coral communities of TPCMP (Tables 3.1 & 3.2). Higher octocoral cover was recorded in the deep water regions in all three study sites, with significantly higher cover in KLS (22.3±7.3%) (Two-Way ANOVA, p<0.001) (Fig. 3.1). All of the octocoral communities examined showed great dominance by particular species, such as *Lobophytum* sp., *Sinularia* sp. and *Echinomuricea* sp., and their abundance varied among different sites and depths.

3.4.1 Diversity Indices

There were significant differences in the Shannon-Wiener diversity index (*H'*) between depth zones (ANOVA, $p<0.001$) and sites (ANOVA, $p=0.013$) (Fig. 3.2). This difference between depth zones appeared to be consistent and independent of site (ANOVA zone x site, $p=0.33$). The highest index was recorded in both the shallow (H' = 0.41±0.48) and the deep water (H' = 1.27±0.55) zones of LLS, with nine and 16 octocoral species recorded respectively. LGS had the lowest coral diversity with nine and 13 species recorded in shallow (H' = 0.21±0.39) and deep (H' = 0.70±0.47) water zones. The Margalef's index (*d*) showed a similar pattern. The highest species richness was found in the deep water community of LLS (d = 1.88±0.84) and the lowest was recorded in the shallow coral community of LGS (d = 0.93±0.87). There was significant difference between depth zones (ANOVA, p=0.019) but not among sites (ANOVA, p=0.592). This difference between depth zones also appeared to be consistent and independent of site (ANOVA zone x site, p=0.65). For Pielou's evennesss index (J'), significant difference was only found between depth zones (Kruskal-Wallis, p=0.011). The shallow water zone of KLS recorded the highest index (J = 0.93±0.08), indicating that the percentage cover of coral species in this region was most even among all sites in TPCMP. However, the index value was the lowest in the deep water zone (J' = 0.63±0.26) of the same site. This could be explained by the over-dominance of *Echinomuricea* sp. A in the area.

3.4.2 Spatial Comparison of Octocoral Cover, Composition and Community Structure

3.4.2.1 Kang Lau Shek (KLS)

The benthos of the shallow water community in KLS was mainly composed of rocks and boulders, with 19.73±8.42% of hard coral cover and 4.80±8.38% of octocoral cover (Fig. 3.3). A total of three soft coral and five gorgonian species were recorded in this area; of which *Sansibia, Sinularia* and *Lobophytum* were the dominant genera contributing to 2.47±7.71%, 1.20±3.51% and 0.77±1.69% of the octocoral cover respectively (Fig. 3.4A). These three soft corals are all zooxanthellate. They would need light to carry out photosynthesis, so their highest abundance was found at the depth of -6- -8 m CD. They usually formed extensive monospecific carpets up to 1-2 m^2 in size.

Species diversity in this site was much higher beyond 8 m deep. Five soft coral species and nine gorgonian species were encountered by transects at these depths. The deeper the water, the higher was the abundance of the gorgonians observed. The octocoral cover jumped to 22.30±7.31% in this region, whereas the coverage of hard coral dropped to 10.67±12.61% of the total benthic cover (Fig. 3.3). The dominant octocoral species switched to *Echinomuricea* sp. A. This species made up 9.70±7.60% of the total octocoral cover in this region (Fig. 3.4B).

There was significant difference (Student *t*-test, $p<0.05$) in the octocoral cover between shallow and deep water zones (Fig. 3.3). The MDS plots and dendrograms of the cluster analysis showed similar results. Samples from the same depth zone tended to be more similar and thus were grouped together (Fig. 3.5). Data points from the two depth zones formed two slightly overlapping groups. Results of cluster analysis showed that most samples from the deep water region separated from the others at the similarity level of about 15% (Figure 3.6). Results of ANOSIM using depth as a factor indicated significant differences in octocoral assemblage structures in KLS. The global R value was greater than 0.5 ($p<0.05$), suggesting that the samples formed two groups with respect to depths. SIMPER analysis showed that *Sansibia* sp. (42.67%) and *Lobophytum* sp. (38.21%) provided the highest contribution in typifying samples in shallow water region, whereas *Echinomuricea* sp. A was the typifying species in deeper water, contributing 53.29% (Fig. 3.7a). The octocoral assemblage structures in the two depth zones were differentiated by the very high abundance of *Echinomuricea* sp. A in deep water region (Figure 3.7B).

3.4.2.2 Lan Guo Shui (LGS)

A total of six soft coral and three gorgonian species were found in the shallow water community of LGS. These octocoral colonies made up 5.03±9.61% of the total benthic cover, whereas the scleractinians contributed to 22.07±9.62% in this area (Fig.

3.8). The community composition here showed great dominance by *Lobophytum* sp., which contributed 4.20±9.45% to the cover of shallow water community (Fig. 3.9A). Colonies of this species were usually found aggregated on rock surfaces.

More octocoral species were found in the deep water zone of LGS. A total of six soft coral and seven gorgonian species were encountered by the transects, contributing 8.83±6.75% of the total benthic cover (Fig. 3.8). Zooxanthellate soft corals dominated in this water zone. High occurrences of *Lobophytum* sp. (3.47±5.46%) and *Sinularia brassica* (3.17±4.45%) were observed (Fig. 3.9b), their abundance was the highest at 10 m deep. In this water region, however, higher hard coral cover (16.63±6.62%) than octocoral cover was found.

No significant difference in the relative octocoral cover was found between depth zones (Student *t*-test, $p>0.05$). In the MDS plot, the sample points of shallow and deep water communities were mixed together without any grouping patterns (Fig. 3.10). Similar pattern was found on the corresponding dendrogram (Fig. 3.11). Octocoral assemblage structures showed no significantly difference among depth zones (ANOSIM, R=-0.026, p>0.05). *Paraplexaura* sp. (54.35%) and *Lobophytum* sp. (38.31%) were often found to be the typical species in shallow water areas, whereas

Sinularia beassica (31.91%), *Lobophytum* sp. (30.05%) and *Paraplexaura* sp. (24.83%) were the typifying species in deeper water (Fig. 3.12A). High abundance of *Lobophytum* sp. was the differentiating spicies that made the shallow water samples different from the others (Fig 3.12B).

3.4.2.3. Lung Lok Shui (LLS)

Hard coral cover was high in LLS, contributing to 18.50±5.09% of the total benthic cover. Octocoral abundance was also quite high in this shallow water region, with 5.09±6.41% of octocoral cover recorded at 3-8 m depth (Fig 3.13). A total of six soft coral and three gorgonian species were recorded, all of them in healthy condition. *Sansibia* sp., *Lobophytum* sp. and *Sinularia* sp. were again the dominant coral species in shallow octocoral community, providing a cover of 2.84±5.27%, 1.28±2.76% and 0.40±1.04% respectively (Fig 3.14A). The finger-like zooxanthellate soft coral, *Cladiella* sp., which was absent in KLS and LGS, was encountered in the shallow water region of LLS. This species made up 0.13±0.50% of the total live octocoral cover in this site (Fig 3.14A).

Highest species diversity and high abundance of octocoral (13.13±6.36%) were observed in the deep water region, with low hard coral cover recorded (4.97±13.13%) (Fig. 3.12). A total of seven soft coral and nine gorgonian species were recorded, with *Lobophytum* sp. having the highest cover (2.50±6.97%), followed by *Sarcophyton* sp. (2.23±3.23%), *Paraplexaura* sp. (1.67±1.65%), *Echinogorgia* sp. A (1.53±1.99%), *Sinularia brassica* (1.50±2.93%) and *Echinogorgia* sp. B (1.30±1.45%) (Fig. 3.14B).

Significant difference was found in the relative octocoral cover of shallow and deep water regions (Student *t*-test, $p<0.05$). The high cover of rock (63.87±16.43%) in the latter could have provided more settlement space for octocorals (Fig. 3.13). Based on the analysis of community structure, two overlapping groups representing shallow and deep water samples could be found (Fig. 3.15). These two groups separated at approximately 10% level of similarity (Fig. 3.16). Global R value generated by ANOSIM, at 0.50 ($p<0.05$), revealed mixing of samples among the two depth zones but the two groups remained significantly different from each other. SIMPER analysis showed that *Sansibia* sp. and. *Paraplexaura* sp. contributed the most to the structure of the shallow and deep water communities respectively and were the typical species for the respective site (Fig 3.17A). Due to their high abundance, *Sansibia* sp. and *Lobophytum* sp. were the differentiating species for the two depth zones (Fig 3.17B).

3.4.2.4 Octocoral Assemblage in Shallow Water Regions of KLS, LGS and LLS

Octocoral cover in shallow water region of KLS, LGS and LLS ranged from 4.80±8.38 to 5.09±6.41% (Fig. 3.18) but the difference was not significant (One-Way ANOVA, $p>0.05$). MDS plot and dendrogram from cluster analysis showed the sample points from these three study sites to be mixed, forming no distinct grouping (Figs. 3.19, 3.20). Results of ANOSIM indicated that the octocoral assemblage structures of LGS and LLS were barely separated (Global $R=0.301$, $p<0.05$) (Fig. 3.21). *Lobophytum* sp. and *Sansibia* sp. were the main common species that differentiated octocoral assemblage structure of the three sites from one another (SIMPER analysis, Fig. 3.22).

3.4.2.5 Octocoral Assemblage in Deep Water Regions of KLS, LGS and LLS

Highest octocoral cover was recorded in the deeper water regions of KLS (22.30±7.32%), followed by that of LLS (13.13±6.36%) and LGS (8.83±6.75%) (Fig. 3.23). Significant difference in the coral cover was revealed with the octocoral cover of KLS being statistically different from those of LLS and LGS (ANOVA, $p<0.05$). The MDS plot showed the data points of LGS to be scattered widely, and those from

KLS and LLS to be forming two slightly overlapping groups (Fig. 3.24). In the dendrogram from the cluster analysis, most of the samples were shown to be mixed together. Samples from KLS and LLS again formed two groups that separated from the others at a similarity level of about 18% (Fig. 3.25). Results of ANOSIM showed significant differences in octocoral assemblage structures among sites. However, the Global R value obtained was 0.274 (Fig. 3.26), indicating that these three groups slightly overlapped to a certain degree with one another. In the subsequent SIMPER analysis *Echinomuricea* sp., *Lobophytum* sp. and *Sinularia brassica* were the three most important species that differentiated the samples among sites (Fig. 3.27).

3.4.3 Mean Size of Octocorals

Zooxanthellate soft corals are usually found in the shallow water regions, as they need sunlight for photosynthesis. All of the zooxanthellate octocorals found in Hong Kong grow in a horizontal plane. From the present study, larger patches of *Sansibia* sp. were found at 3-8 m depth in KLS, with the mean area of up to 5040±3008 cm^2 (Fig. 3.28A). In LGS, the areas of the octocoral species in shallow and deeper water zones were similar, but bigger sizes of *Sinularia brassica* (1030±1658 cm^2) and *Sarcophyton* sp. (382±224 cm^2) were recorded in the deeper zones (Fig. 3.28B). The mean size of all octocorals in shallow water was higher than that in deep water of LLS, and the colony sizes of *Lobophytum* sp. (102±74 cm^2) and *S. brassica* (118±120 cm^2) were the smallest among sites (Fig. 3.28C).

Dendronephthya spp. grew in a vertical plane and were commonly found in most of the octocoral communities. The colony heights of this genus usually ranged from 4.0 cm – 17.0 cm in Hong Kong waters (Figs. 3.29). The difference between those in shallow and deeper waters was not big.

The heights of gorgonians were similar among sites, which ranged from 8.5 cm – 30.0 cm tall (Fig. 3.29). Just like those of *Dendronephthya* spp., no significant difference in the height of gorgonians was observed between the two depth zones.

Paraplexaura sp. was the most common octocoral species found in TPCMP, which was recorded in all of the study sites. In the shallow water region, tallest colonies of *Paraplexaura* sp. (21.7±6.7 cm) were recorded in LGS (Fig. 3.30). However, no significant difference in their colony height was observed among the three study sites (One-Way ANOVA, $p>0.05$). In order to have a better understanding of the size structure of *Paraplexaura* sp., heights of these gorgonians were further divided into nine size classes at 5 cm intervals. The MDS plot generated using size class data of *Paraplexaura* sp. in shallow waters of the three study sites showed the samples to be widely scattered (Fig. 3.31). Cluster analysis of size class data also indicated the size structure of this gorgonian species to be quite different among sites (Fig. 3.32). In ANOSIM (Global R = -0.069), however, the significance level of sample statistic was larger than 0.5, suggesting no significant groupings of the size class structure of this species were revealed.

The largest colonies of *Paraplexaura* sp. were found in the deep water zones of LLS (mean size = 18.87±9.11 cm), followed by those in LGS (17.50±10.66 cm) and KLS (14.32±7.12 cm) (Fig. 3.33). The difference in the mean height of *Paraplexaura* sp. among the three study sites was significant (ANOVA, p=0.037). However, MDS plot and dendrogram constructed using the size class data showed that the samples from different sites were mixed together, with no distinct grouping patterns observed (Figs. 3.34-3.35). Global R value obtained in ANOSIM was 0.048 but with p>0.05, suggesting that the groupings were not significant.

3.4.4. Vertical Zonation Pattern of Octocorals

Vertical distribution pattern of soft corals and gorgonians varied among genera. All the alcyoniid soft corals encountered in this survey are zooxanthellate (Fig 3.36), the lower depth limit for them in TPCMP was around -5 m CD. *Cladiella* was an uncommon genus, its colonies were usually found in shallower water zone around 6-8 m deep. Encrusting soft corals *Lobophytum* and *Sinularia* were distributed throughout the shallow and deep water zones, ranging from 6-13 m deep. These two genera usually formed mono-specific carpets with area of 2-3 m^2 in size. Patches of them dominated the areas at 6-8 m deep in LGS, and occupied most of the bare rocks and boulders there. The living habitat of *Sarcophyton* was a bit different, with several patches of colonies found in the deeper and more turbid water region.

There appears to be no distinct vertical zonation pattern for most of the azooxanthellate soft corals, as their growth was not limited by the amount of sunlight received. Nephthyid soft corals *Dendronephthya* and *Scleronephthya* had a wide distribution in both shallow and deep waters of TPCMP (Fig. 3.37). Higher abundance of their colorful colonies was observed in deeper waters with strong current. Few colonies of nidaliid corals, *Chironephthya* and *Nephthyigorgia* were encountered in deep water areas of the study sites. They were uncommon octocoral genera in Hong Kong, and were usually found on bottoms with moderate level of sedimentation. Xeniid coral *Sansibia*, which was zooxanthellate and could only be found in TPCMP, dominated the shallow water region of KLS, LGS and LLS. As polyps of this species are united by a thin and soft membrane, they form patches or aggregations that could occupy a large area up to 2-4 m^2 in size. Due to this reason, it was not possible to count the number of single polyps of *Sansibia* nor was it easy to determine what constituted a "single" colony. Thus, no abundance data of this species could be estimated.

All gorgonians recorded in Hong Kong waters are azooxanthellate. Plexauridae was the most dominant gorgonian family, contributing nine genera in the waters of TPCMP (Figs. 3.38-3.39). *Astrogorgia* was found in deep water region, and sparse number of them was recorded. The purple and branching gorgonians *Euplexaura* frequently occurred in the depth of 5-13 m, with higher occurrence recorded in LGS. The genera *Echinomuricea*, *Echinogorgia*, *Paraplexaura* and *Menella* had a strong preference for the deeper water regions. The highest number of them was observed at 8-13 m deep in KLS due possibly to the presence of steep and rocky topography in that site. Besides Plexauridae, other families of gorgonians were rarely observed.

Species composition of the octocorals changed at the depth beyond 12 m and the dominant genera changed to whip-like gorgonians like *Viminella*.

3.5 Discussion

TPCMP is located in the most northeastern waters of Hong Kong, it is famous for supporting a healthy and biodiversity-rich coral community. More than 65 species of scleractinian corals are recorded in this park (Ang *et al.* 2003). Other than hard corals, high species richness and abundance of marine organisms likes seaweeds (>65 species, So 2005) and reef fish (~110 species, Tam 2006) have also been reported. However, the information on octocorals, which is a major component of coral reef worldwide (Benayahu & Loya 1981; Tursch & Tursch 1982; Dinesen 1983), remained unknown. Until recently, it has not received much attention from local marine scientists. This two-year study provides the first baseline information on octocoral species richness, cover, distribution pattern and size structure in this marine park. Dominant species in different sites in two depth zones are also reported.

3.5.1 Species Diversity of Octocorals

This present study indicates that the coral communities of TPCMP support a diverse octocoral fauna. A total of 23 genera (10 soft corals and 13 gorgonians) belonging to nine families were recorded (Tables 3.1 & 3.2). Distribution of xeniid *Sansibia* was only confined to the shallow water areas of the park, and *Elbeenus*, *Subergorgia*, *Leptogorgia*, *Viminella* and *Ellisella* reported here are also the new zoogeographical records for Hong Kong. Soft coral family Alcyoniidae and gorgonian family Plexauridae dominated the octocoral communities in both the shallow and deep water regions, covering 4.8 - 22.3% of the bottom substrata (Fig. 3.1). Earlier, Clark (1997) and Fabricius & McCorry (2006) also reported Plexauridae as the most dominant octocoral family in Hong Kong. A greater number of soft coral and gorgonian species was found in TPCMP, when compared with that of Cape D' Aguilar, the only marine reserve of Hong Kong. In this reserve, only 10 genera belonging to five families of octocorals were recorded, and Paramuriceidae (= Plexauridae) was found to dominate the community (Clark 1997). In the study of Fabricius & McCorry (2006), rapid ecological assessment technique (REA) was employed in 19 sites from northeastern to southern coastal regions of Hong Kong and only 23 genera of octocorals were recorded over such a large water area (> 2,000 ha). In this sense, TPCMP truly supports a very rich soft coral and gorgonian fauna as within its 260 ha of water area, the number of octocoral species found is as much as that over the entire northeastern to southeastern coastal regions of Hong Kong.

3.5.2 Factors Structuring the Horizontal Distribution Pattern of Octocorals

Availability of hard substratum could be one of the factors causing the difference in the cover and structure of octocoral communities. Lack of suitable substrata would limit the distribution and abundance of octocorals (Kinzie 1973, Benayahu 1985, Goh & Chou 1994, Clark 1997). If the coral settles on rubbles or sand, it cannot attach on the substratum firmly. Toppling of the colony will easily occur, smothering, abrasion and burying parts of the coral will follow and may result in killing the coral eventually (Kinzie 1973). During this study, octocorals were mainly observed settling on boulders and rocks. None of them were found on the sandy substratum. Higher diversity and abundance of octocorals found in deep water areas of KLS and LLS may probably be due to the high cover of rocks in these sites, which contributed 64.1% and 63.9% of the total benthic cover respectively (Figs 3.3 & 3.13). For the benthic composition of LGS, low cover of rock (47.2±23.2%) and high cover of rubbles (21.9±28.9%) and sand (2.6±4.7%) were recorded (Fig. 3.8). As mentioned before, these kinds of bottom structure are loose. Dislodgment of rubbles could easily result because of strong current or water motion. These are not suitable substrata for octocorals to settle, leading to low octocoral cover in LGS.

Comparable octocoral cover ranging from 4.80±8.38 to 5.09±6.41% was recorded in the shallow water region of KLS, LGS and LLS. This low cover may be a result of space limitation. Space is one of the most important limiting resources in a coral reef, so that competition between fauna and flora are common (Benayahu & Loya 1981, Sammarco *et al.* 1982, Dai 1990, Maida *et al.* 1995, Fabricius 1997, Griffith 1997, Maida *et al.* 2001). Space availability is the factor that would affect the cover of octocoral. In TPCMP, besides octocorals, the major benthic organisms occupying space of the shallow coral communities were hard corals (18-22%), and algae (1-11%) (Fig. 3.41). *Sansibia*, *Sinularia* and *Lobophytum* were the most common zooxanthellate genera dominating the communities of shallow waters, while *Favia speciosa*, *Plesiastrea versipora* and *Cyphastrea serailia* were the top three dominant hard coral species (unpublished data). Both of these soft and hard corals need sunlight for photosynthesis. In this sense, they have the same ecological niche. Dai (1990) noted that *Favia speciosa* was a moderately aggressive species, *Plesiastrea versipora* and *Cyphastrea seralia* were the subordinate corals which had weak attacking ability.

However, as the number of hard and soft corals in the shallow water region of TPCMP was small, these corals were not observed to be located closely next to one another so no aggressive interactions between them were apparent. Competition between hard and soft corals is unlikely to be a major factor structuring the abundance of octocoral in Hong Kong, at least not in the shallow water region of these three study sites examined.

On the other hand, highest cover of seaweed, *Lobophora* sp. and *Sargarssum* spp. were found occupying the boulder and rock surfaces in the very shallow water region of LLS, contributing to 11% of the total benthic cover (Fig. 3.41). This high cover of algae may affect the growth of soft coral and gorgonians. In the study of Kuffner *et al.* (2006), *Lobophora* sp. was found to be deterring the survival and settling chance of octocoral larvae. This may also explain the absence of octocoral colonies near patches of algae in the study sites, although plenty of bare rock surface were available.

Large numbers of xeniid *Sansibia* patches were found occupying the space in shallow waters (-4 - 6 m CD), at times forming carpets of up to 3 - 4 m^2 in size. Their successful exploitation of the substratum may be due to their ability for fast asexual propagation (Benayahu *et al.* 2004). Other xeniid species like *Xenia macrospiculata* in the Red Sea (Benayahu & Loya 1985) was shown to be opportunistic species that utilize active movement mechanism to quickly occupy the vacant space nearby. Such mechanism may also be employed by *Sansibia* sp. in LLS, but no attempt to observe this was made in the present study.

Lower cover of hard corals and seaweeds were recorded in deep water zones, as high turbidity was likely the main factor that limits the growth of these organisms in deeper water (Fig. 3.42). The absence of these potential competitors (Goh & Chou 1994) may allow octocorals to become more abundant in deep water zones in the three study sites. Octocorals were more tolerant to high turbidity and sedimentation conditions (Fabricius & McCorry 2006). Octocoral cover of KLS (22.30±7.32%) was much higher than that in LLS (13.13±6.36%) and LGS (8.83±6.75%) (Fig. 3.23). This may be due to the presence of special topographic relief in KLS in the form of steep slope formed by layers of sedimentary rocks found underwater. Big boulders and rocks are the most common substratum type, providing suitable firm surface for the attachment and growth of soft corals and gorgonians. High topographic relief is also related to low wave energy and moderate sediment transport across the bottom substrata (Yoshioka & Yoshioka 1989), which are both critical for the growth of octocorals. Details about these are discussed in Chapter 4.

3.5.3 Vertical Zonation Patterns of Octocorals in TPCMP

Neither soft corals nor gorgonians were observed in very shallow waters (0- -4 m CD). Extreme wave action and hydrodynamic exposure are probably the reasons for their absence (Dinesen 1983, Riegl & Velimirov 1994). Alcyoniids and Xeniids started to appear beyond 5-6 m depth. *Lobophytum*, *Sinularia brassica* and *Sansibia* were the zooxanthellate species dominating the communities at this depth (Figs. 3.36 & 3.37). Their encrusting growth form helped them to adapt to wave-exposed areas, subjecting them to the least amount of drag forces from wave stress (Fabricius & Klumpp 1995). The lower depth limit for these zooxanthellate taxa in the study sites was around -13 m CD, suggesting that they had already adapted to low light environment and became the low-light-associated species in Hong Kong. Elsewhere in other places around the Indo-west Pacific, these species tend to be predominantly found in very clear water reefs down to a depth of 25 m (Fabricius & Alderslade 2001, Fabricius & McCorry 2006). These colonies found in Hong Kong usually have a more flattened morphology and a very dark brown pigmentation, indicating the presence of high zooxanthellae densities. This was a typical response to low light and high nutrient conditions (Fabricius & McCorry 2006). *Sarcophyton* sp. colonies started to appear beyond 8 m deep with the highest abundance recorded around the depth of 9-10 m. This species was shown to be efficient predator and was able to completely satisfy its respiratory losses by heterotrophic feedings (Fabricius & Klumpp 1995). It is the most deep-water adapted zooxanthellate species in Hong Kong.

The richness of zooxanthella-free taxa in the three study sites increased with depth. Gorgonian family Plexauridae dominated the deep water areas, with the greatest abundance at 12-13 m depth. Goh *et al.* (1997) also reported that the greatest species richness and abundance of octocorals was in the bottom zone of Singapore's reef. Jokiel (1980) suggested that the deeper occurrence of gorgonians may be influenced by the harmful ultraviolet radiation. Grigg (1974) also suggested that negative phototaxis in gorgonian larvae could account for their depth zonation. As water in deeper areas was much more turbid than that in shallow waters, light attenuation would be significant, thus providing an environment which may favor the growth of the gorgonian larvae. Deeper abundance of gorgonians, like that observed in Hong Kong waters, may be related to larval choice.

3.5.4 Octocoral Sizes

Size is an important and useful tool for helping to get a better understanding of an organism's life-history (Pearson 1981, Yoshioka 1994), growth (Mistri & Ceccherelli 1994, Goh & Chou 1995) and reproductive status (Bastidas *et al.* 2004). This study is the first to examine the size structures of Hong Kong octocorals.

Octocorals are heterotrophic suspension feeders. They usually feed on small food particles such as phytoplankton and zooplankton (Fabricius & Klumpp 1995, Fabricius *et al.* 1995b). As their nematocysts are small and weak, they need the help of the current to bring them their food items. Water transported food particles are filtered and captured by their tentacles and pinnules. Moderate water flow brings the greatest benefits for the filtration and uptake of their food. Positive correlation between gorgonian size and strength of water flow was elucidated from the study of Sebens (1984). Colonies usually grow to a certain size and stop where flow is too rapid for feeding, or where the drag generated was too strong, causing detachment of the gorgonian colonies. In TPCMP, the heights of the gorgonians ranged mainly from 10-20 cm, which were even shorter than those from the sedimented waters of Singapore (Goh & Chou 1995). The difference in the mean size structure of

Paraplexaura sp. among the three study sites was significant. This may be related to the differences in the strength of water flow in these sites. More information about how water movement could affect the octocoral community structure in these study sites is examined in Chapter 4.

Other than water current (water movement), which may be directly or indirectly related to sedimentation load and the availability of food particles to octocorals, and the availability of suitable substrata for octocoral settlement and growth, there are very little studies that consider the role of other environmental factors in affecting the spatial distribution of octocorals. This remains a wide open area of research and certainly should be given more focus in the near future if a better understanding of the ecology and biology of octocorals as a very important component of the reef community is to be achieved.

3.6 Summary

A total of 23 genera of octocorals (10 soft corals and 13 gorgonians) belonging to nine families were recorded in TPCMP. Significant difference in the octocoral cover and community structure between sites and depth was detected. Coral covers of deep water regions of KLS and LLS were higher than that in the shallower regions. At a finer scale, results of ANOSIM suggested that the octocoral community structure of KLS and LLS formed two groups with respect to depths. Distinct vertical zonation pattern of octocorals was observed, with zooxanthellate soft corals dominating the shallow water region and zooxanthellate-free gorgonians occupying most of the available space in deep water region. Besides the availability of hard substratum, current and sedimentation load are physical factors likely to affect the distribution, community structure and size structure of octocorals in TPCMP.

Table 3.1 List of soft corals recorded in the three study sites. "*" indicates the species encountered by transects, while "+" are the species observed in free dives. KLS = Kang Lau Shek, LGS = Lan Guo Shui, LLS = Lung Lok Shui. S = Shallow water region (<8 m CD), D = Deep water region (>8 m CD).

Family	**Genera**	**Species**	**KLS**		**LGS**		**LLS**	
			S	**D**	**S**	**D**	**S**	**D**
Alcyoniidae	*Cladiella*		+		+		*	*
	Elbeenus			+				
	Lobophytum		*	*	*	*	*	*
	Sarcophyton			+	*	*		*
	Sinularia	*brassica*	*	*	*	*	*	*
Nephtheida	*Dendronephthya*	A	+	+	*	*	*	*
	Dendronephthya	B	+	*	*	*	*	*
	Scleronephthya				+			
Nidaliidae	*Chironephthya*			*				*
	Nephthyigorgia	A		*				+
Xeniidae	*Sansibia*		*	*	*	*	*	*
Total 4	**10**		**6**	**9**	**8**	**6**	**6**	**9**

Table 3.2 List of gorgonians recorded in the three study sites. "*" indicates the species encountered by transects, while "+" are the species observed in free dives. Site and depth abbreviations as in Table 3.1.

Family	Genera	Species	KLS		LGS		LLS	
			S	D	S	D	S	D
Acanthogorgiidae	*Acanthogorgia*			+		+		+
	Anthogorgia	A				+		*
Ellisellidae	*Dichotella*			+				
	Verrucella							+
	Viminella			*				+
Gorgoniidae	*Leptogorgia*			+	+		+	
Plexauridae	*Astrogorgia*			*	*	*		*
	Echinogorgia	A	*	*		*		*
	Echinogorgia	B		*				*
	Echinomuricea	A		*		*	*	*
	Echinomuricea	B	*	*		*	*	*
	Euplexaura		*	+	*	*		*
	Menella	A	*	*		*		*
	Menella	B		*				
	Paraplexaura		*	*	*	*	*	*
Subergorgiidae	*Subergorgia*							+
Total 5	**13**		**5**	**13**	**4**	**9**	**4**	**13**

Table 3.3 Diversity indices of octocoral communities in shallow and deep water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS).

	KLS		LGS		LLS	
	Shallow	**Deep**	**Shallow**	**Deep**	**Shallow**	**Deep**
Margalef's index (*d*)	1.0060	1.4417	0.9320	1.2859	0.9728	1.8811
Shannon-Wiener's index (H')	0.2855	1.0562	0.2082	0.6979	0.4095	1.2708
Pielou's index (*J'*)	0.9327	0.6315	0.6094	0.7412	0.8575	0.7449

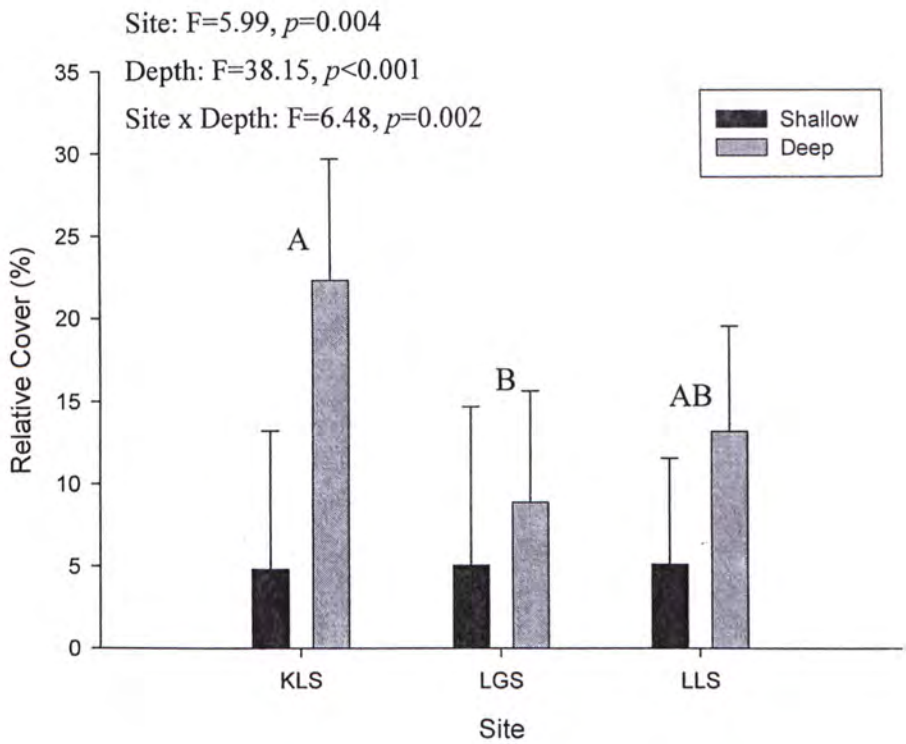


Figure 3.1 The mean (± SD) percentage cover of octocorals in shallow and deep water regions of three sites in Tung Ping Chau Marine Park. n = 15. KLS = Kang Lau Shek; LGS = Lan Guo Shui; LLS = Lung Lok Shui. Areas denoted by same letter indicate non-significant difference in site.

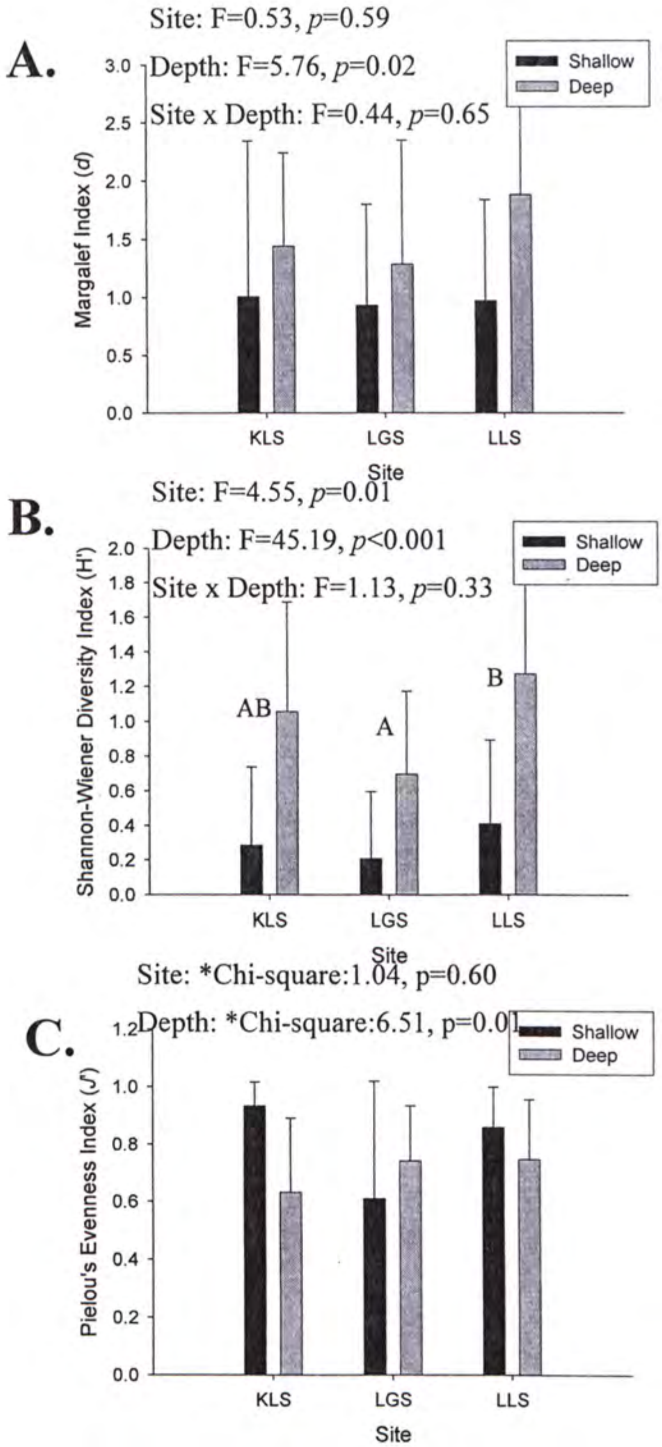


Figure 3.2 Comparison of **A.** Margaref Index, **B.** Shannon Wiener Diversity Index and **C.** Pielou's Evenness Index of shallow and deep water octocoral communities in Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS). n = 15. F values and level of significance indicated. Asterisk indicates that Kruskal-Wallis test was performed instead of Two-Way ANOVA. Areas denoted by same letter indicate non-significant difference in site.

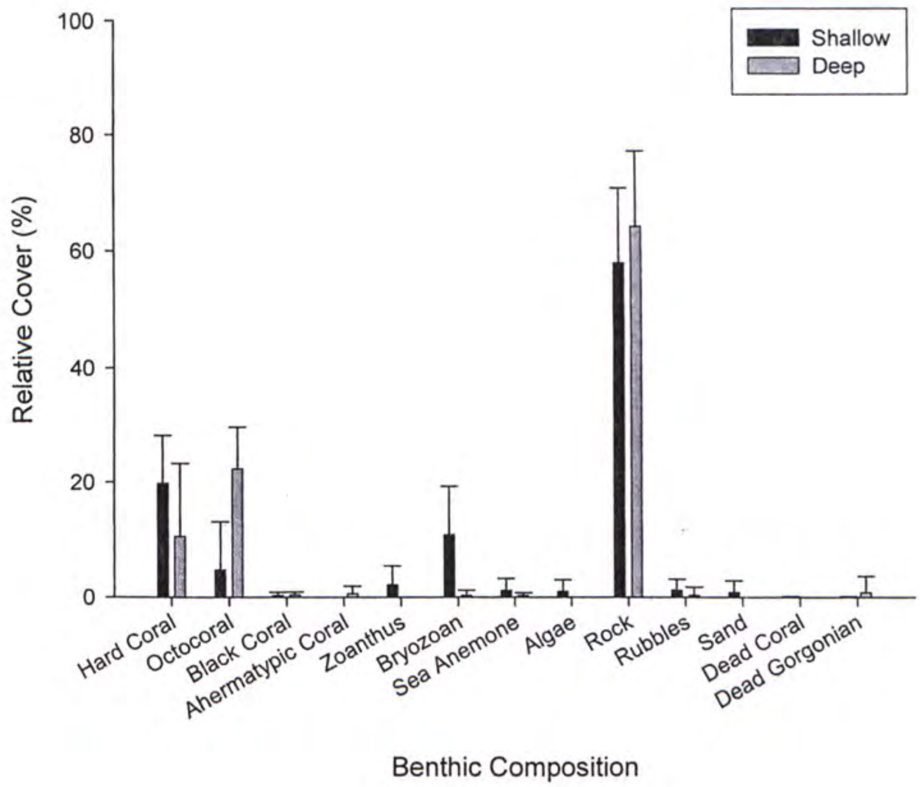
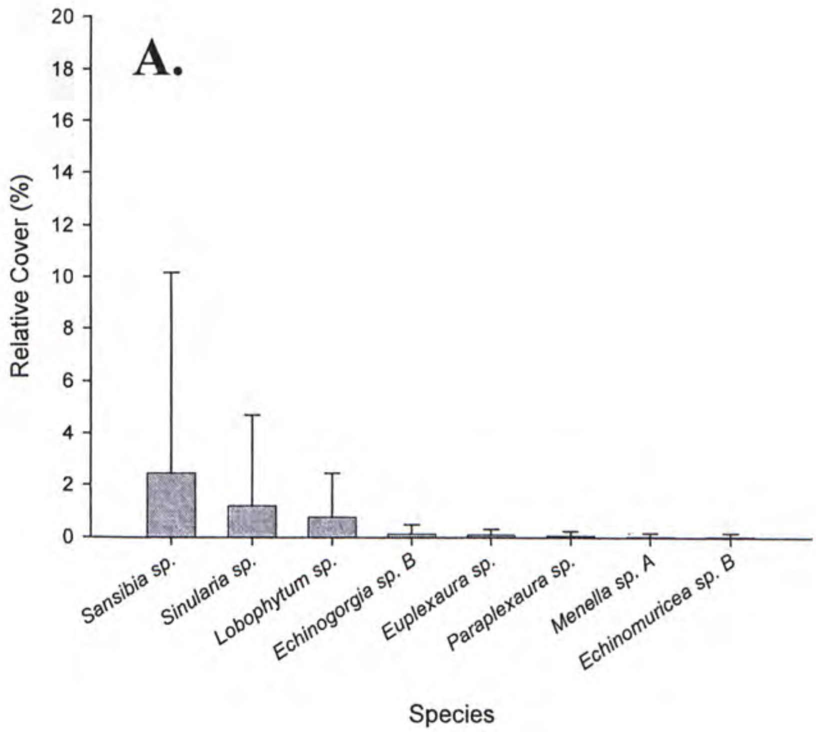


Figure 3.3 Mean (± SD) percentage cover of benthic compositions in Kang Lau Shek using data from 30 transects laid in shallow and deep water regions.



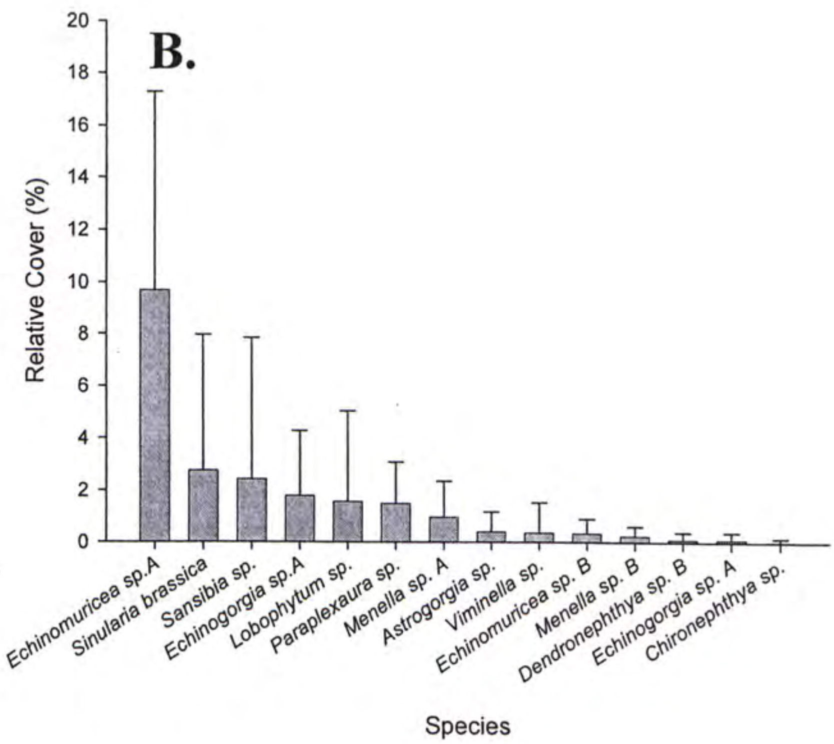


Figure 3.4 Mean (± SD) percentage cover of soft corals and gorgonians in (**A**) shallow and (**B**) deep water regions of Kang Lau Shek.

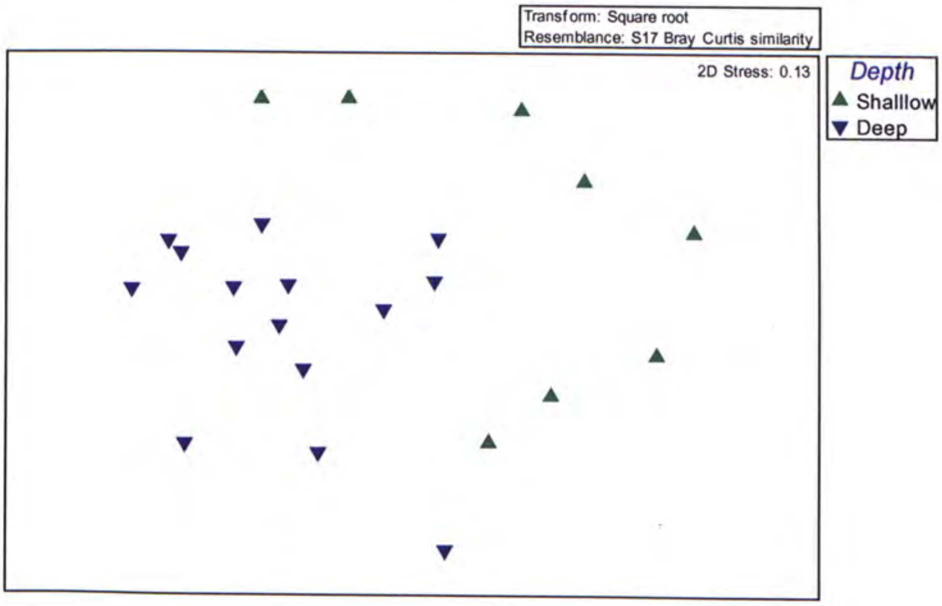


Figure 3.5 MDS plot for the spatial comparison of octocoral assemblage structures of the two depth zones in Kang Lau Shek using relative percentage coral cover data. Each point represents data from one transect.

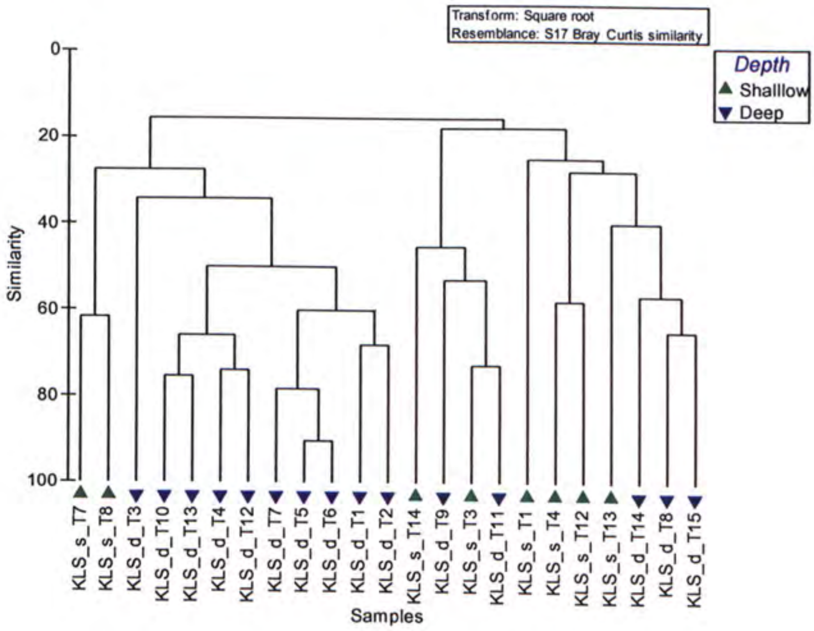


Figure 3.6 Dendrogram for the spatial comparison of octocoral assemblage structures of the two depth zones in Kang Lau Shek using relative percentage coral cover data. Each point represents data from one transect.

A. Similarity:

Shallow		Deep	
Species	**Contribution %**	**Species**	**Contribution %**
Sansibia sp.	42.67	*Echinomuricea* sp. A	53.29
Lobophytum sp.	38.21	*Paraplexaura* sp.	12.79
Sinularia brassica	8.05	*Echinogorgia* sp. A	10.19

B. Dissimilarity:

Species	Contribution %
Echinomuricea sp. A	28.23
Sansibia sp.	13.87
Sinularia brassica	13.35

Figure 3.7 Results of SIMPER analysis for the spatial comparison of octocoral assemblage structure of the two depth zones in Kang Lau Shek using relative percentage coral cover data from 30 transects. (**A**). Top three octocoral species that contributed most to similarities in shallow and deep water regions (in order of percentage contribution). (**B**) Top three octocoral species that contributed most to dissimilarities between depth zones (in order of percentage contribution).

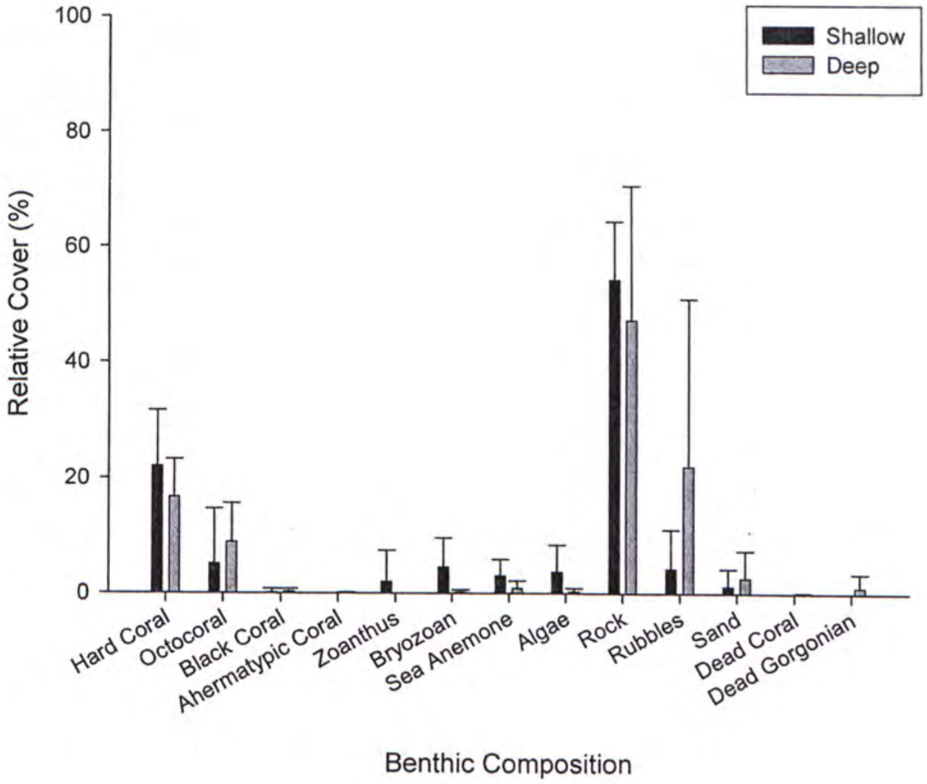
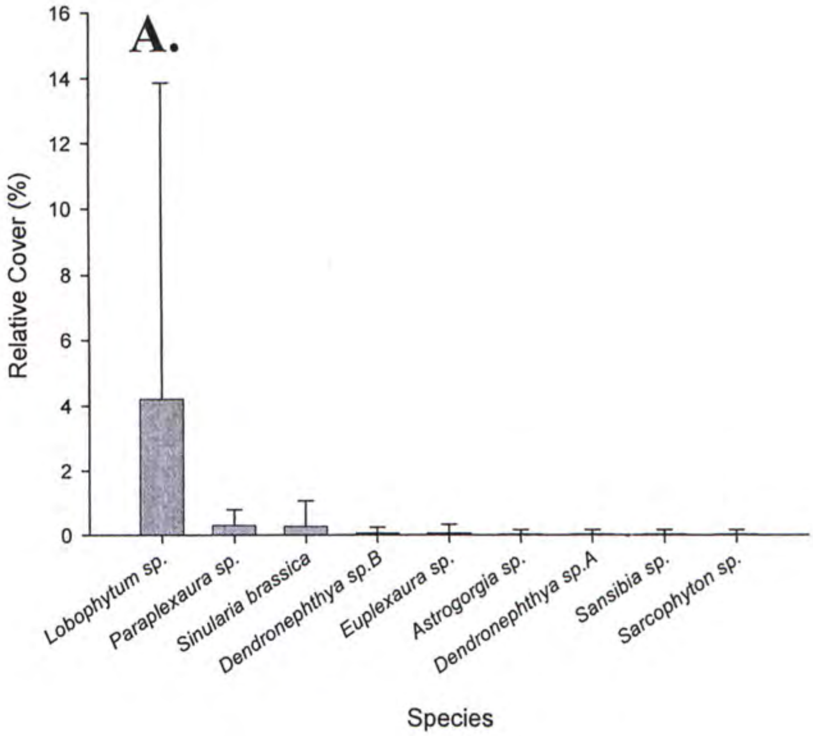


Figure 3.8 Mean (± SD) percentage cover of benthic compositions in Lan Guo Shui using data from 30 transects laid in shallow and deep water regions.



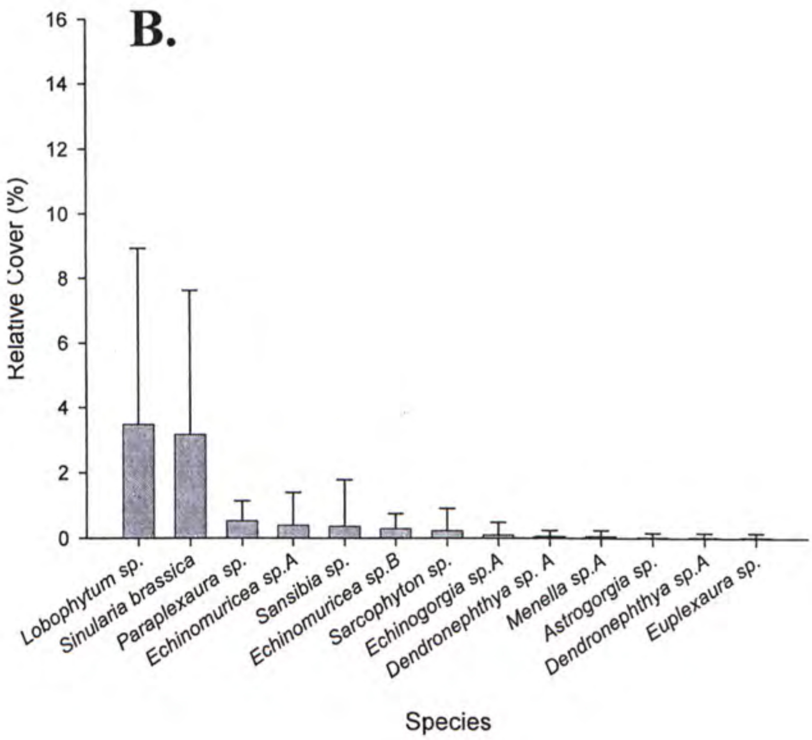


Figure 3.9 Mean (± SD) percentage cover of soft corals and gorgonians in (**A**) shallow and (**B**) deep water regions of Lan Guo Shui.

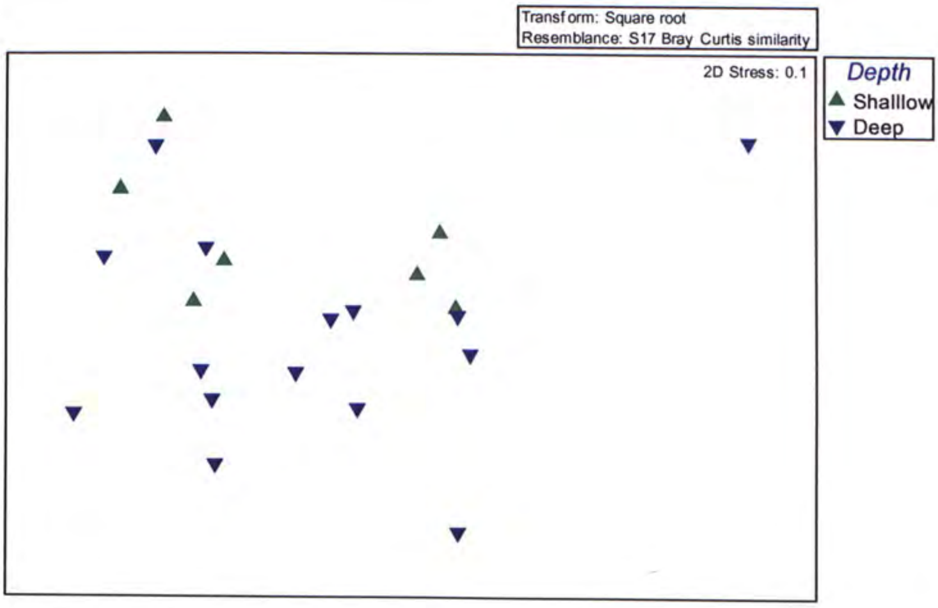


Figure 3.10 MDS plot for the spatial comparison of octocoral assemblage structures of the two depth zones in Lan Guo Shui using relative percentage coral cover data. Each point represented data from one transect.

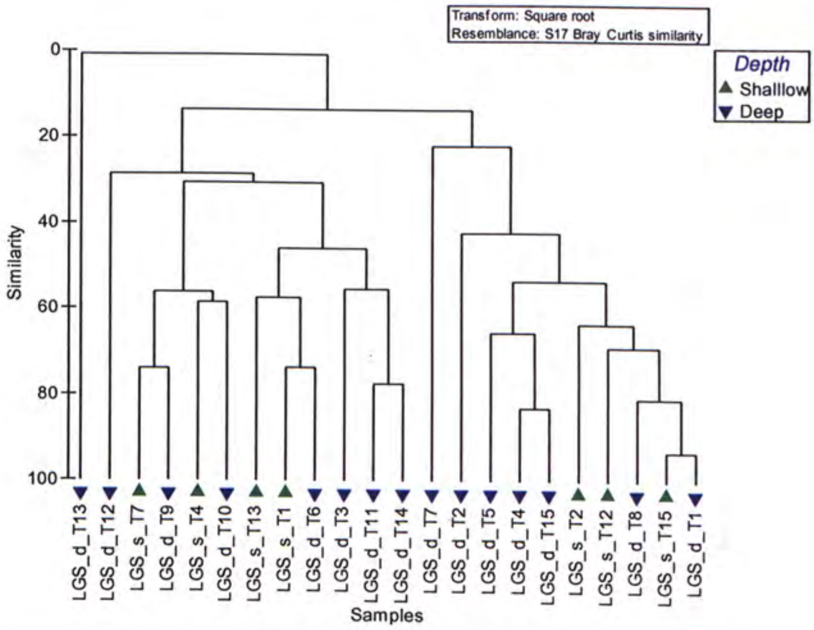


Figure 3.11 Dendrogram for the spatial comparison of octocoral assemblage structures of the two depth zones in Lan Guo Shui using relative percentage coral cover data. Each point represents data from one transect.

A. Similarity:

Shallow		Deep	
Species	**Contribution %**	**Species**	**Contribution %**
Paraplexaura sp.	54.35	*Sinularia brassica*	31.91
Lobophytum sp.	38.31	*Lobophytum* sp.	30.05
		Paraplexaura sp.	24.83

B. Dissimilarity:

Species	Contribution %
Lobophytum sp.	25.95
Sinularia brassica	14.74
Paraplexaura sp.	7.83

Figure 3.12 Results of SIMPER analysis for the spatial comparison of octocoral assemblage structure of the two depth zones in Lan Guo Shui using relative percentage coral cover data from 30 transects. (**A**). Top three octocoral species that contributed most to similarities in shallow and deep water regions (in order of percentage contribution). (**B**) Top three octocoral species that contributed most to dissimilarities between depth zones (in order of percentage contribution).

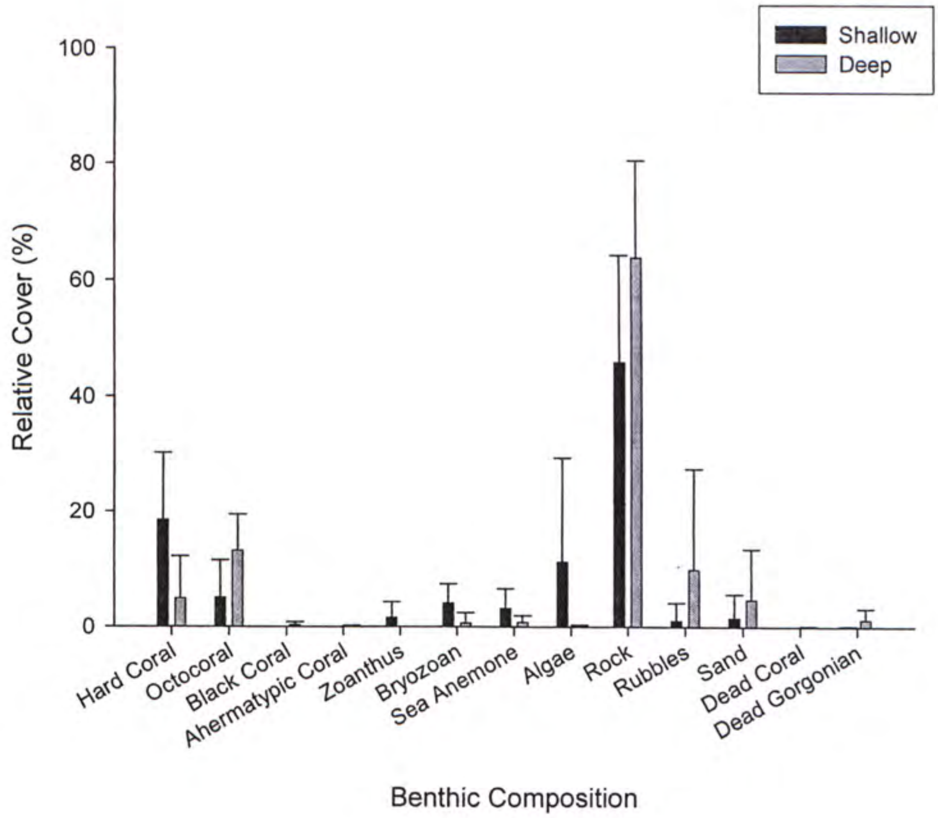


Figure 3.13 Mean (± SD) percentage cover of benthic compositions in Lung Lok Shui using data from 30 transects laid in shallow and deep water regions.

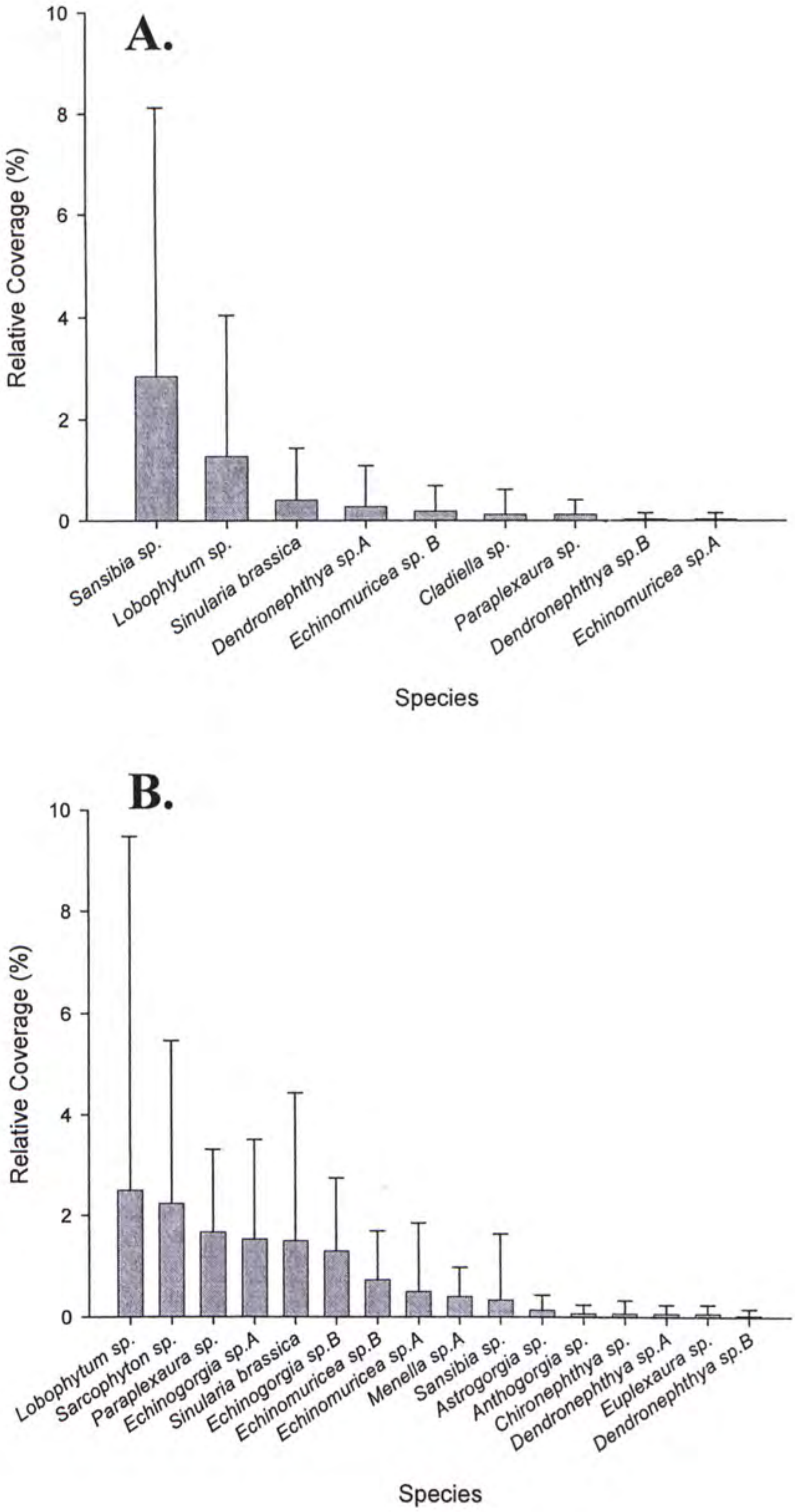


Figure 3.14 Mean (± SD) percentage cover of soft corals and gorgonians in (**A**) shallow and (**B**) deep water regions of Lung Lok Shui.

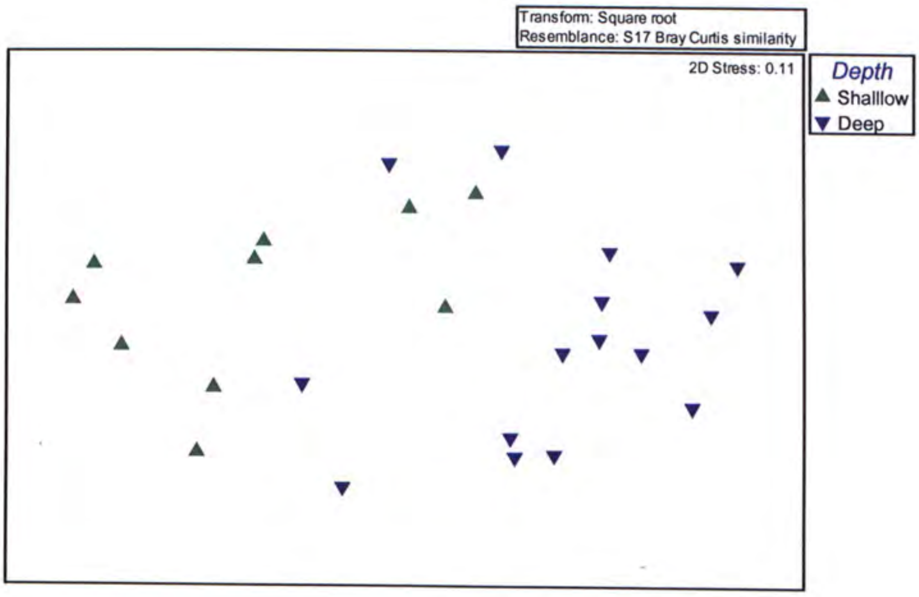


Figure 3.15 MDS plot for the spatial comparison of octocoral assemblage structures of the two depth zones in Lung Lok Shui using relative percentage coral cover data. Each point represented data from one transect.

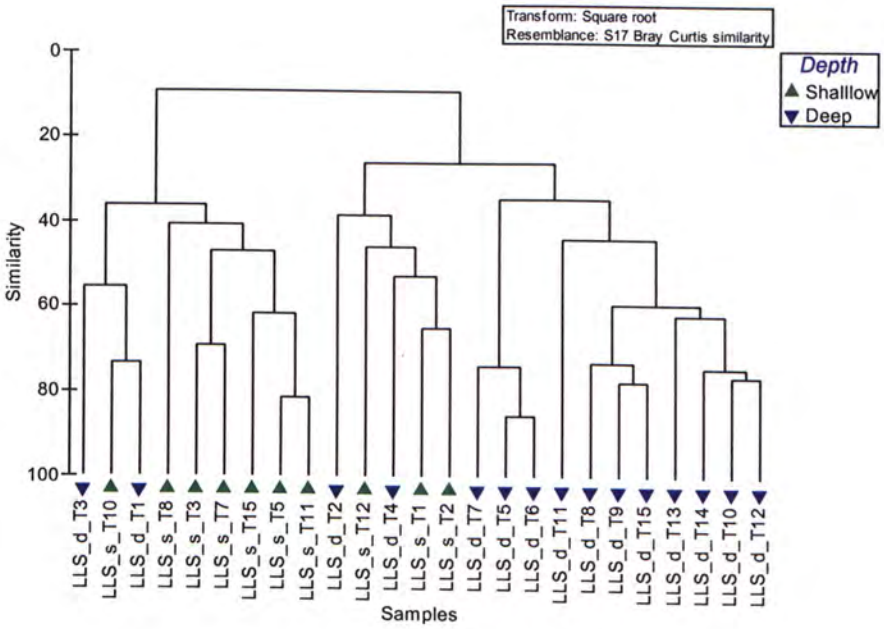


Figure 3.16 Dendrogram for the spatial comparison of octocoral assemblage structures of the two depth zones in Lung Lok Shui using relative percentage coral cover data. Each point represents data from one transect.

A. Similarity:

Shallow		Deep	
Species	**Contribution %**	**Species**	**Contribution %**
Sansibia sp.	68.68	*Paraplexaura* sp.	22.31
Lobophytum sp.	21.62	*Echinogorgia* sp. A	17.61
		Lobophytum sp.	15.69

B. Dissimilarity:

Species	Contribution %
Sansibia sp.	18.01
Lobophytum sp.	12.68
Sinularia brassica	9.73

Figure 3.17 Results of SIMPER analysis for the spatial comparison of octocoral assemblage structure of the two depth zones in Lung Lok Shui using relative percentage coral cover data from 30 transects. (**A**) Top three octocoral species that contributed most to similarities in shallow and deep water regions in order of percentage contribution. (**B**) Top three octocoral species that contributed most to dissimilarities between depth zones (in order of percentage contribution).

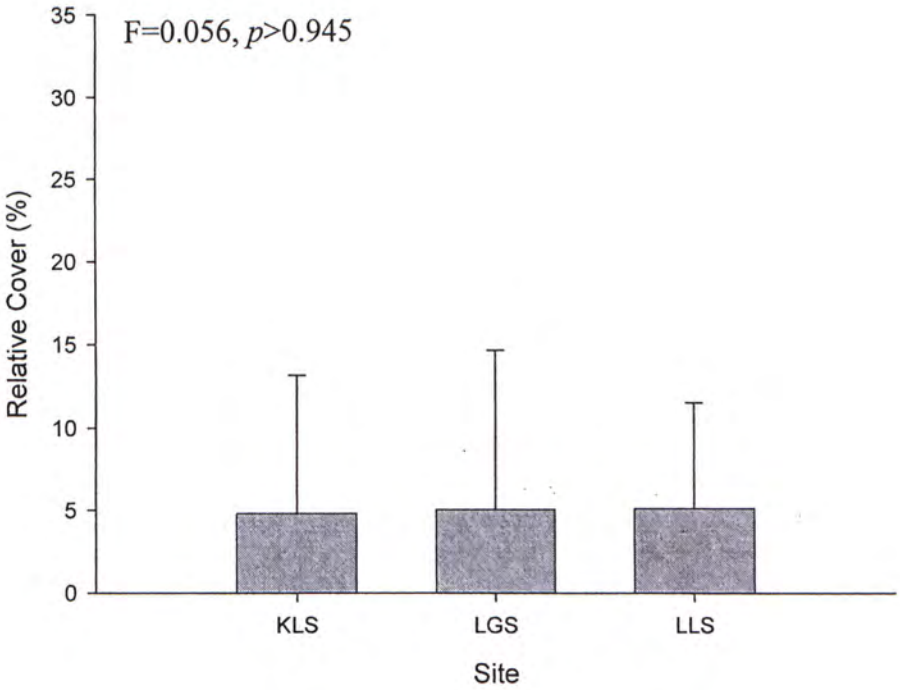


Figure 3.18 Mean (± SD) percentage cover of octocorals in shallow water region of three sites in Tung Ping Chau Marine Park. KLS = Kang Lau Shek; LGS = Lan Guo Shui; LLS = Lung Lok Shui. One-Way ANOVA was performed, with F values and level of significance indicated.

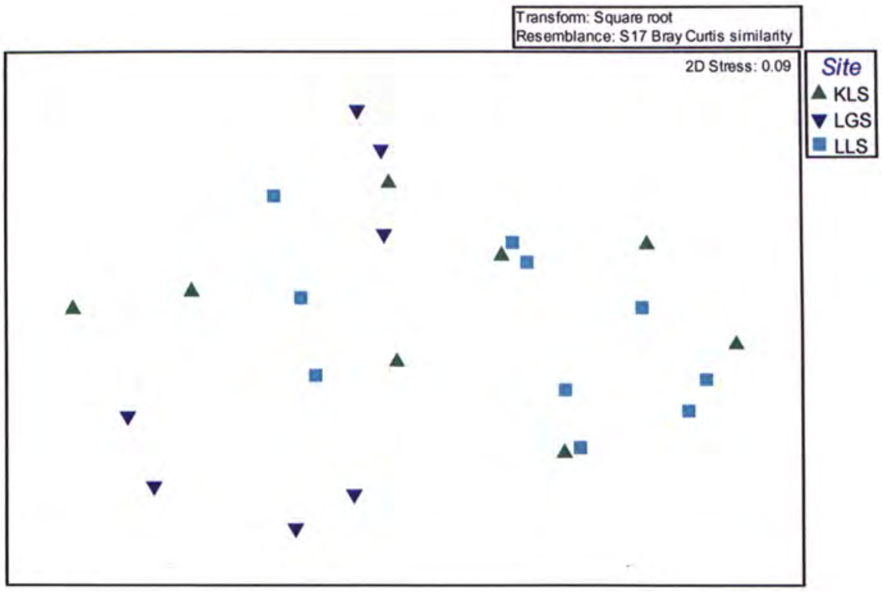


Figure 3.19 MDS plot for the spatial comparison of octocoral assemblage structures in shallow water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. Each point represents data from one transect.

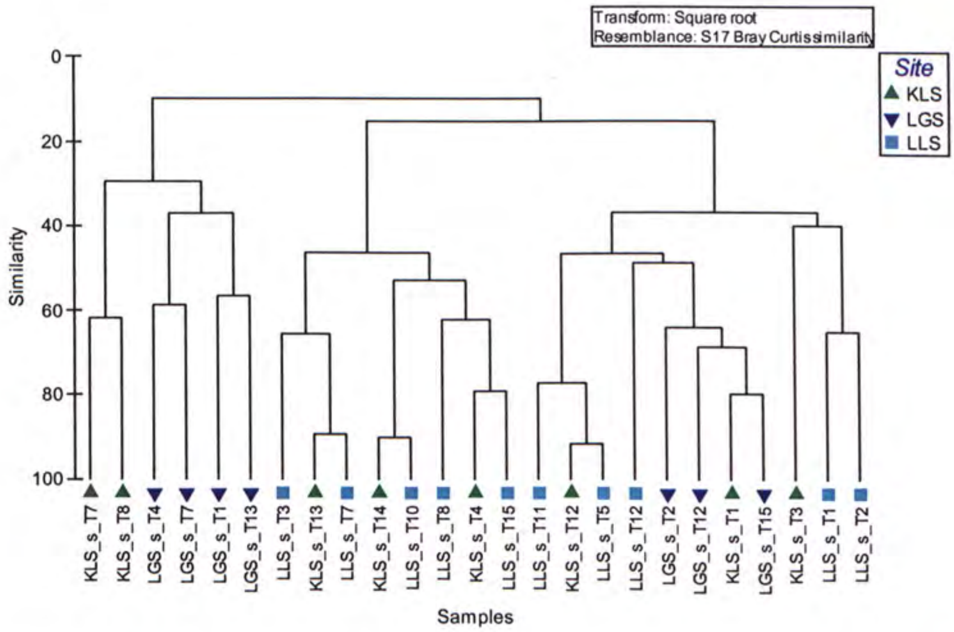


Figure 3.20 Dendrogram for the spatial comparison of octocoral assemblage structures in shallow water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. Each point represents data from one transect.

	LGS	LLS
KLS	0.137 0.10	-0.014 0.48
	LGS	0.301 0.01
		LLS

Figure 3.21 Results of ANOSIM analysis for spatial comparison of octocoral assemblage structures in shallow water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. Global R=0.138, p<0.05. Upper figure represents the R value and lower one the significance level for the pair-wise comparison.

	LGS	LLS
KLS	*Lobophytum* sp. **(33.29)** *Sansibia* sp. **(21.15)** *Sinularia brassica* **(14.89)**	*Sansibia* sp. **(34.24)** *Lobophytum* sp. **(21.34)** *Sinularia brassica* **(16.64)**
	LGS	*Lobophytum* sp. **(30.73)** *Sansibia* sp. **(29.00)** *Paraplexaura* sp. **(11.57)**
		LLS

Figure 3.22 Results of SIMPER analysis comparing octocoral assemblage structures in shallow water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. The top three octocoral species that contributed most to dissimilarities between sites are shown (in order of percentage contribution indicated in ( )).

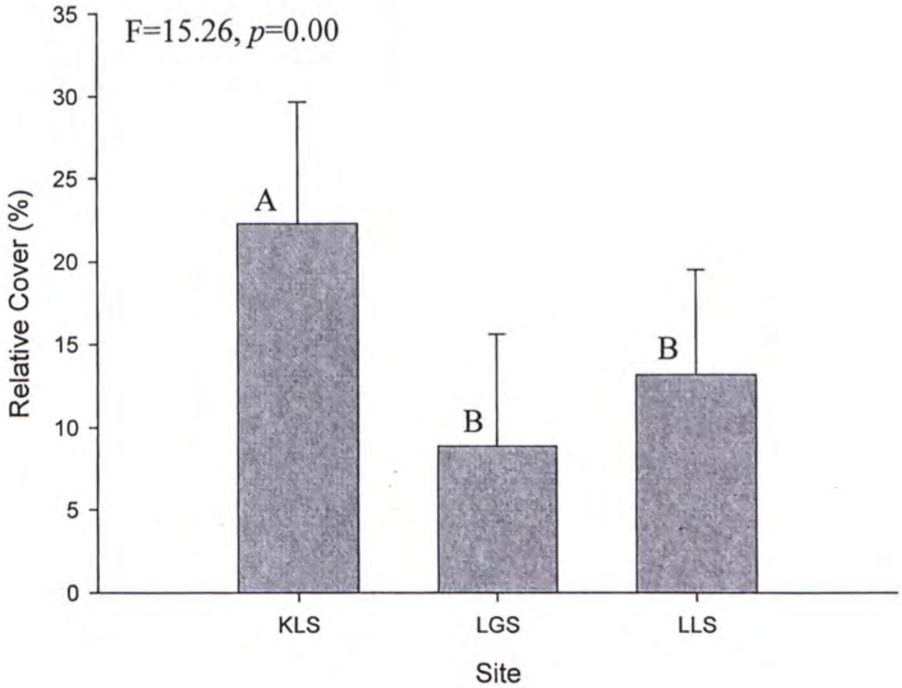


Figure 3.23 Mean (± SD) percentage cover of octocorals in deep water region of three sites in Tung Ping Chau Marine Park. KLS = Kang Lau Shek; LGS = Lan Guo Shui; LLS = Lung Lok Shui. One-Way ANOVA was performed, with F values and level of significance indicated.

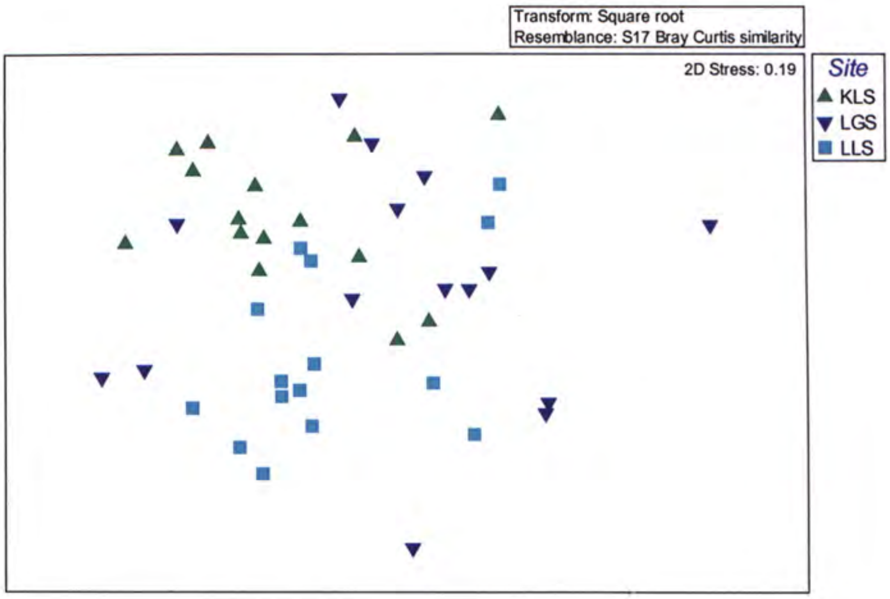


Figure 3.24 MDS plot for the spatial comparison of octocoral assemblage structures in deep water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. Each point represents data from one transect.

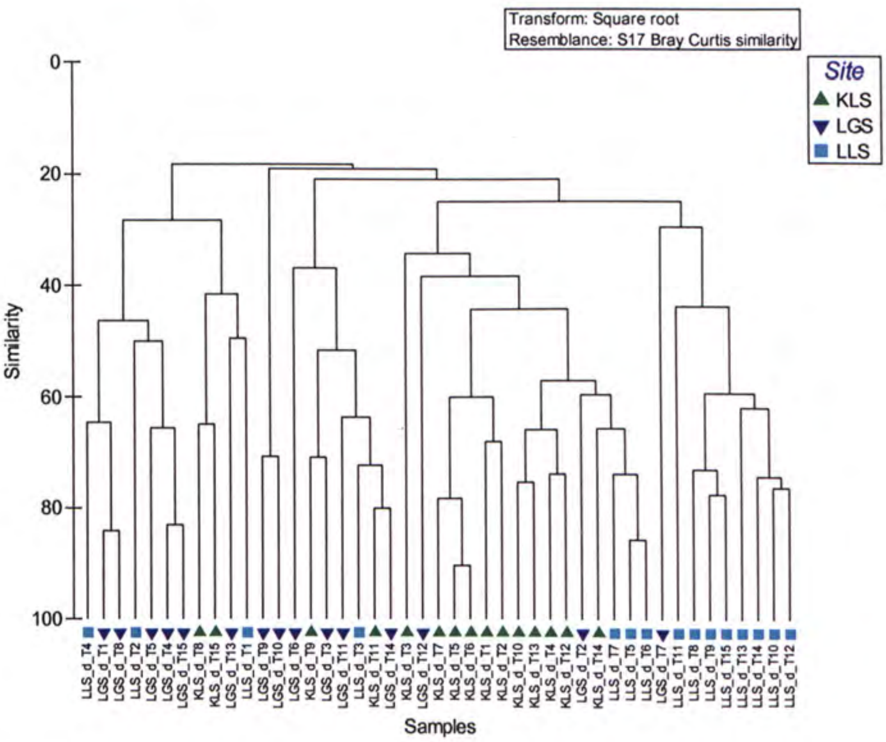


Figure 3.25 Dendrogram for the spatial comparison of octocoral assemblage structures in deep water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. Each point represents data from one transect.

	LGS	**LLS**
KLS	0.318 0.001	0.354 0.001
LGS		0.146 0.012
		LLS

Figure 3.26 Results of ANOSIM analysis for spatial comparison of octocoral assemblage structures in deep water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. Global R=0.274, $p<0.05$. Upper figure represents the R value and lower one the significance level for the pair-wise comparison.

	LGS	**LLS**
KLS	*Echinomuricea* sp. A **(26.52)** *Sinularia brassica* **(14.38)** *Lobophytum* sp. **(12.38)**	*Echinomuricea* sp. A **(22.56)** *Sinularia brassica* **(10.88)** *Lobophytum* sp. **(9.84)**
LGS		*Lobophytum* sp. **(16.66)** *Sinularia brassica* **(15.05)** *Sarcophyton* sp. **(10.95)**
		LLS

Figure 3.27 Results of SIMPER analysis comparing octocoral assemblage structures in deep water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using relative percentage coral cover data. Top three octocoral species that contributed most to dissimilarities between sites are shown (in order of percentage contribution indicated in ( )).

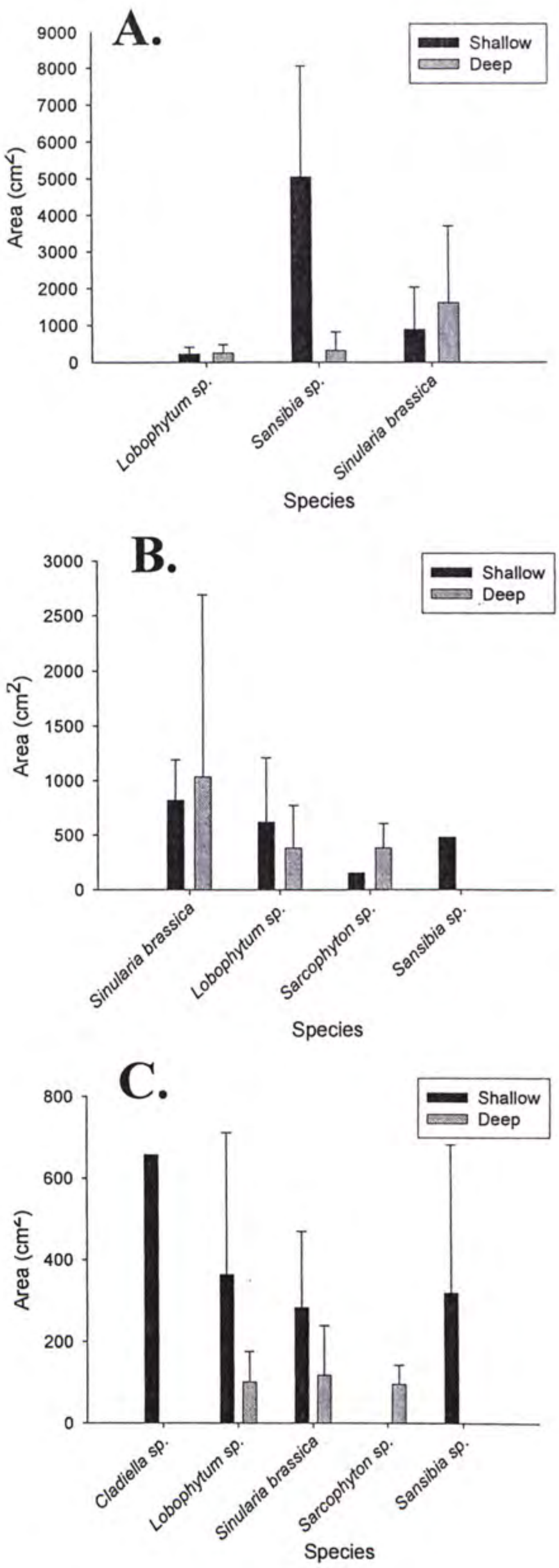


Figure 3.28 The mean (± SD) area (cm^2) of octocorals growing on horizontal plane in shallow and deep water regions of the three sites in Tung Ping Chau Marine Park: (**A**) Kang Lau Shek; (**B**) Lan Guo Shui; (**C**) Lung Lok Shui. Total n = 910. Note Y axes are in different scales.

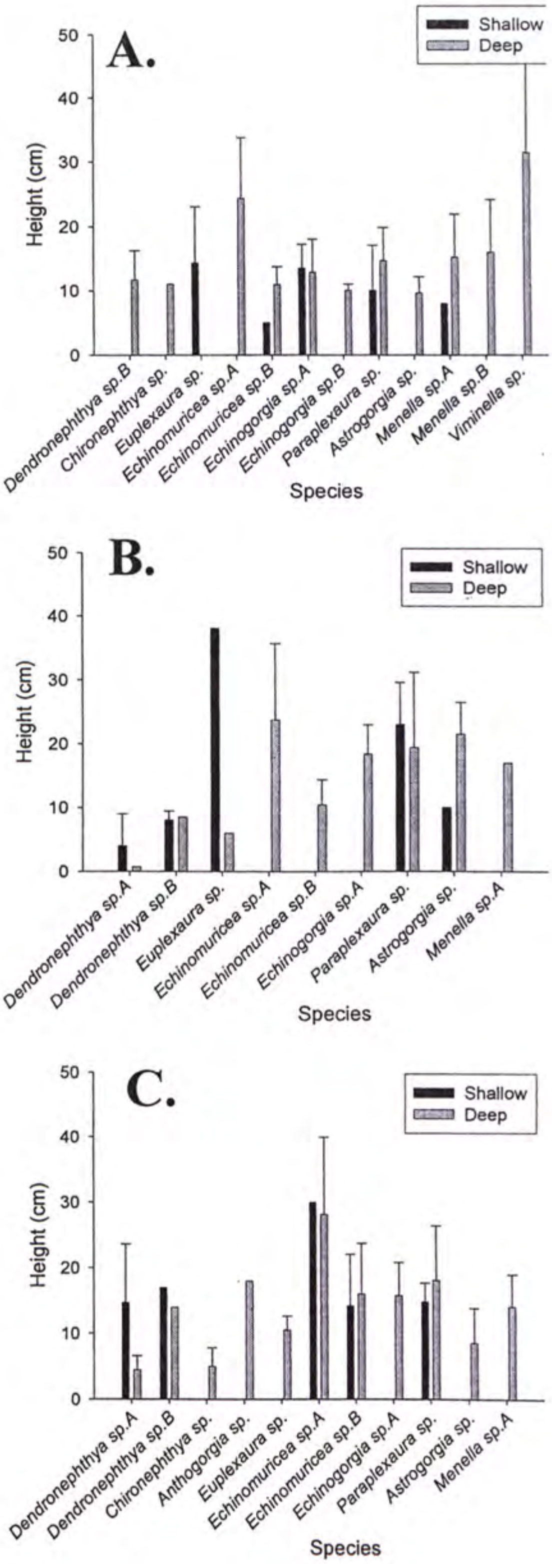


Figure 3.29 The mean (± SD) height (cm) of octocorals growing on vertical plane in shallow and deep water regions of the three sites in Tung Ping Chau Marine Park: (**A**) Kang Lau Shek; (**B**) Lan Guo Shui; (**C**) Lung Lok Shui. Total n = 1042.

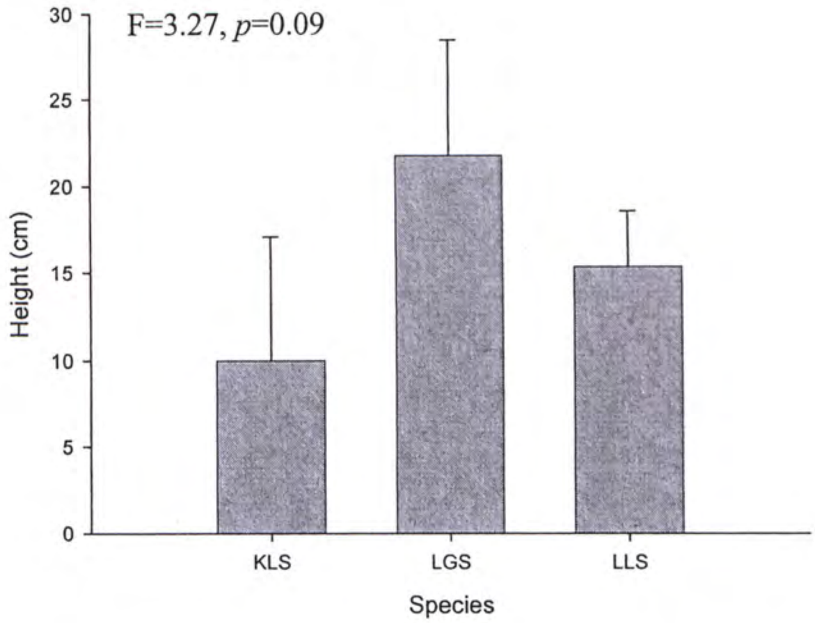


Figure 3.30 The mean height (cm) of *Paraplexaura* sp. in shallow water region of the three sites in Tung Ping Chau Marine Park. KLS = Kang Lau Shek; LGS = Lan Guo Shui; LLS = Lung Lok Shui. Total n = 12. One-Way ANOVA was performed, with F values and level of significance indicated.

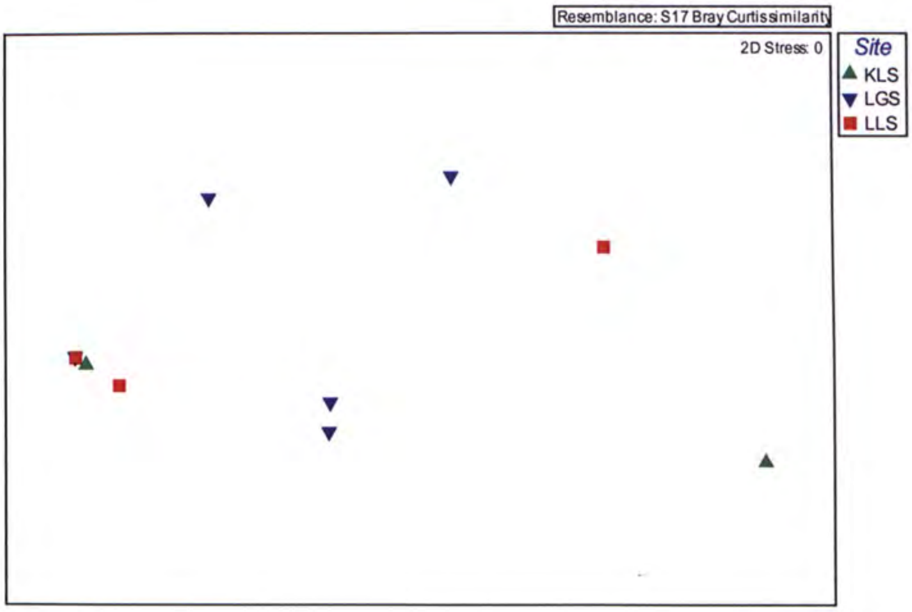


Figure 3.31 MDS plot for the spatial comparison of *Paraplexaura* sp. size structure in shallow water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using size class data. Each point represents data from one transect.

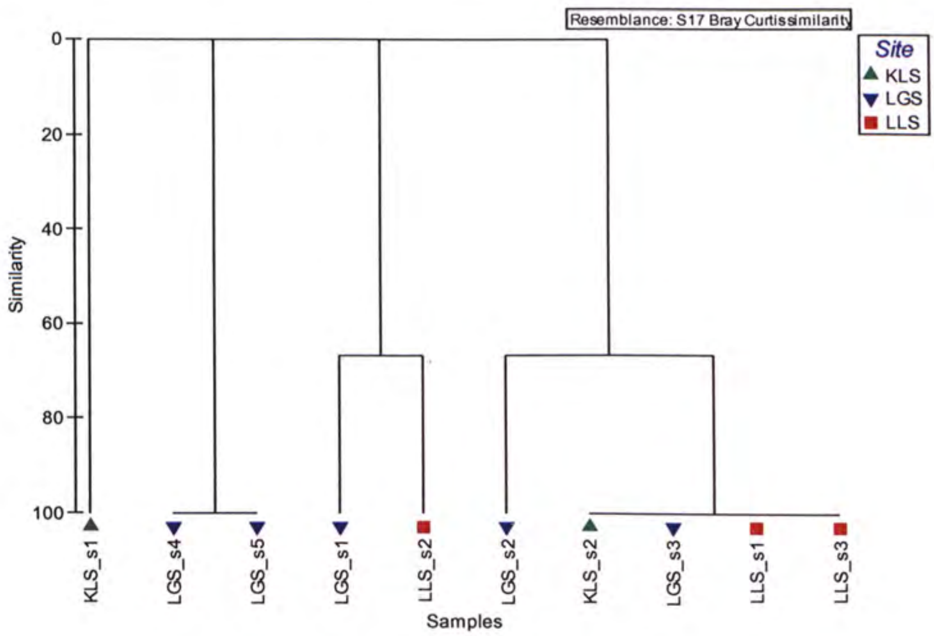


Figure 3.32 Dendrogram for the spatial comparison of *Paraplexaura* sp. size structure in shallow water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using size class data. Each point represents data from one transect.

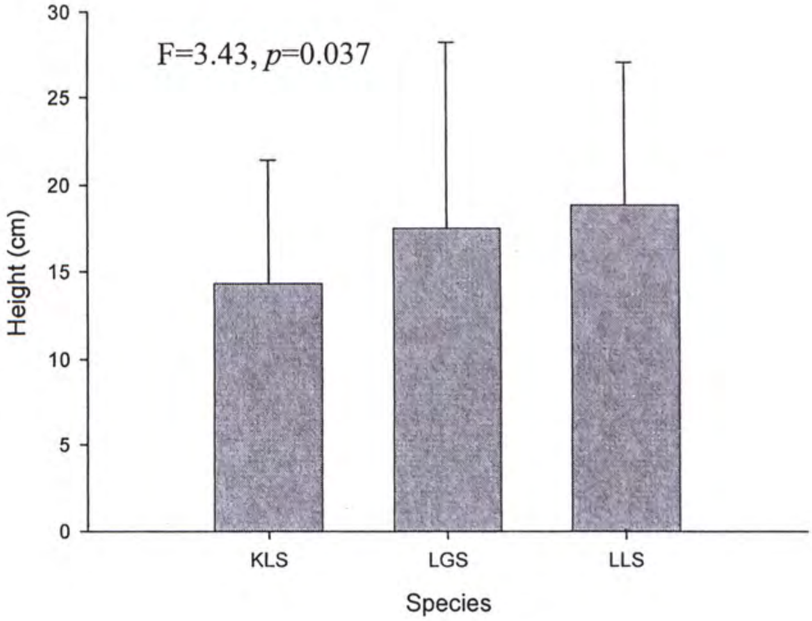


Figure 3.33 The mean height (cm) of *Paraplexaura* sp. in deep water region of the three sites in Tung Ping Chau Marine Park. KLS = Kang Lau Shek; LGS = Lan Guo Shui; LLS = Lung Lok Shui. n = 86. One-Way ANOVA was performed, with F values and level of significance indicated.

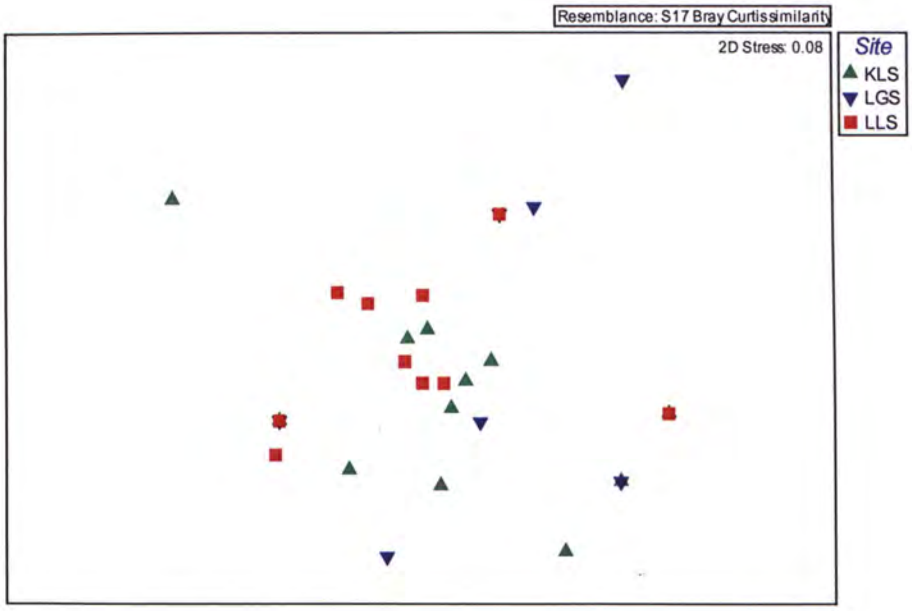


Figure 3.34 MDS plot for the spatial comparison of *Paraplexaura* sp. size structure in deep water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using size class data. Each point represents data from one transect.

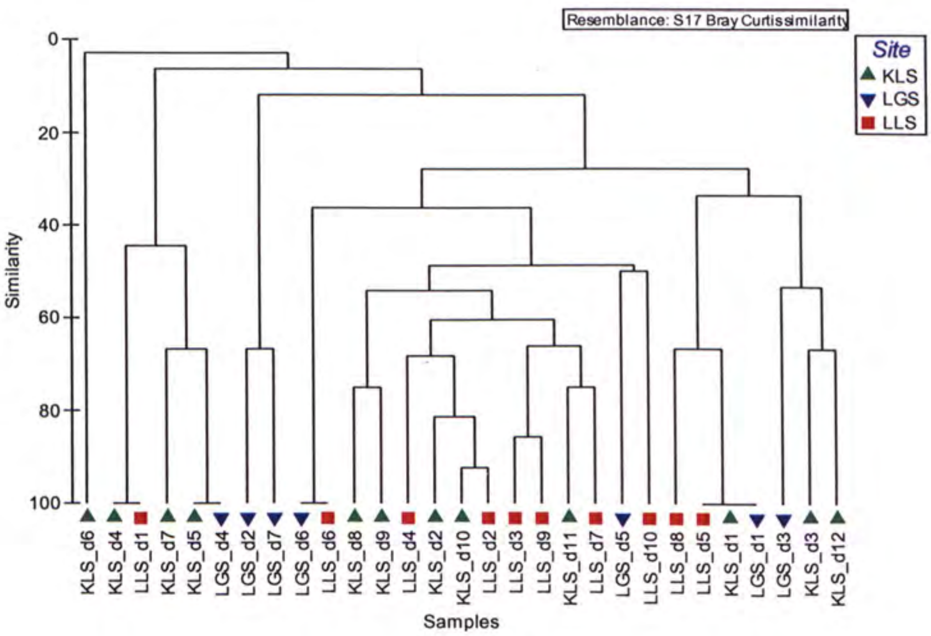


Figure 3.35 Dendrogram for the spatial comparison of *Paraplexaura* sp. size structure in deep water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS) using size class data. Each point represents data from one transect.

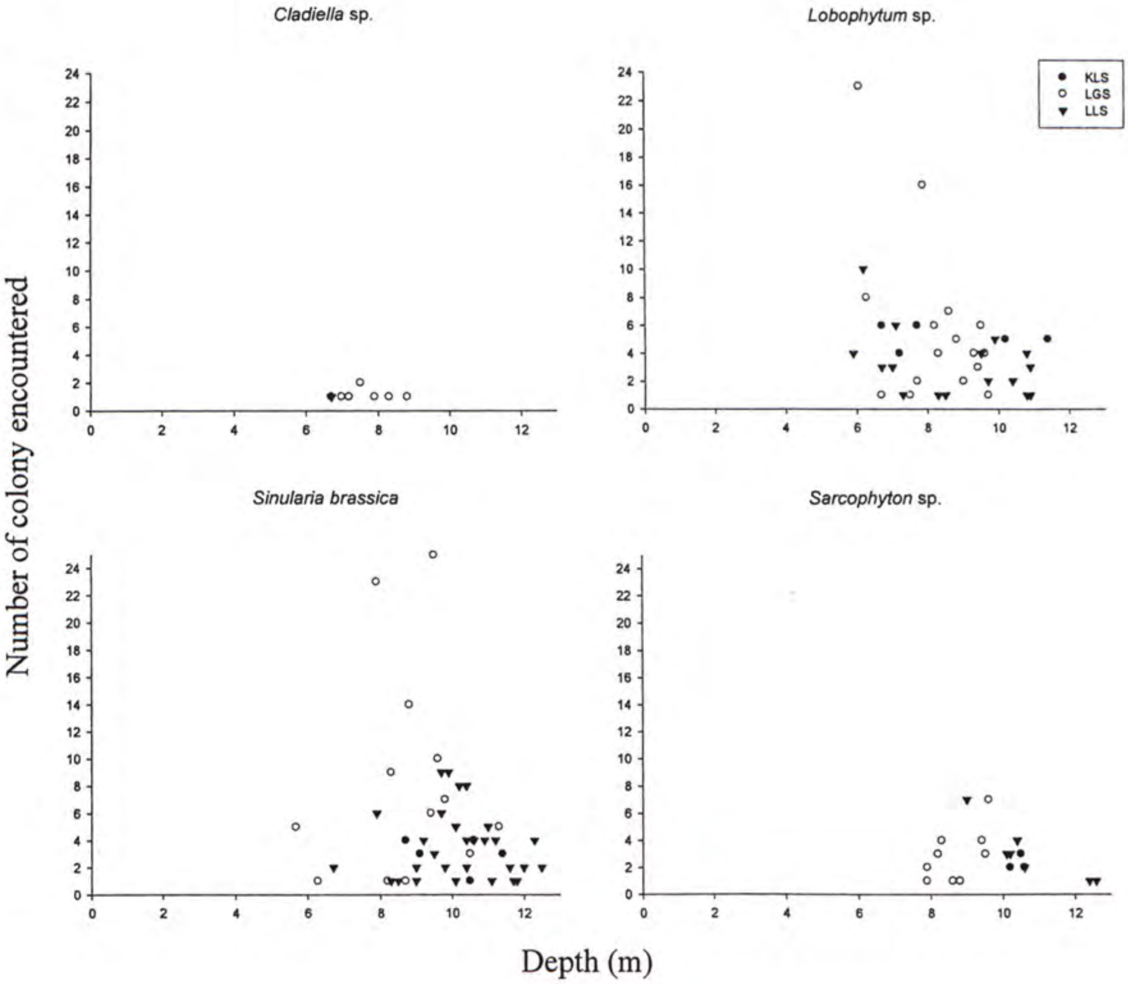


Figure 3.36 The vertical zonation profile of Alcyoniid soft corals *Cladiella* sp., *Lobophytum* sp., *Sinularia brassica* and *Sarcophyton* sp. in Kang Lau Shek (● KLS), Lan Guo Shui (○ LGS) and Lung Lok Shui (▼ LLS).

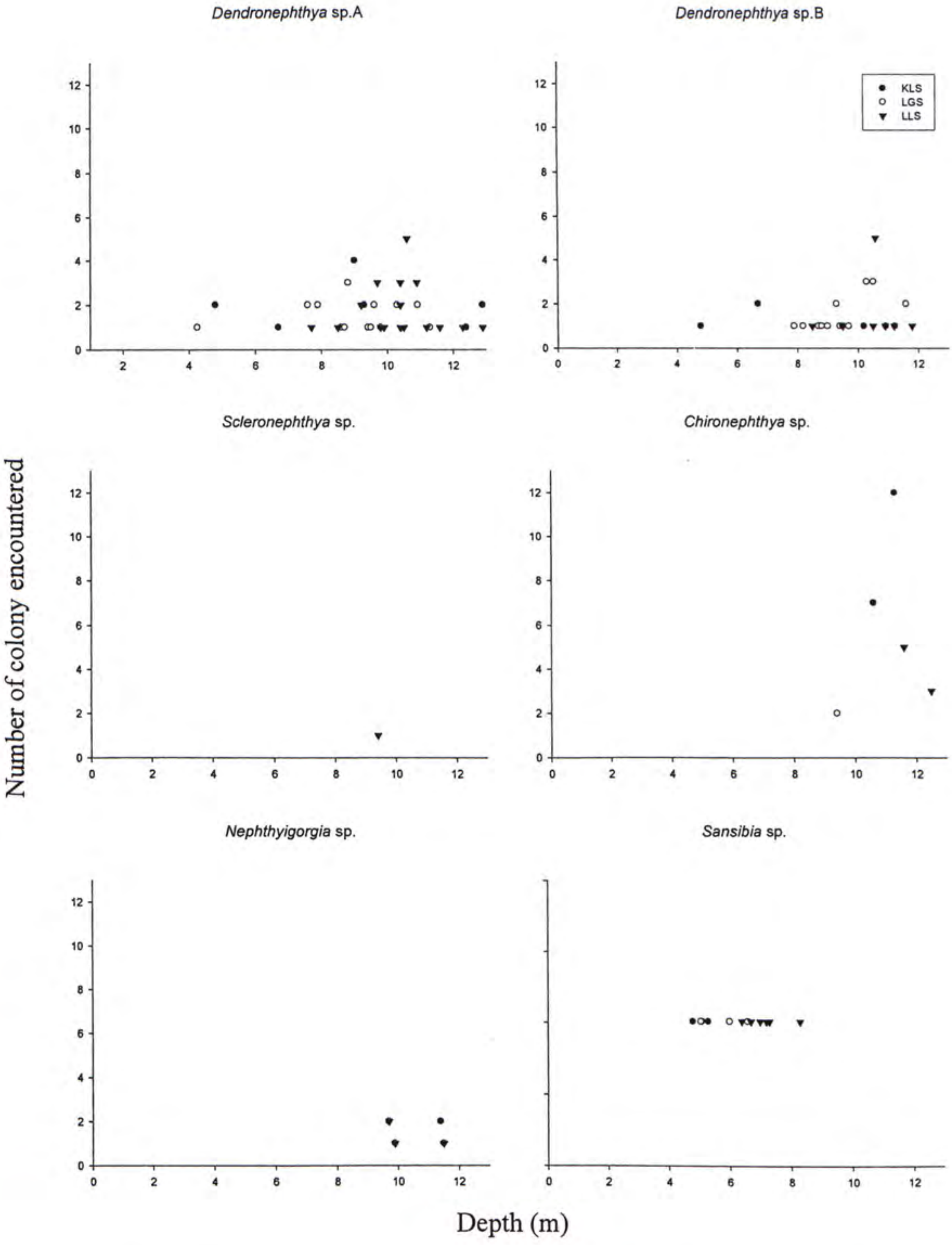


Figure 3.37 The vertical zonation profile of Nephthyid soft corals *Dendronephthya* spp., *Scleronephthya* sp., Nidaliid *Chironephthya* sp., *Nephthyigorgia* sp. and Xeniid *Sansibia* sp. in Kang Lau Shek (● KLS), Lan Guo Shui (O LGS) and Lung Lok Shui (▼ LLS). No abundance data are shown for *Sansibia* sp.

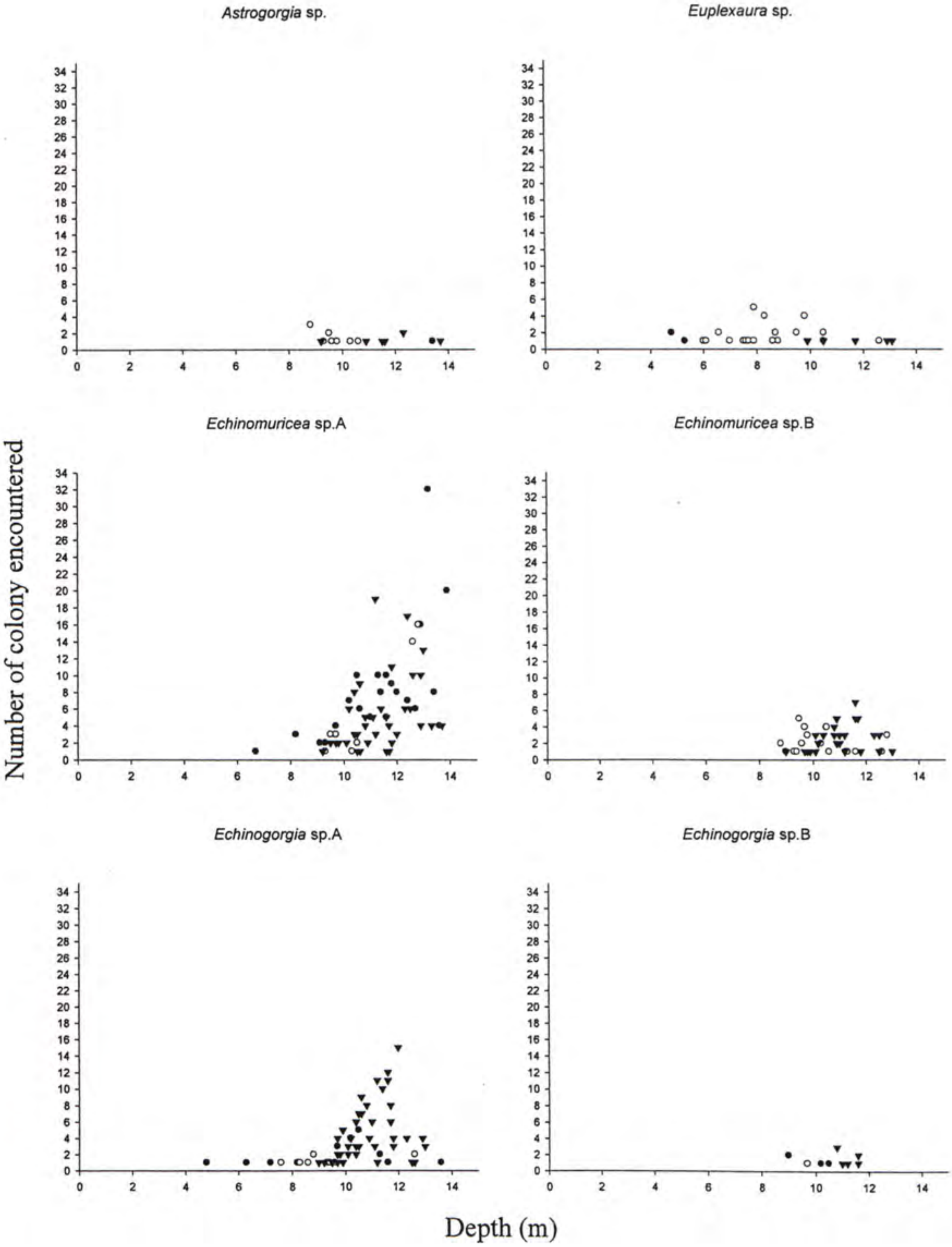


Figure 3.38 The vertical zonation profile of Plexaurid gorgonians *Astrogorgia* sp., *Euplexaura* sp., *Echinomuricea* spp., and *Echinogorgia* spp. in Kang Lau Shek (● KLS), Lan Guo Shui (○ LGS) and Lung Lok Shui (▼ LLS).

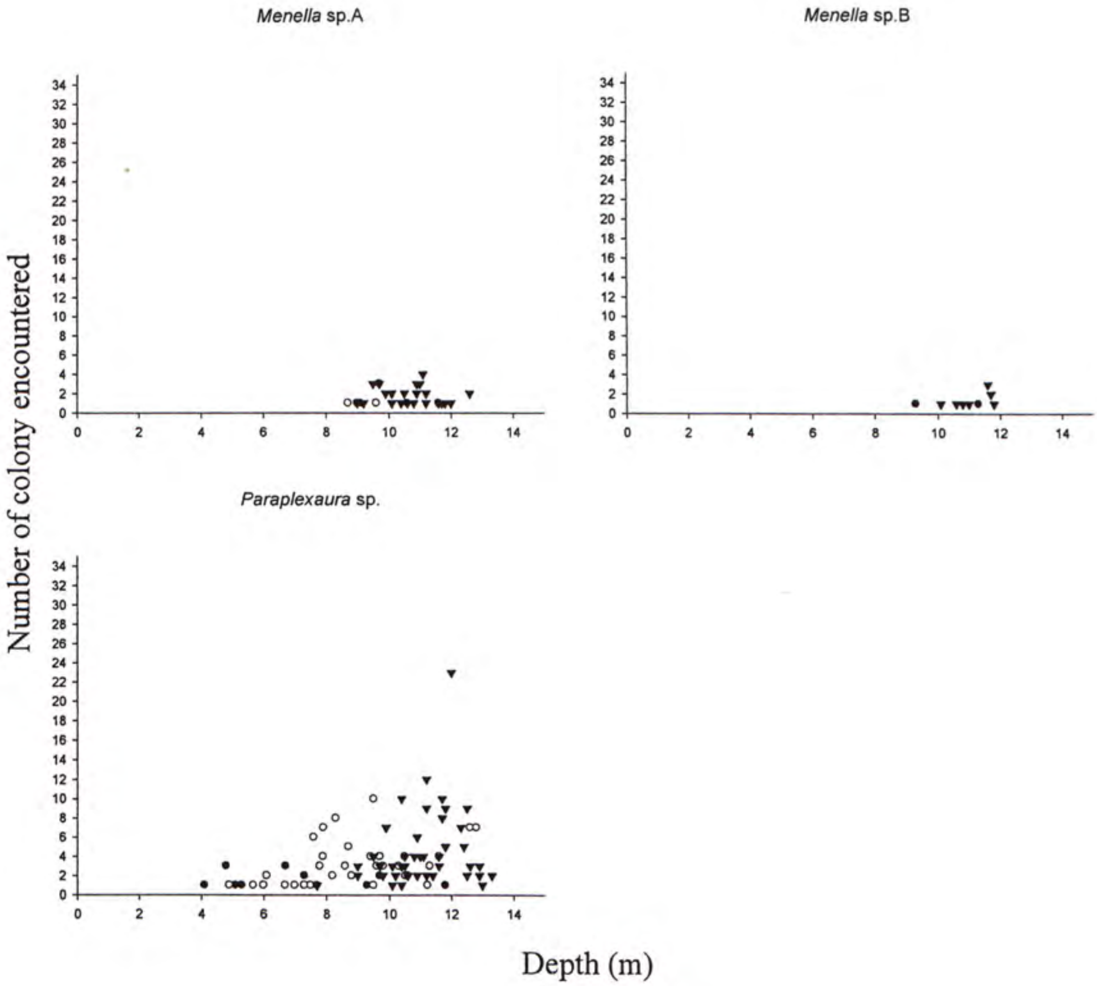


Figure 3.39 The vertical zonation profile of Plexaurid gorgonians *Menella* spp. and *Paraplexaura* sp. in Kang Lau Shek (● KLS), Lan Guo Shui (○ LGS) and Lung Lok Shui (▼ LLS).

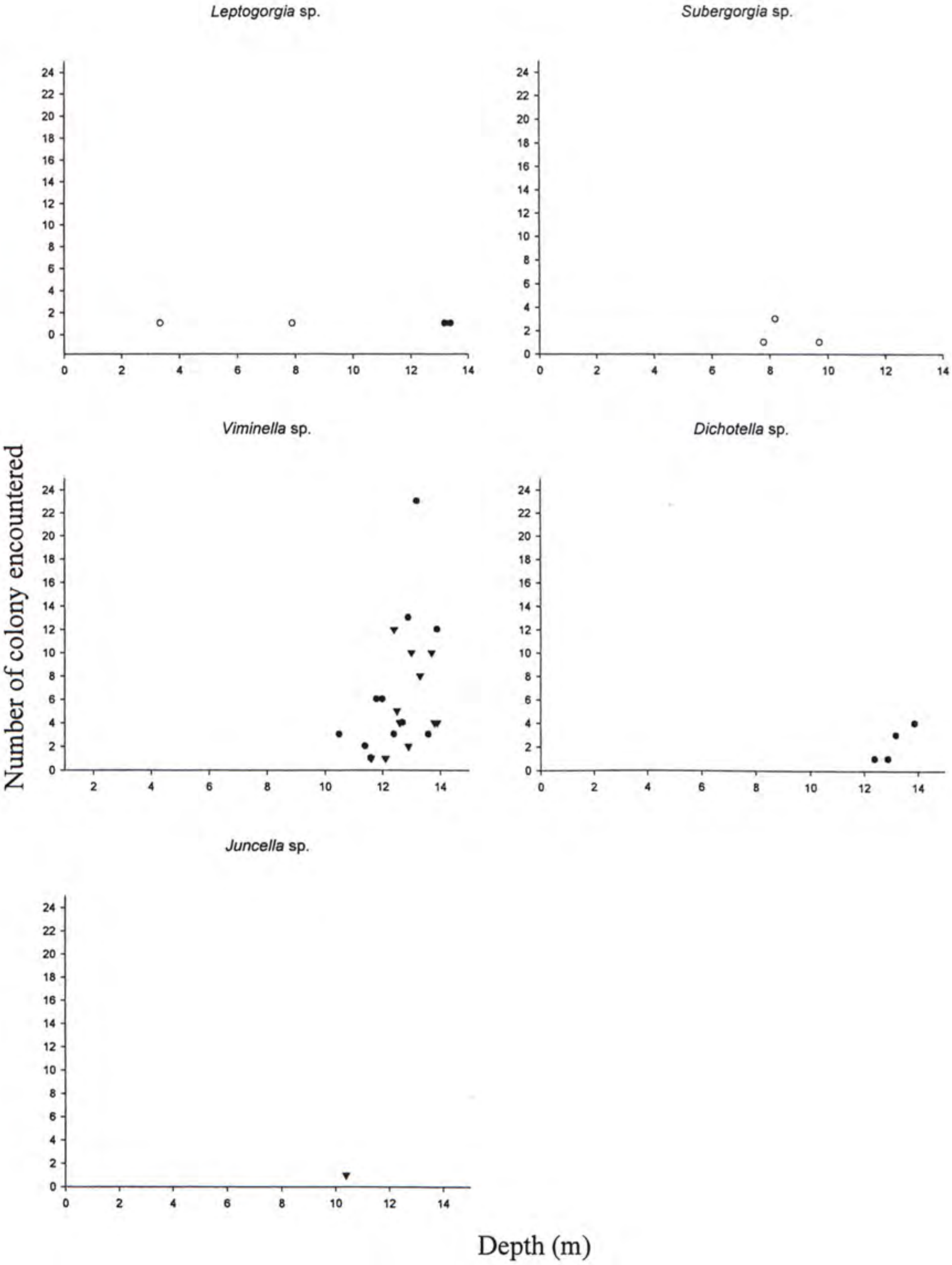


Figure 3.40 The vertical zonation profile of Gorgoniid *Leptogorgia* sp., Subergorgiid *Subergorgia* sp., Ellisellid *Viminella* sp., *Dichotella* sp. and *Juncella* sp. in Kang Lau Shek (● KLS), Lan Guo Shui (O LGS) and Lung Lok Shui (▼ LLS).

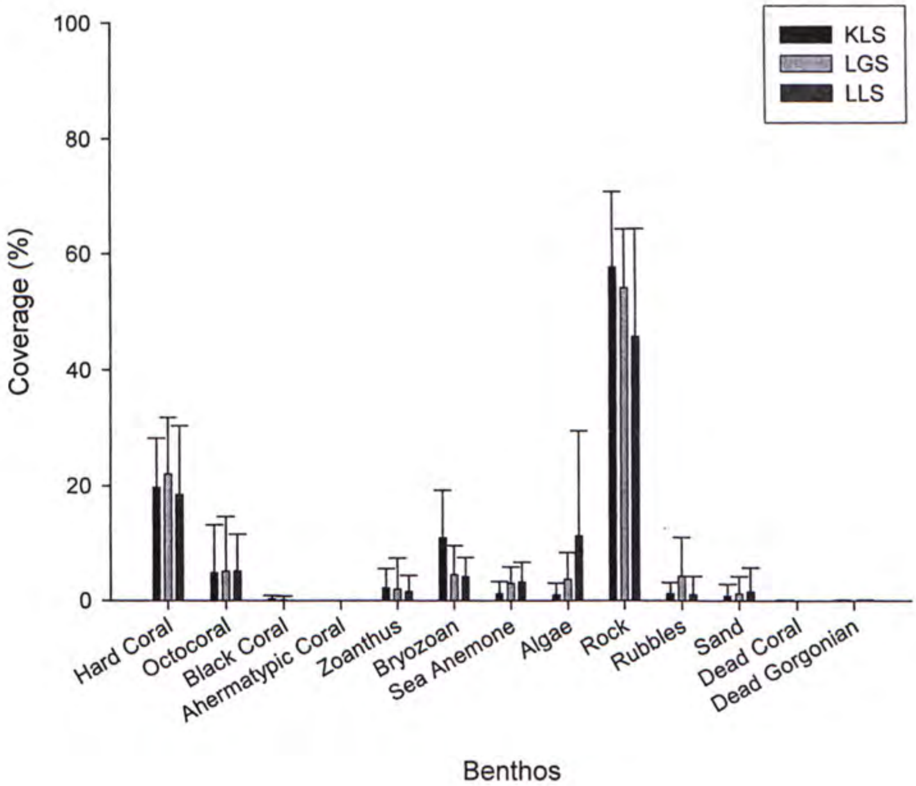


Figure 3.41 Mean (± SD) percentage cover of benthic composition using data from 45 transects in shallow water regions of Kang Lau Shek (KLS), Lang Guo Shui (LGS) and Lung Lok Shui (LLS).

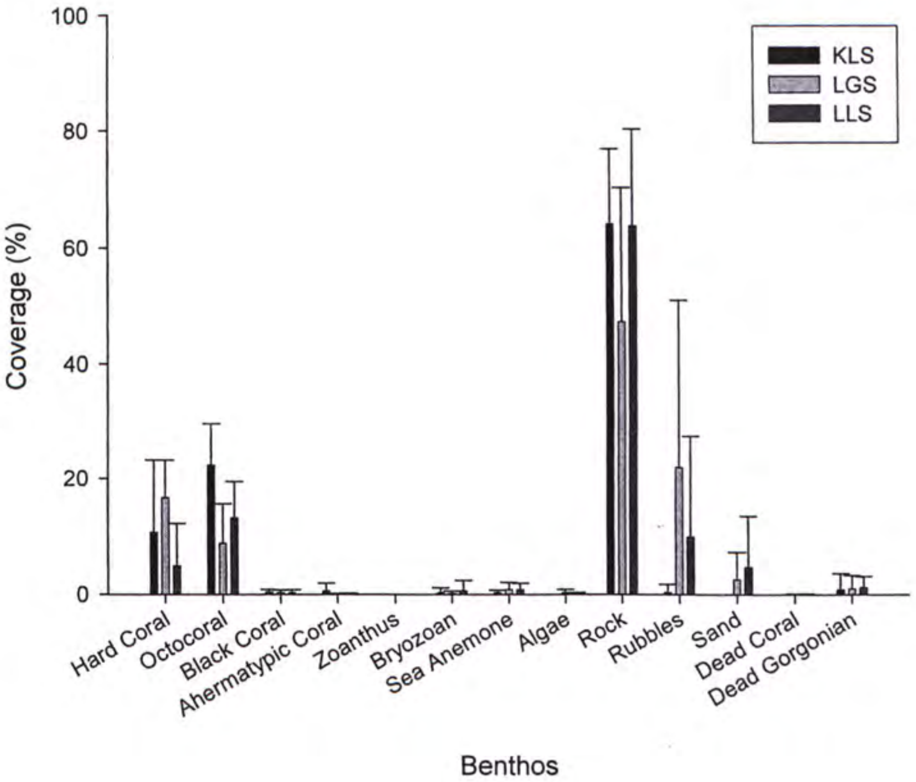


Figure 3.42 Mean (± SD) percentage cover of benthic composition using data from 45 transects in deep water regions of Kang Lau Shek (KLS), Lang Guo Shui (LGS) and Lung Lok Shui (LLS).

Chapter 4 Ecological Relationship of Amount of Suspended Particulates and Water Motion with Octocoral Assemblages

4.1 Introduction

Environmental factors have been shown to play a very important role in controlling the distribution of marine fauna and flora. Water clarity (Kelmo *et al.* 2003, Fabricius & McCorry 2006), topographic relief (Yoshioka & Yoshioka 1989), load of suspended particulates (Fabricius & Dommisse 2000), sedimentation (McClanahan & Obura 1997), turbidity (Anthony & Larcombe 2000), water flow (Dai & Lin 1993) and depth (Fabricius & De'ath 1997) have been reported to exert certain effects in influencing the distribution pattern, abundance and growth rate of octocorals.

The principal feeding mode of octocorals is suspension feeding. As in other suspension feeders like bryozoans (Genovese & Witman 1999) and barnacles (Eckman & Duggins 1993), they obtain their food from the suspended particulate matter (SPM) in the water column. They differ from the scleractinians and other hydrozoans in possessing only small and weak nematocysts on their tentacles. Their diets are small in size, usually consist of phytoplankton, dinoflagellates and weakly swimming or damaged zooplankton (Fabricius & Dommisse 2000, Fabricius *et al.* 1995a & b). As octocorals have passive heterotrophic feeding mode, they need to rely on water current to help transporting the food particles through their filter structure in order to capture them, intake and fulfill their daily energetic requirement. Thus, beside food concentration, strength of current is also a key factor in influencing the distribution and growth of octocorals.

Water motion controls the exchange rate of materials between the sea water and coral surface tissue (Jokiel 1978). Different flow rates of current can greatly influence the feeding efficiency of suspension feeders like octocorals, especially the azooxanthellate ones. This group of octocorals does not host any symbiotic algae so no photosynthesis would be undertaken. Thus, these octocorals depend solely on the need to capture organic matters in the water in order to meet their daily carbon need. Many studies have examined the effects of water flow on the efficiency of food capture in octocorals (Patterson 1991, Dai & Lin 1993, Fabricius *et al.* 1995a, b). At slow water flow, the rate of food particles transported to the colony decreases. This adversely affects the amount of food encountered and the intake rate by the coral tentacles. Moreover, under this low-speed flow, smaller size of polyps would be observed as it is too costly for the corals to spend energy to keep the polyps fully expanded. If the current is too strong, coral colonies will quit feeding as their polyps will be bent and deformed by the drag. Similarly, the energy cost of keeping the polyps expanded is also high. Thus, colonies may retract their polyps rather than keep them expanded for feeding. Intermediate water flow will bring the greatest benefit to the coral colonies. Greatest size of polyps would be observed, with the highest food encounter and intake rate recorded. Due to this reason, azooxanthellate octocorals usually grow with their fan-shaped colony perpendicular to the prevailing current direction to maximize food particle interception (Grigg 1972). However, the optimal water flow varies among different species. Water current can thus act as a major force in delimiting octocoral distribution, growth and abundance.

Species abundance data can be a good indicator of how environmental factors are exerting certain degree of effects on the distribution pattern of marine organisms. Other than this, use of morphological data is also a good approach to reveal how physical parameters influence the assemblages of marine organisms like octocorals. This approach is cost-effective, requires less time and resources than the collection of species abundance data (Bell *et al.* 2006). This method has been applied on the study of sponges, but seldom on octocorals. Fabricius and De'ath (1997) reported that soft corals on Davis Reef of Great Barrier Reef were distributed systematically in relation to the physical variables. Water flow was found to be the key factor in affecting the distribution of small soft, capitate (SSC) soft corals, with the highest cover at intermediate flow recorded. This study provided strong evidence that soft coral zonation and composition could be predicted based on information about the environmental factors.

The octocoral distribution pattern in Hong Kong is quite specific. No octocorals are recorded in very shallow waters (<-4 m CD (Chart Datum)), while high abundance of them is found at this depth zone in many other places (Benayahu & Loya 1981, Tursch & Tursch 1982, Dinesen 1983, Benayahu 1985, Goh & Chou 1994, Goh *et al.* 1997, Benayahu *et al.* 2004). Differences in environmental parameters other than depth would likely contribute in structuring their distribution. In the previous chapter (Chapter 3), significant difference in octocoral cover and community structure between sites and depth in three sites within the Tung Ping Chau Marine Park (TPCMP) was reported. In this Chapter, the relationships between octocoral morphological assemblages and other physical parameters of the water in these sites were further investigated. Specifically, the correlation between octocoral morphological assemblages in these sites and the amount of suspended particulates in the water, as well as the strength of water motion in each site was examined. Information on suspended particulate amount is useful to estimate the food concentration available to the octocorals. Water motion on the other hand, can affect the distribution of food particles, chances of food encounter and intake rate of octocorals. These two parameters are likely to be most important in affecting octocoral distribution, assemblage structure and morphology. This study is the first of its kind in Hong Kong.

4.2 Methodologies

Experiments were carried out in shallow (-6 m CD) and deep (-13 m CD) water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Long Lok Shiu (LLS) of TPCMP, Hong Kong (For description of these sites, please refer to Chapter 3 Section 3.2).

4.2.1 Suspended Particulates Collection

Samplings for the amount of suspended particulates in the water over the three study sites were carried out twice a month, starting from November 2005 to June 2006. In every sampling, three replicates of 250 ml of water were collected by water sampler in both shallow and deep water regions of each site. These water samples were brought back to the laboratory and immediately filtered through 0.45 μm pore size pre-weighed filter papers separately. After filtration, the papers were transferred to a tray carefully, and dried in a drying oven at 70 °C for two days. The completely dried filter papers were then re-weighed using an electronic balance.

4.2.2 Clod Card Method

Clod cards had been used as indicators of relative water motions (Thompson & Glenn 1994). Measurement of weight loss in clod cards placed in water for a fixed period of time could be used to reflect the strength of water motion.

Clod cards were prepared according to the instructions of Jokiel & Morrissey (1993) and Thompson & Glenn (1994). Exactly 250 g of plaster of Paris (industrial grade Calcium sulphate) were added into 250 ml of distilled water and then thoroughly stirred using a plastic spoon. After the mixing, the slurry was poured into a flexible plastic ice-cube tray. The tray was tapped several times in order to remove any air bubbles inside the liquid. The mix was allowed to harden for 48 hours at room temperature (25 °C). Afterwards, the clods were removed from the molds and glued to water-resistant plastic cards. Two holes were punched in the end corners of the plastic cards to allow fastening of the cards to the cement blocks placed underwater before hand. In order to eliminate the humidity effects on the clods in different seasons, the clod cards were further oven-dried at 50 °C for 24 hours and weighed on an electronic balance before use.

Samplings were carried out once a month, starting from January 2006 to June 2006. Three replicates of clod cards were placed at 6 and 13 m deep for 24 hours at each of the study sites. After 24 hours, the cards were retrieved. In the laboratory, the cards were rinsed with distilled water, oven-dried at 70 °C for 72 hours and reweighed.

4.3 Data Analysis

4.3.1 Amount of Suspended Particulates

Amount of suspended particulates collected in different depth zones of the three study sites were determined by calculating the differences in the weight of filter papers before and after use. To find out any significant differences in particulate amount between sites and depth zones, Two-Way ANOVA was used. In every case, assumptions of homogeneity of variance and normality of data were first evaluated. If the assumptions cannot be satisfied (i.e. $p<0.05$, Levene's Test of Equality of Variances), the data sets were further transformed and tested. Non-parametric Kruskal-Wallis test was used instead if attempts at data transformation could not satisfy the parametric assumptions.

4.3.2 Weight Loss of Clod Cards

Net weight loss of clod cards was calculated as the difference in the dry weight of the clod cards before and after use. As none of the data passed the homogeneity of variances test ($p<0.05$), Kruskal-Wallis test was used to evaluate the differences of weight loss between depth zones and sites.

4.3.3 Correlation between Suspended Particulate Amount and Weight Loss of Clod Cards

Pearson correlation was used to detect any relationship between the two environmental factors, the suspended particulate amount (food concentration) and weight loss of clod cards (relative strength of water motion). Data collected in different depth zones and sites were pooled according to the sampling months and then compared.

4.3.4 Octocoral Morphological Assemblages and Their Relationship with Physical Parameters

To elucidate the relationship between octocoral morphological assemblages and physical parameters, multivariate analysis was performed using PRIMER 6. Generic cover data collected by belt transect quadrat sampling method (refer to Chapter 3, Section 3.3.1) were pooled into six morphological groups detailed below:

Fan shape (FAN): Colonies grow in one plane, with branches fused together forming a net-like structure. This category includes the gorgonian species *Acanthogorgia* sp. *Astrogorgia* sp, *Echinogorgia* spp. and *Menella* spp..

Branching form (BRA): Colonies grow with few slender, short or long branches; can be in one plane or multi-directional. Net-like structure would not be observed. Soft coral *Chironephthya* sp. and gorgonians *Echinomuricea* spp., *Euplexaura* sp. and *Paraplexaura* sp. belong to this group.

Encrusting form (ENC): Colonies are flattened and encrusted on the substratum.

Members include *Cladiella* sp., *Lobophytum* sp., *Sinularia brassica* and *Sansibia* sp..

Arborescent form (ARB): Colonies are bushy and branched with polyp bunches. Soft coral *Dendronephthya* spp. belongs to this category.

Mushroom-like (MUS): Colonies have a conspicuous stalk and fleshy polypary. Soft coral *Sarcophyton* sp. belongs to this group.

Whip-like (WHI): Colonies are tall and whip-liked. Gorgonian *Viminella* sp. has this kind of growth form.

The pooled data were square-root transformed to reduce the effects of dominance by any particular morphological group. MDS plot was then generated to visualize the relationship between samples. An MDS plot was also generated using data on the amount of suspended particulates and water motion from each depth of each site. The function BIOENV in PRIMER 6 was applied to help reveal the "Best" match between the biotic samples (morphological assemblage structure) and the abiotic samples (environmental variables). BIOENV investigates the degree of relationship between the two underlying similarity matrices of the MDS plots, one based on the morphological data and one on the environmental data, using Spearman Correlation. By running this test, the degree to which physical factors affect the octocoral morphological assemblage structure could be detected.

4.4 Results

4.4.1 Seasonal and Spatial Comparison of Suspended Particulate Amount

The amount of suspended particulates collected from the shallow and deep water regions at each site in different months varied, ranging from 0.0071 to 0.0141 g in 250 ml of sea water samples (Fig. 4.1). Increasing trend of particulate amount was obtained from November 2005 to March 2006, with a little drop in April 2006 that was followed by an increase again in May and June 2006. In general, significant difference in particulate amount between months was detected in both water zones. However, no difference was found among sites (Fig. 4.1).

When data for each site were analyzed separately, more findings were obtained. Significant difference in particulate amount between different sampling months was found in all study sites (Fig. 4.2). The difference was also significant between shallow and deep water regions in KLS and LGS but not in LLS (Fig. 4.2). However, at least in KLS, variation in monthly amount of suspended particulates was not affected by differences detected between depth zones (Fig. 4.2A).

4.4.2 Seasonal and Spatial Comparison of Net Clod Card Weight Loss

Amount of weight loss in clod cards can reflect the relative intensity of water motion. Weight loss of clod cards in shallow waters was relatively higher than that in the deeper waters (Fig. 4.3). Greatest loss was found in June 06, with 12.75-13.78 g and 8.52-9.93 g of weight loss recorded in shallow and deep water regions respectively in all study sites. When the data from different depth zones in each site were analyzed, weight loss between sites was found not to be statistically significantly different, but the difference between times remained significant (Fig. 4.3). This indicated that the strength of water motion in these sites in TPCMP varied among the different months examined.

In all three study sites, clod card weight loss in shallow water areas was always higher than that in deeper waters (Fig. 4.4). The clod card weight loss in shallow water of LGS in April 06 was even 1.77 fold higher than that in deep water (Fig. 4.4B). All these suggest that the water motion in shallow water regions was always stronger than that in the deeper regions. However, this difference was statistically significant only in

LGS and LLS but not in KLS.

4.4.3 Pearson Correlation between Suspended Particulate Amount and Clod Card Weight Loss

A negative correlation between the amount of suspended particulate and clod card weight loss for each site and each depth zone from January 06 to June 06 was detected. However, these correlations were not statistically significant (Fig. 4.5).

4.4.4 Relationship between Octocoral's Morphological Assemblage and Environmental Variables

Encrusting form was the most dominant growth form of octocorals in shallow water regions, occupying 7.45%, 9.64% and 7.45% of the bottom of KLS, LGS and LLS respectively (Fig. 4.6). The dominant growth form then shifted to fan-shaped and branching form with increasing depth, whereas these growth forms were rarely observed in shallow waters. The covers of octocorals having these two growth forms were particularly higher in the deeper water region of KLS, at 3.50% and 11.57% respectively, when compared with 0.07% and 0.64% respectively in the shallow water region (Fig. 4.6A).

MDS plots generated using the data of octocoral morphological assemblage showed the samples to tend to separate widely from one another but cursorily along depth, except for those from LGS where the data points representing the shallow and deep water zones were grouped very close to each other (Fig 4.7A). MDS plot generated using the data of suspended particulate amount and clod card weight loss clearly showed the samples from shallow and deep water regions to be well separated (Fig. 4.7B)

BIOENV results indicated that octocoral morphological assemblage from KLS, LGS and LLS was only slightly positively correlated with the amount of suspended particulate (Spearman's rank r=0.061), and negatively correlated with the clod card weight loss (Spearman's rank r=-0.393). Both correlations are, however, not statistically significant.

4.5 Discussion

This study aimed at investigating the spatial differences of the amount of suspended particulate and water motion between sites and depth zones, and how these could possibly affect the spatial distribution of octocorals. Thus, only short-term data were collected (eight and six months respectively) for the two environmental parameters. Although significant differences in these physical parameters were detected between the sampling months, the pattern of change was consistent between the two depth zones in each site and among the three study sites. Thus, short term data were sufficient to evaluate the relationship between these physical parameters and octocoral community structures and a longer term yearly data was not collected for it would have served the same purpose.

4.5.1 Effects of Environmental Factors on Octocoral Distribution in TPCMP

This study demonstrates that environmental variables, i.e. suspended particulate and water motion, could exert certain level of effects in influencing the distribution, species diversity and community structure of octocorals in TPCMP. Amount of suspended particulates in the water may be an indication of the amount of food available in the water column. The clod card measurement can give an idea on the intensity of water motion, which in some ways, could affect the availability of these food particles to octocorals.

The diet of octocorals is mainly consisted of small particulate organic matter such as phytoplankton and zooplankton. Study in coral reefs of Kenya revealed that the higher the food concentration in the water, the greater is the enrichment to the coral colonies, resulting in higher octocoral cover (McClanahan & Obura 1997). In this current study, higher amount of fine suspended particulates was found in deep water zones where higher cover and species diversity of soft corals and gorgonians were also found (see Chapter 3). This suggests that higher food concentration could facilitate the growth of these octocoral colonies. Although high amount of suspended particulate could be beneficial to the growth of octocorals, too high a concentration will actually become a stress to the stability of the community. Particulates in the water, in fact, will absorb and reflect sunlight. Light attenuation will increase if the turbidity of water is high. This factor will have a greater effect on the distribution of zooxanthellate corals but may not affect the azooxanthellate ones. Long-term exposure under high sediment condition will severely diminish the productivity and decrease the respiration of the octocoral colonies (Riegl & Branch 1995). Heavy sediment load will smother the octocorals, causing excessive mucus production and tissue necrosis (Riegl 1995), and finally mortality.

Water flow has been shown to be one of the major forces in delimiting soft coral distribution and abundance. It can increase the efflux of oxygen from coral tissue, and for the zooxanthellate octocorals, it can help to bring away the metabolic waste produced by the zooxanthellae during photosynthesis (Finelli *et al.* 2006). However, water motions that are too slow or too fast will depress the feeding efficiency of the corals (Fabricius & De'ath 1997). In this study, higher weight loss of clod card was found in the shallow water regions of KLS, LGS and LLS (Figs. 4.3-4.4), indicating that the water motion was much stronger in the shallower region than in the deeper water region. As strong water motion would inhibit the octocoral growth, significantly lower cover and species diversity of soft corals and gorgonians found in the shallow water region may be a result of higher water motion in this zone (see Chapter 3). Weight loss of clod card decreased with depth. This is correlated with increasing abundance of octocorals. In the shallow water regions, water motion is predominantly characterized by bidirectional flow. When the depth increases, the water motion will turn into much slower unidirectional flow in the deep water zones (Sebens & Johnson 1991). Thus, although no direct measurement of water current was carried out in this present study, the weaker water motion at deep water zones of KLS, LGS and LLS as revealed by lower clod card weight loss did suggest the deeper water region to be a more suitable place for the growth of octocorals.

The relationship between the octocoral assemblages and the environmental variables shown in the present study also helps to explain why octocorals can only be found in the more exposed sides of TPCMP, (i.e. in KLS, LGS and LLS) but not in the more sheltered sites east northeast sides of the island (i.e. A Ye Wan and A Ma Wan) where scleractinion corals are more abundant. In A Ye Wan and A Ma Wan the water is calmer and clearer most time of the year. The slope is gentle, and the substratum is mainly composed of rock, rubbles and sand. These physical variables together provide a good environment for the growth of scleractinian corals that cover >40% of the bottom at the depth of -1 to -3 m CD (Ang *et al.* 2003). The substratum becomes more sandy beyond 5 m deep with an absence of big rocks or boulders. These environmental conditions are clearly not suitable for the growth of octocorals, when compared with the physical conditions of KLS, LGS and LLS.

4.5.2 Distribution and Orientation of Morphological Groups

Growth morphologies influence the food intake and survival of octocoral colonies; in turn, growth form of octocorals is greatly affected by water flow and depths (Riegl &

Branch 1995). As Dinesen (1983) pointed out, damaging effect of wave action is a major factor inhibiting the growth of soft corals.

In the present study, different morphological groups of soft corals and gorgonians were found in different areas. The majority of encrusting group was found on the rocky substratum of shallow water regions (Fig. 4.6). These coral species are flattened and tightly encrusted on the rocks by heavily calcified base (*Cladiella* sp., *Lobophytum* sp., *Sinularia brassica*) or stolon (*Sansibia* sp.). With these special morphological features, they can attach on the substratum firmly even under strong water motion. Moreover, as these corals are zooxanthellate, this flatten growth form greatly increases their surface area to volume ratio, allowing a larger area for the uptake of sunlight needed for photosynthesis. Apart from wave action and irradiance, different morphologies of octocorals also help them to survive under sediment stress. Many tall ridges and lobes are found on the upper surface of *Lobophytum* colonies. This helps to create a large proportion of the surface that cannot be covered by sediment (Riegl & Branch 1995). *Sansibia* sp. has slender and soft polyps. Their sweeping motion under the water current will help to sweep away sediments accumulated on the colonies.

The dominant morphological groups occupying the space in deep water regions are those having branching and fan shape growth forms (Fig. 4.6). These growth forms maximize the surface area for suspended particulates interception (Riegl & Branch 1995) and are beneficial in the presence of high food concentration. The gorgonians found in KLS, LGS and LLS are all oriented perpendicularly to the current direction, and this orientation allows the coral colonies to maximize their feeding rate while minimizing drag formed by the hydrodynamic forces (Leversee 1976). In a study by Grigg (1972), fan-shaped *Muricea californica* colonies originally facing perpendicularly to the current were transplanted parallel to the surge. During his experiment, he found the transplanted colonies slowly turned and twisted until a position perpendicular to the current was reached. This special orientation of fan-shaped gorgonians thus is a useful indicator of water motion direction.

Results of BIOENV analysis in the present study did not find food concentration (suspended particulate) and water motion (clad card weight loss) to be significantly correlated with octocoral morphological assemblages. It is thus difficult to evaluate how these environmental factors could have influenced the distribution of different growth forms of octocorals in TPCMP.

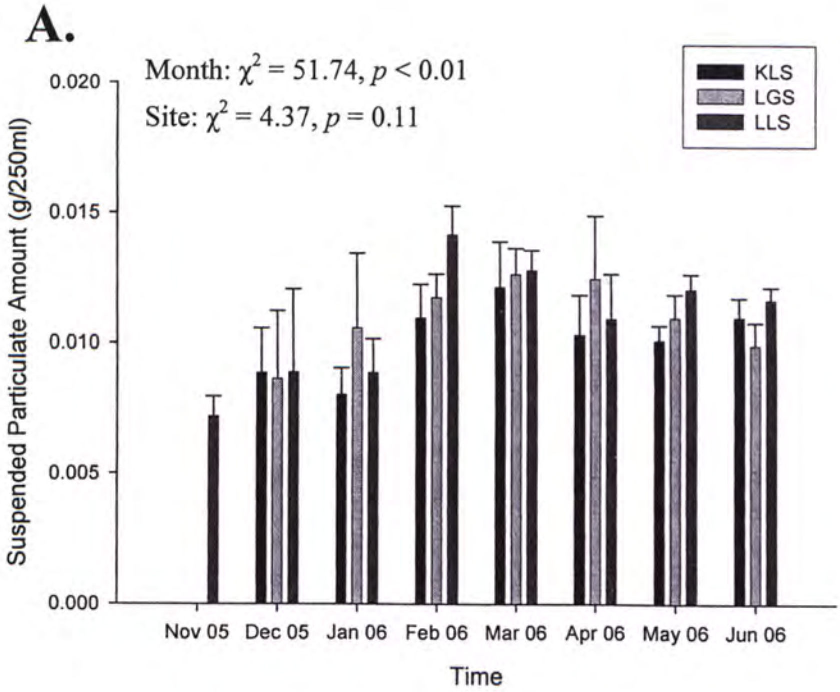
4.5.3 Possible Roles of Other Physical Factors

Other than the amount of suspended particulate and water motion, irradiance and temperature may be some of the possible factors that could influence the growth and distribution of octocorals. Light promotes growth of zooxanthellate species as they need plenty of sunlight for the photosynthesis of their symbionts. However, light will inhibit the distribution of azooxanthellate species, because these octocoral larvae need to settle in a relative dark environment (Fabricius and Alderslade 2001). Apart from light exposure, zooxanthellate soft corals are also susceptible to heat stress. Optimal seawater temperature for octocoral growth ranges from 18-31 °C (Fabricius and Alderslade 2001). However, their temperature tolerance is very narrow. Heat tolerance of octocoral is species-specific and varies in different regions. Elevated temperature which exceeds the octocoral's maximum tolerance level may lead to the temperature-induced bleaching. This is a heat-stress response resulting in the expulsion of zooxanthellae from the octocoral body (Strychar *et al.* 2005). The El Niño events that occurred in 1998 produced a very warm seawater that was 2 to 3 °C above long-term average temperature. This phenomenon led to high mortality of soft corals in Kenyan reefs, with 75% of them decimated (McClanahan et *al.* 2001). Temperature may also affect the longevity and competence of soft coral planulae. In

Zaslow & Benayahu's study (1996), higher metamorphosis rate of *Heteroxenia fuscescens* planulae was recorded in summer time (97.8%), when compared with that in winter (52.3%). Such a difference may be related to the energy expenditure of the planulae. Surface seawater temperature of Hong Kong usually ranges from 14-33 °C, which is relatively out of the optimal growth temperature range of octocorals. Thus, water temperature could potentially limit the distribution of soft corals and gorgonians in Hong Kong, especially in shallow water. More experiments on the effects of physical parameters on octocoral biology are needed in order to know more about how environment factors could be related to the structure and distribution of octocoral assemblages.

4.6 Summary

Amount of suspended particulate in the water (food concentration) and water motion (clod card weight loss) are two factors that could influence the distribution of soft corals and gorgonians. Higher amount of suspended particulate and weaker water flow appeared to favor the growth of octocorals in deep water regions of KLS, LGS and LLS. The morphologies of octocorals are different in different depths, with encrusting form dominating the shallow water regions and fan-shaped colonies dominating the deeper waters. However, the octocoral morphological assemblages and the amount of suspended particulate and water motion were found not to be correlated, suggesting that other physical variables could be more important in influencing the structure of octocoral morphological assemblages in the three study sites examined.



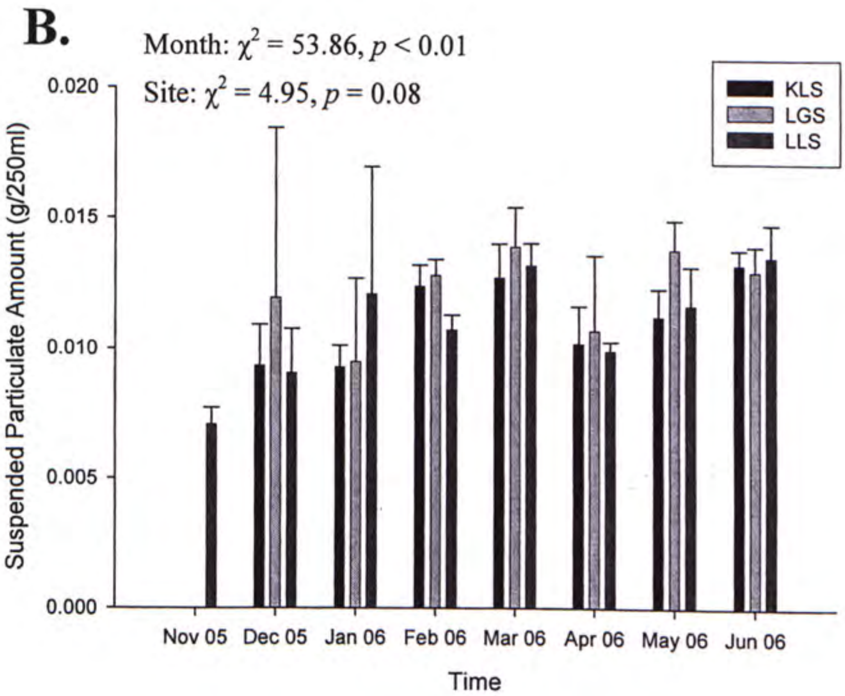


Figure 4.1 Mean weight (g) (± SD) of suspended particles collected at (**A**) shallow and (**B**) deep waters of Kang Lau Shek (KLS), Lan Guo Shiu (LGS) and Lung Lok Shui (LLS). n = 6. Kruskal-Wallis test was performed, with Chi-Square (χ^2) values and level of significance indicated.

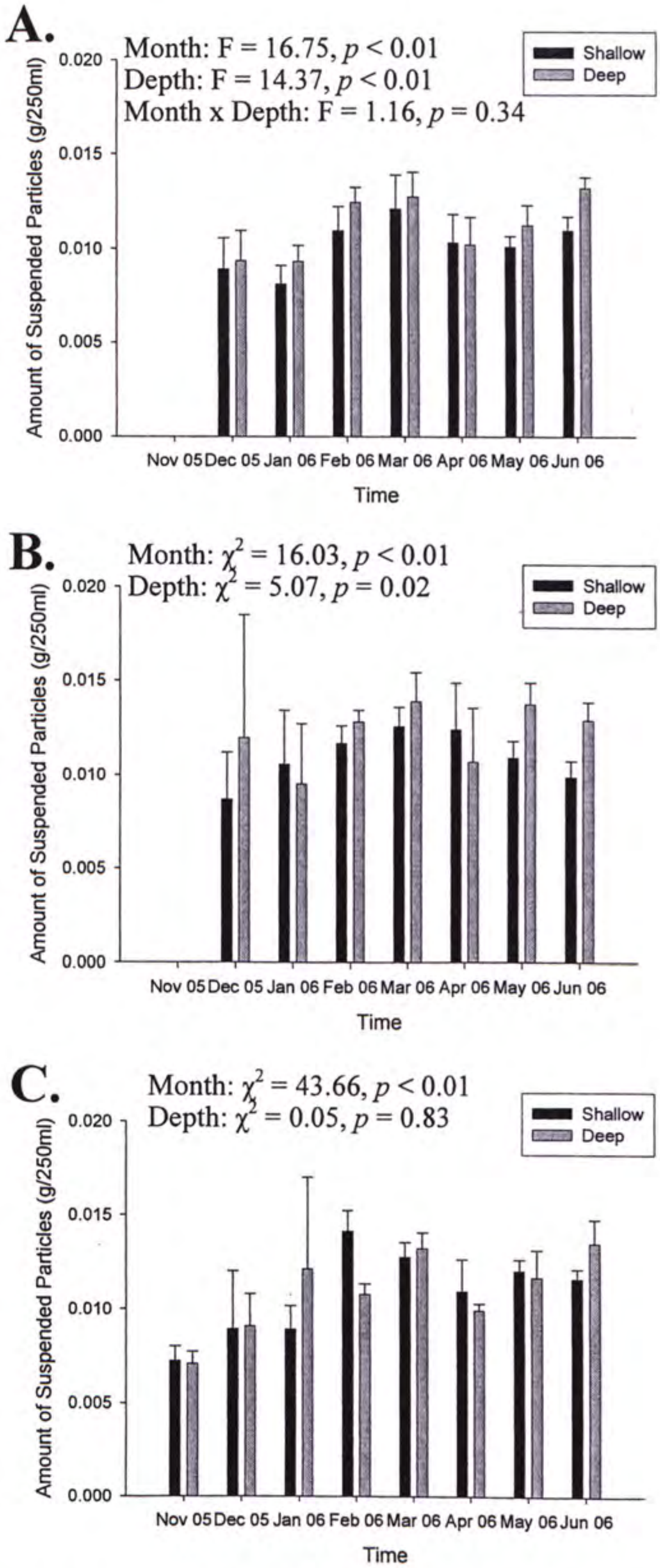
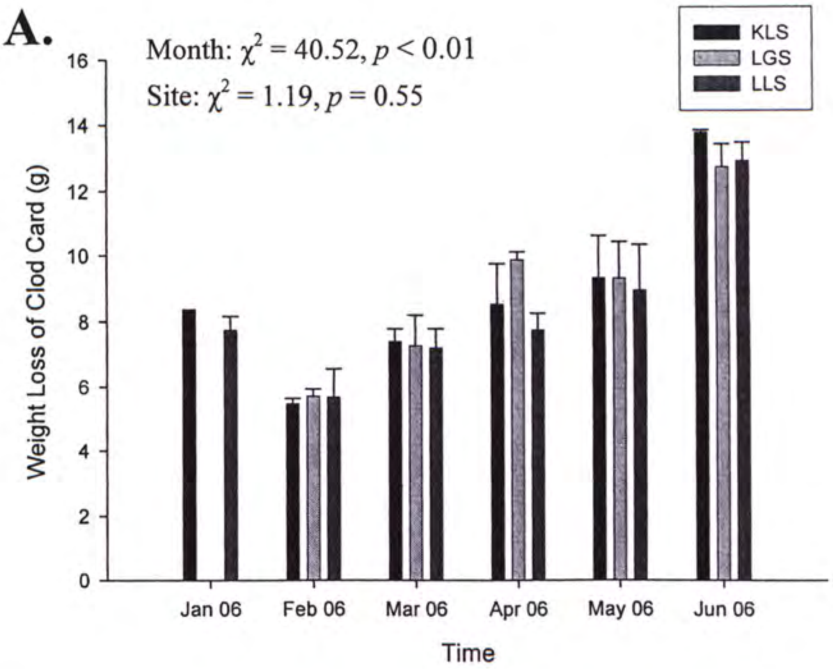


Figure 4.2 Mean net weight (g) (± SD) of suspended particulates collected at shallow and deep waters of (**A**) Kang Lau Shek (KLS), (**B**) Lan Guo Shiu (LGS) and (**C**) Lung Lok Shui (LLS). n = 6. Two-Way ANOVA and Kruskal-Wallis test were performed, with F value, or Chi-Square (χ^2) values and level of significance indicated.



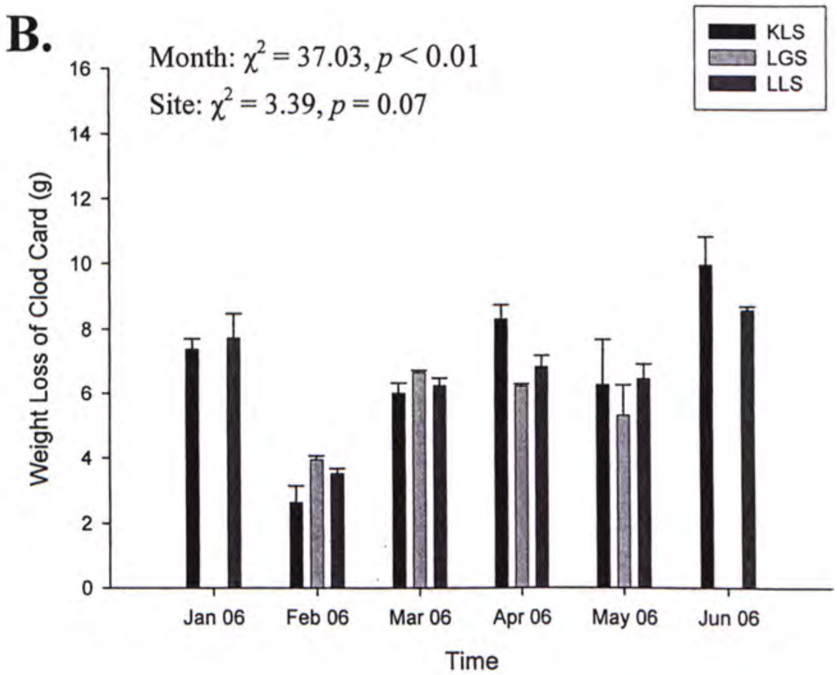


Figure 4.3 Mean weight loss (g) (± SD) of clod cards in (**A**) shallow and (**B**) deep waters of Kang Lau Shek (KLS), Lan Guo Shiu (LGS) and Lung Lok Shui (LLS). n = 3. Kruskal-Wallis test was performed, with Chi-Square (χ^2) values and level of significance indicated. During the whole period of the experiment, some clod-card setups (in Jan 06 and Jun 06) were lost. Hence missing data were present in the graphs.

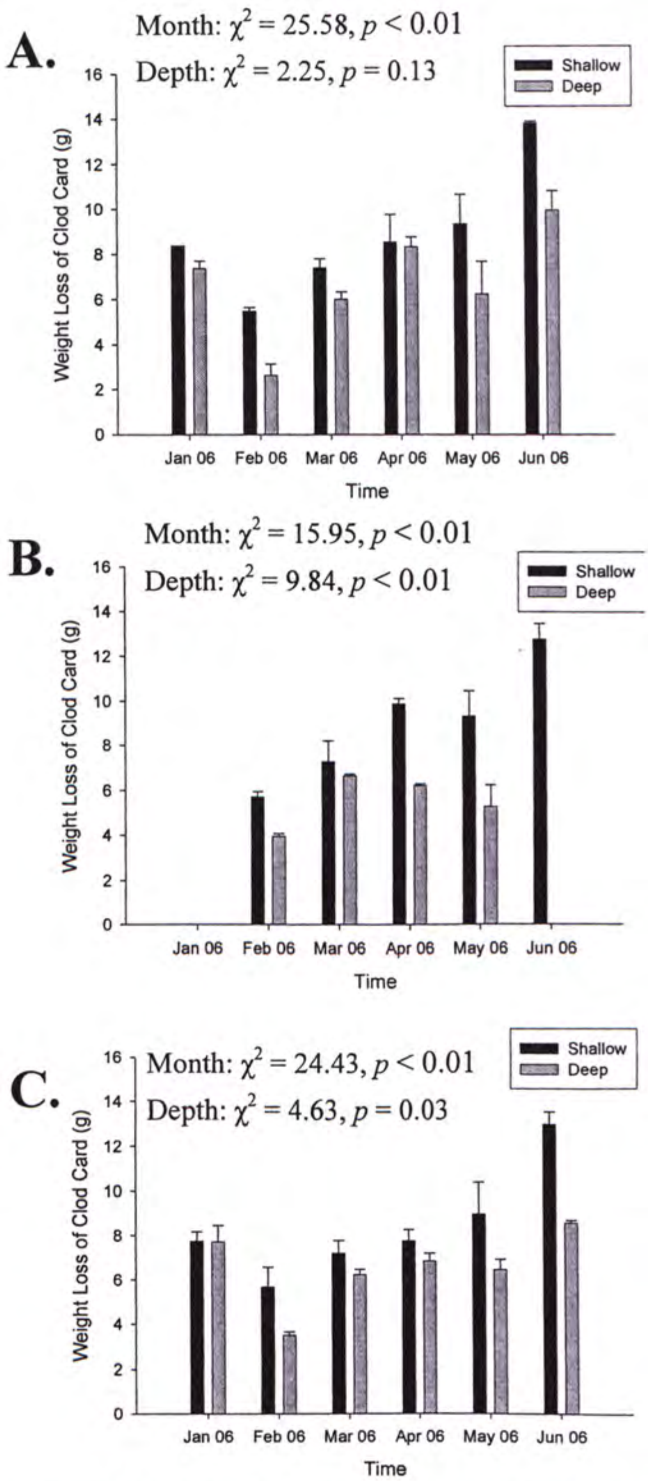


Figure 4.4 Mean weight loss (g) (± SD) of clod cards in shallow and deep waters of (**A**) Kang Lau Shek (KLS), (**B**) Lan Guo Shiu (LGS) and (**C**) Lung Lok Shui (LLS). n = 3. Kruskal-Wallis test were performed, with Chi-Square (χ^2) values and level of significance indicated. During the whole period of the experiment, some clod-card setups (in Jan 06 and Jun 06) were lost. Hence missing data were present in the graphs.

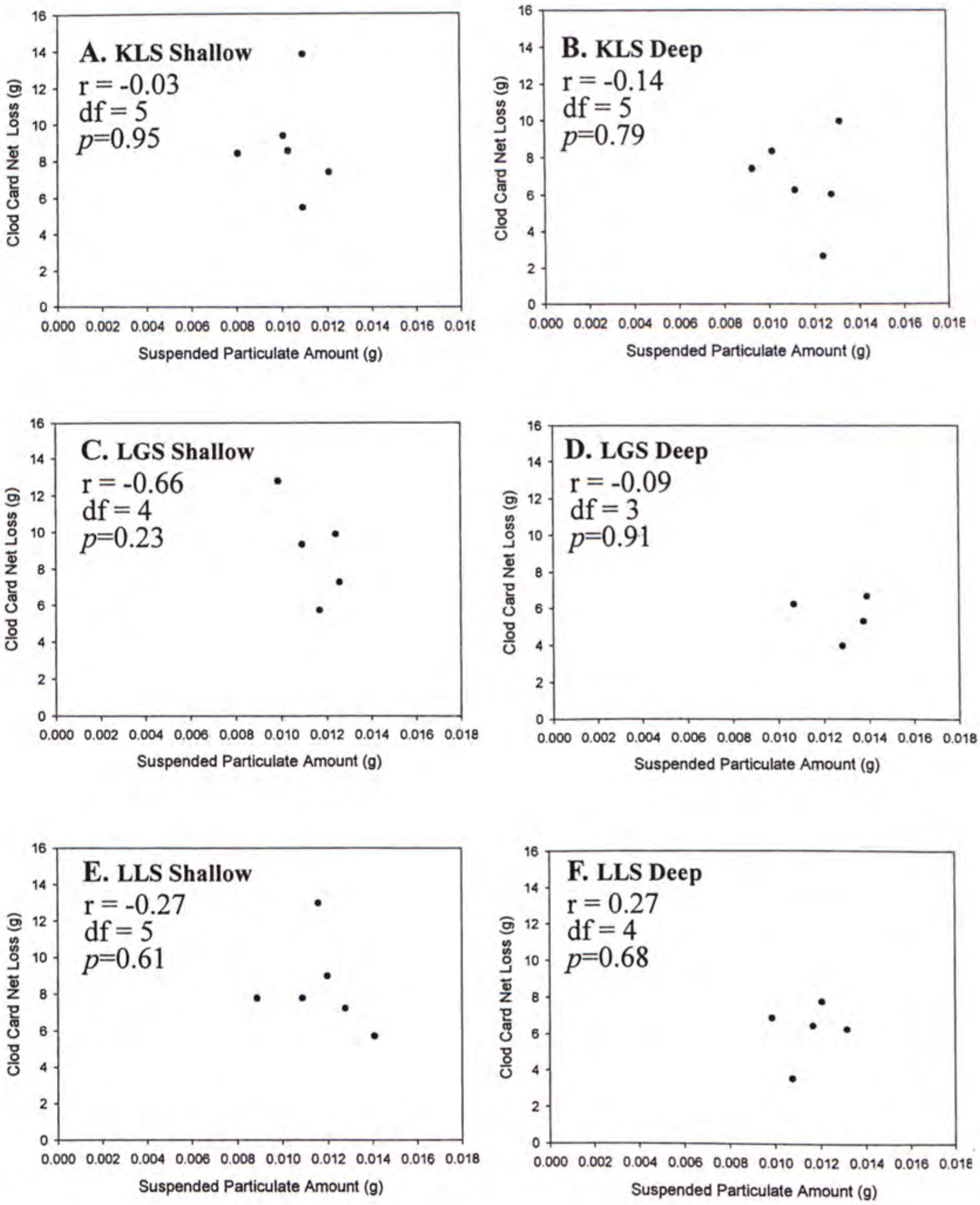


Figure 4.5 Pearson correlation between the amount of suspended particulate and the net weight loss of clod cards recorded in each site at the shallow and deep water regions. KLS = Kang Lau Shek; LGS = Lan Guo Shui; LLS = Lung Lok Shui. Sample size was not consistent in different sites as some clod-card setups (in Jan 06 and Jun 06) were lost.

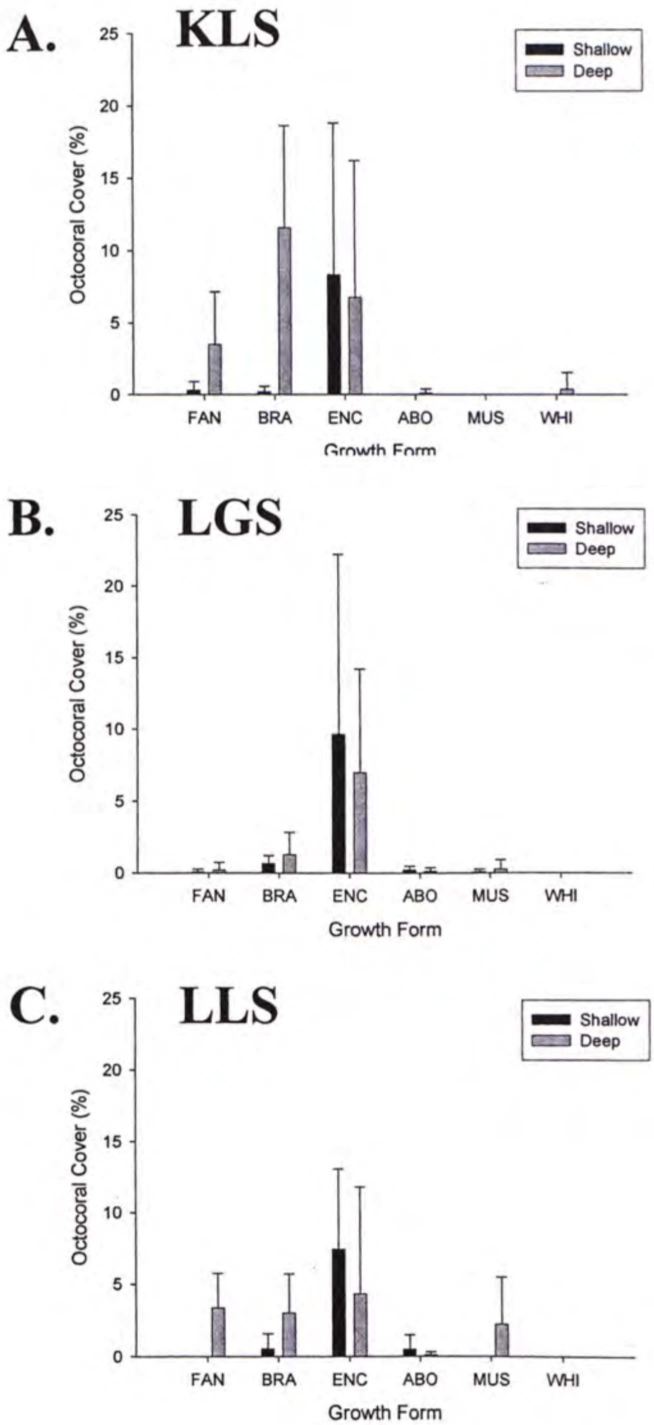


Figure 4.6 Mean octocoral cover (%) (± SD) in shallow and deep water regions of (**A**) Kang Lau Shek (KLS), (**B**) Lan Guo Shui (LGS) and (**C**) Lung Lok Shui.(LLS) in Tung Ping Chau Marine Park. n = 15. The cover data are represented in six growth forms (FAN-Fan shape; BRA-Branching form; ENC-Encrusting form; ABO-Arborescent form; MUS-Mushroom like; WHI-Whip like).

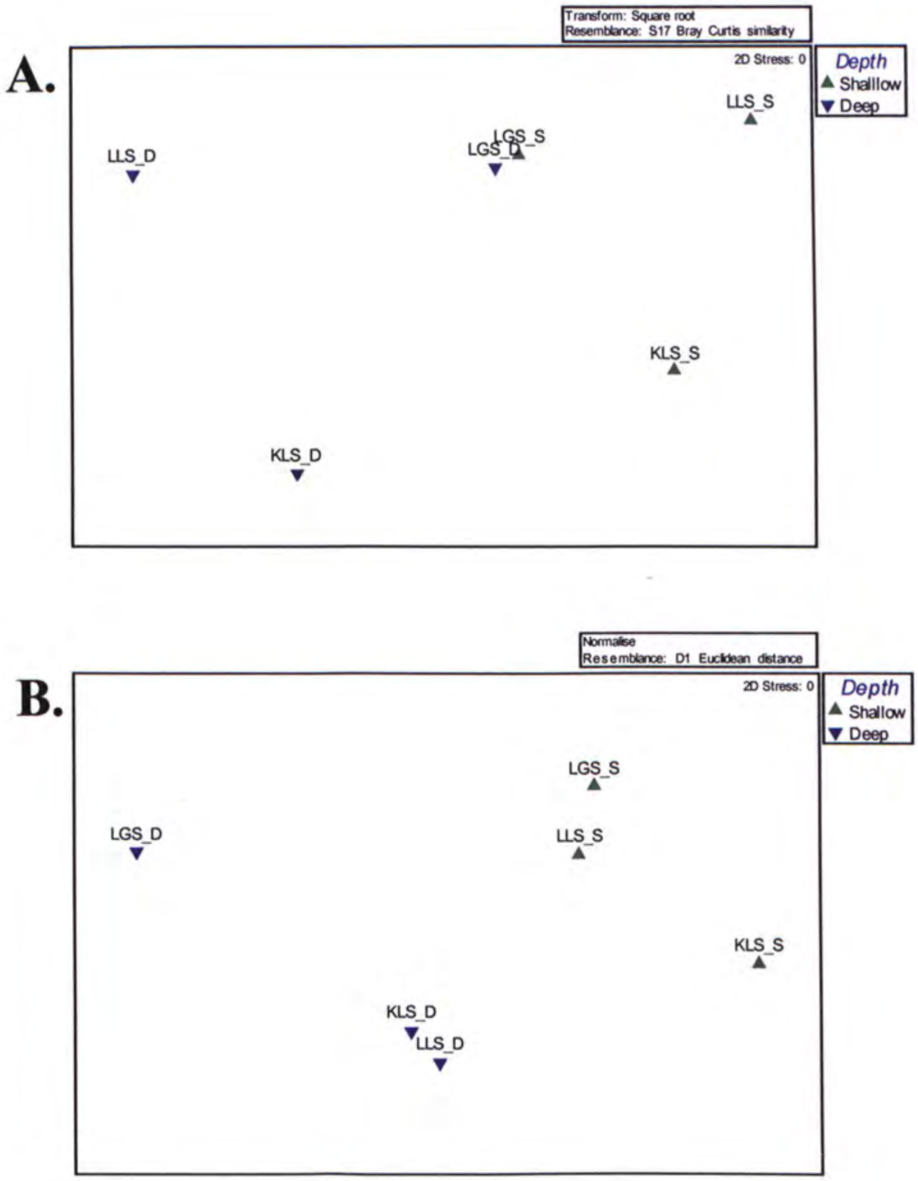


Figure 4.7 MDS plots generated using the data of (**A**) morphological assemblage and (**B**) environmental variables from shallow (S) and deep (D) water regions of Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS).

Chapter 5 Summary and Perspectives

This current study is the first comprehensive research on octocoral diversity, distribution and assemblage structures in the northeastern to southeastern waters of Hong Kong. Three sites, Kang Lau Shek (KLS), Lan Guo Shui (LGS) and Lung Lok Shui (LLS), located in the more exposed shores of Tung Ping Chau Marine Park (TPCMP) were examined for their octocoral community structures, and 30 sites along the northeastern to southeastern waters of Hong Kong were spot-checked for the presence of different soft coral and gorgonian genera (species).

A total of 27 genera of octocorals (12 soft corals and 15 gorgonians) are now recorded from this part of Hong Kong waters. Compared with the previous studies (Zou & Scott 1982, Clark 1997, Fabricius & McCorry 2006), two genera of soft corals (*Carijoa* and *Elbeenus*) and two genera of gorgonians (*Leptogorgia* and *Viminella*) in this present study are new records for Hong Kong. *Dendronephthya*, found in 29 out of the 30 sites spot-checked, is the most widespread octocoral genus in Hong Kong waters.

This study result indicates that the marine communities of Tung Ping Chau Marine

Park support a very rich octocoral fauna. Out of 27 octocoral genera recorded in Hong Kong waters, 23 genera (10 soft corals and 13 gorgonians) belonging to nine families were found within this 260 ha of water area. Significantly higher diversity and abundance of octocorals were recorded in the deep water areas of KLS and LLS due probably to the presence of high cover of rocks in these sites. Special topographic relief, availability of hard substratum and space were the main factors that likely caused the spatial variation of octocoral assemblages among sites (KLS, LGS and LLS) and depths (< -8 m and > -8 m CD).

In TPCMP, distinct vertical zonation pattern of octocorals was observed, with zooxanthellate soft corals dominating the shallow water region and zooxanthellate-free gorgonians occupying most of the available space in deeper water. Zooxanthellate soft coral species like *Lobophytum*, *Sinularia brassica* and *Sansibia* predominantly occupied the space of the coral communities at the depth of -5 – -6 m CD. The richness of zooxanthella-free taxa in these three study sites increased with depth. Gorgonian family Plexauridae dominated the deep water areas, with the greatest abundance at 12-13 m depth.

In general, the sizes of both the soft corals and gorgonians recorded in different sites in TPCMP were similar, no significant difference was also observed between the two depth zones. The most common gorgonian species, *Paraplexaura* sp. was chosen as a representative to analyze the spatial variation in its size structures in different depth zones among sites. The mean size structure of *Paraplexaura* sp. in the deep water region among the three study sites was significantly different, suggesting that there are probably some differences in the conditions of the environment in these sites.

This study further demonstrates that environmental variables, i.e. the amount of suspended particulate and water motion, could exert certain level of effects in influencing the distribution, and community structure of octocorals in TPCMP. However, their effect on octocoral morphological assemblages was less obvious. Significantly higher amount of suspended particulate was detected in deep water region of LGS and LLS than in their shallow water region, but the difference was not significant among sites. Clod card weight loss in shallow water regions was always higher than that in deeper regions, but again, this difference was statistically significant only in LGS and LLS but not in KLS. As higher abundance and diversity of otocorals were recorded in deeper water regions in these sites, these results suggest that higher level of suspended particulate and weaker level of water motion appear to favor the growth of this group of corals in deeper waters.

The dominant morphologies of octocorals found in different depths vary, with encrusting form dominating the shallow water regions and fan-shaped colonies dominating the deeper waters. However, octocoral morphological assemblages were found not to be significantly correlated with the amount of suspended particulate and the level of water motion, suggesting that other physical variables like irradiance and seawater temperature could be more important in influencing the structure of octocoral morphological assemblages in the three study sites examined.

The results of this study provide important baseline information in evaluating the biodiversity and distribution of soft corals and gorgonians in Hong Kong waters. Diversity of octocorals recorded here is undoubtedly rich when compared with that of the surrounding areas like Taiwan and Singapore (Chapter 1). Moreover, a very rare soft coral species, *Elbeenus* sp. was spotted in TPCMP (Chapter 2), a second record of this rare genus worldwide. Thus, the marine environment in Hong Kong should be better protected given its uniqueness and the presence of such a high diversity of octocorals, a very fragile group of marine organisms.

No doubt, a more systematic evaluation of Hong Kong octocoral species should be further carried out. As different taxonomic criteria were employed in the identification of Hong Kong octocorals in previous studies, a more detailed review will be needed to verify the existing taxonomic identities of the specimens collected. The precise and complete documentation of octocoral species information, including their distribution and ecological status, are important as baseline data for future conservation works. Moreover, Breaker's Reef and Ninepins were found in this study to support a very diverse and rich octocoral community. These two sites have received very little attention from the government or the public. More comprehensive and systematic dive surveys should be carried out in other parts of Hong Kong waters in order to spot for more potential sites with high conservation value. These types of information will be essential for the planning and designation of more Hong Kong marine parks or marine reserves in the future.

References

Alderslade P (1984) Subclass Alcyonaria. *In P. Mather & I. Bennet (eds), A Coral Reef Handbook, 2nd edn. The Australian Coral Reef Society* pp. 45-48

Alderslade P (2002) A new soft coral genus (Coelenterata: Octocorallia) from Palau. *The Beagle. Records of the Museums and Art Galleries of the Northern Territory* 18:1-8

Ang PO, Chu KH, Chu LM, Wong CK, Woo NYS (2000) Study on the suitability of Ping Chau to be established as Marine Park or Marine Reserve, Final Report. *Marine Park Division, Agriculture, Fisheries and Conservation Department, HKSAR Government.*

Ang PO, McCorry D, Choi CLS (2003) *Establishing a Reference Collection and Field Guides for Hong Kong Scleractinian Corals. Report submitted to the Agriculture, Fisheries and Conservation Department, Government of the Hong Kong Special Administrative Region.*

Anthony KRN, Larcombe P (2000) Coral reefs in turbid waters: sediment-induced stresses in corals and likely mechanisms of adaptation. *Proceedings 9th International Coral Reef Symposium* 1:23-27

Badria FA, Guirguis AN, Perovic S, Steffen R, Müller WE, Schröder HC (1998)

Sarcophytolide: a new neuroprotective compound from the soft coral *Sarcophyton glaucum*. *Toxiocology* 131:133-143

Bastidas C, Fabricius KE, Willis BL (2004) Demographic aspects of the soft coral *Sinularia flexibilis* leading to local dominance on coral reefs. *Hydrobiologia* 530-531:433-441

Bell JJ, Burton M, Bullimore B, Newman PB, Lock K (2006) Morphological monitoring of subtidal sponge assemblages. *Marine Ecology Progress Series* 311:79-91

Benayahu Y (1985) Faunistic composition and patterns in the distribution of soft corals (Octocorallia Alyonacea) along the coral reefs of Sinia Peninsula. *Proceedings of the Fifth International Coral Reef Congress, Tahiti* 6:255-260

Benayahu Y (1995) Species composition of soft corals (Octocorallia, Alyconacea) on the coral reefs of Sesoko Island, Ryukyu Archipelago, Japan. *Galaxea* 12:103-124

Benayahu Y, Jeng MS, Perkol-Finkel S, Dai CF (2004) Soft corals (Octocorallia: Alcyonacea) from Southern taiwan. II. Species diversity and distribution patterns. *Zoological Studies* 43:548-560

Benayahu Y, Loya Y (1977) Space partitioning by stony corals, soft corals and benthic algae on the coral reefs of the northern Gulf of Eilat (Red Sea).

Helgoländer wiss. Meeresunters 30:362-382

Benayahu Y, Loya Y (1981) Competition for space among coral reef sessile organisms at Eilat, Red Sea. *Bulletin of Marine Science* 31:514-522

Benayahu Y, Loya Y (1985) Settlement and recruitment of a soft coral: why is *Xenia macrospiculata* a successful cololnizer? *Bulletin of Marine Science* 36:177-188

Benayahu Y, Yosief T, Schleyer MH (2002) Soft corals (Octocorallia, Alyconacea) of the Southern Red Sea. *Israel Journal of Zoololgy* 48:273-283

Brill EJ, Backhuys W (1983) Illustrated trilingual glossary of morphological and anatomical terms applied to octocorallia. *In: Bayer et al. (eds.) EJ Brills, the Netherlands*. 75pp.

Buhl-Mortensen L, Mortensen PB (2004) Crustaceans associated with the deep-water gorgonian corals *Paragorgia arborea* (L., 1758) and *Primnoa resedaeformis* (Gunn., 1763). *Journal of Natural History* 38:1233-1247

Buss LW (1986) Competition and community organization on hard surfaces in the sea. *In: Diamond, J., and T.J., Case (eds.). Community Ecology. Harper and Row, New York.* pp. 517-536

Carpine C, Grasshoff M (1975) Les Gorgonians de la Méditerranée. *Bulletin de P Institut Océanographique de Monaco* 71 (1430):1-140

Chen CC, Chang KH (1991) Gorgonacea (Coelenterata: Anthozoa: Octocorallia) of Southern Taiwan. *Bulletin of the Institute of Zoology, Academia Sinica* 30:149-182

Chiappone M, Dienes H, Swanson DW, Miller SL (2003) Density and gorgonian host-occupation patterns by flamingo tongue snails (*Cyphoma gibbosum*) in the Florida Keys. *Caribbean Journal of Science* 39:116-127

Clark TH (1997) The distribution of ahermatypic corals at Cape D' Aguilar, Hong Kong. *In: Morton B. (ed.), Proceedings of the Eighth International Marine biological Workshop: The Marine Fauna and Flora of Hong Kong and Southern China. Hong Kong University Press, Hong Kong.* pp. 219-233

Clarke KR, Gorley RN (2006) PRIMER v 6: User Manual/Tutorial." *PRIMER-E Ltd. United Kingdom*. 190pp.

Dahan M, Benayahu Y (1997) Clonal propagation by the azooxanthellate octocoral *Dendronephthya hemprichi*. *Coral Reefs* 16:5-12

Dai CF (1990) Interspecific competition between Taiwanese corals with special reference to interactions between alcyonaceans and scleractinians. *Marine Ecology Progress Series* 60:291-297

Dai CF, Lin MC (1993) The effects of flow on feeding of three gorgonians from southern Taiwan. *Journal of Experimental Marine Biology and Ecology*

173:57-69

Dinesen ZD (1983) Patterns in the distribution of soft corals across the Central Great Barrier Reef. *Coral Reefs* 1:229-236

Eckman JE, Duggins DO (1993) Effects of flow speed on growth of benthic suspension feeders. *Biological Bulletin* 185:28-41

Erhardt H, Knop D (2005) Corals Indo-Pacific Field Guide. *In IKAN-Unterwasserarchiv, Germany.* pp. 17-103

Fabricius KE (1997) Soft coral abundance on the central Great Barrier Reef: effects of *Acanthaster planci*, space availability, and aspects of the physical environment. *Coral Reefs* 16:159-167

Fabricius KE (2000) *Identification and Documentation of Octocorals from Hong Kong Waters*. Unpublished report submitted to the Agriculture, Fisheries and Conservation Department, Government of the Hong Kong Special Administrative Region.

Fabricius KE, Alderslade P (2001) *Soft Corals and Sea Fans: A Comprehensive Guide to the Tropical Shallow Water Genera of the Central-west Pacific, the Indian Ocean and the Red Sea. Australian Institute of Marine Science, Townsville,* 264pp.

Fabricius KE, Benayahu Y, Genin A (1995a) Herbivory in asymbiotic soft corals.

Science 268:90-92

Fabricius KE, De'ath G (1997) The effects of flow, depth and slope on cover of soft coral taxa and growth forms on Davies Reef, Great Barrier Reef. *Proceedings 8th International Coral Reef Symposium* 2:1071-1076

Fabricius KE, Dommisse M (2000) Depletion of suspended particulate matter over coastal reef communities dominated by zooxanthellate soft corals. *Marine Ecology Progress Series* 196:157-167

Fabricius KE, Genin A, Benayahu Y (1995b) Flow-dependent herbivory and growth in zooxanthellae-free soft corals. *Limnology and Oceanography* 40:1290-1301

Fabricius KE, Klumpp DW (1995) Widespread mixotrophy in reef-inhabiting soft corals: the influence of depth, and colony expansion and contraction on photosynthesis. *Marine Ecology Progress Series* 125:195-204

Fabricius KE, McCorry D (2006) Changes in octocoral communities and benthic cover along a water quality gradient in the reefs of Hong Kong. *Marine Pollution Bulletin* 52:22-33

Finelli CM, Helmuth BST, Pentcheff ND, Wethey DS (2006) Water flow influences oxygen transport and photosynthetic efficiency in corals. *Coral Reefs* 25:47-57

Genovese SJ, Witman JD (1999) Interactive effects of flow speed and particle concentration on growth rates of an active suspension feeder. *Limnology and Oceanography* 44:1120-1131

Gerhart DJ (1990) Fouling and gastropod predation: Consequences of grazing for a tropical octocoral. *Marine Ecology Progress Series* 62:103-108

Goh NKC, Chou LM (1994) Distribution and biodiversity of Singapore gorgonians (sub-class Octocorallia) - a preliminary survey. *Hydrobiologia* 285:101-109

Goh NKC, Chou LM (1995) Growth of five species of gorgonians (Subclass Octocorallia) in the sedimented waters of Singapore. *Marine Ecology* 16:337-346

Goh NKC, Chou LM (1996) An annotated checklist of the gorgonians (Anthozoa: Octocorallia) of Singapore, with a discussion of gorgonian diversity in the Indo-west Pacific. *The Raffles Bulletin of Zoology* 44:435-459

Goh NKC, Loo MGK, Chou LM (1997) An analysis of gorgonian (Anthozoa; Octocorallia) zonation on Singapore reefs with respect to depth. *Environmental Monitoring and Assessment* 44:81-89

Griffith JK (1997) Occurrence of aggressive mechanisms during interactions between soft corals (Octocorallis: Alcyoniidae) and other corals on the Great Barrier Reef, Australia. *Marine and Freshwater Research* 48:129-135

Grigg RW (1972) Orientation and growth form of sea fans. *Limnology and Oceanography* 17:185-192

Grigg RW (1974) Growth rings: Annual periodicity in two gorgonian corals. *Ecology* 55:876-881

Hill J, Wilkinson C (2004) *Methods for Ecological Monitoring of Coral Reefs. A Resource for Managers, Version 1. Australian Institute of Marine Science, Townsville.* 117pp

Jokiel PL (1978) Effects of water motion on reef corals. *Journal of Experimental Marine Biology and Ecology* 35:87-97

Jokiel PL (1980) Solar ultraviolet radiation and coral reef epifauna. *Science* 207:1069-1071

Jokiel PL, Morrissey JI (1993) Water motion on coral reefs: evaluation of the "clod card" technique. *Marine Ecology Progress Series* 93:175-181

Jones G., Synms C (1998) Disturbance, habitat structure and the ecology of fishes on coral reefs. *Australian Journal of Ecology* 23:287-297

Kelman D, Kushmaro A, Loya Y, Kashman Y, Benayahu Y (1998) Antimicrobial activity of a Red Sea soft coral, *Parerythropodium fulvum fulvum*: reproductive and developmental considerations. *Marine Ecology Progress*

Series 169:87-95

Kelmo F, Attrill MJ, Jones, MB (2003) Effects of the 1997-1998 El Niño on the cnidarian community of a high turbidity coral reef system (northern Bahia, Brazil). *Coral Reefs* 22:541-550

Kilar JA, Hanisak MD (1988) Seasonal patterns of morphological variability in *Sargassum polyceratium* (Phaeophyta). *Journal of Phycology* 24:467-473

Kinzie RA III (1973) The zonation of West Indian gorgonians. *Bulletin of Marine Science* 23:93-155

Kuffner IB, Walters LJ, Becerro MA, Paul VJ, RitsonWilliams R, Beach KS (2006) Inhibition of coral recruitment by macroalgae and cyanobacteria. *Marine Ecology Progress Series* 323:107-117

Leversee GJ (1976) Flow and feeding in fan-shaped colonies of the gorgonian coral, *Leptogorgia*. *Biological Bulletin* 151:344-356

Mahadi M, Zulfigar Y, Tan ASH (2004) The distribution of the soft coral genus *Dendronephthya* (Alcyonacea: Nephtheidae) at Pemanggil Island in South China Sea, Malaysia. *In: Phang et al. (eds). Marine Science into the New Millennium: New perspectives & Challenge.* University of Malaya, Kuala Lumpur, Malaysia. pp. 103-124

Maida M, Sammarco PW, Coll JC (1995) Effects of soft corals on scleractinians coral recruitment. I: Directional allelopathy and inhibition of settlement. *Marine Ecology Progress Series* 121:191-202

Maida M, Sammarco PW, Coll JC (2001) Effects of soft corals on scleractinian coral recruitment. II. Allelopathy, spat survivorship and reef community structure. *Marine Ecology* 22:397-414

Mayer AMS, Jacobson PB, Fenical W, Jacobs RS, Glaser KB (1998) Pharmacological characterization of the pseudopterosins: Novel anti-inflammatory natural products isolated from the Caribbean soft coral, *Pseudopterogorgia elisabethae*. *Life Sciences* 62:401-407

Margalef R (1958) Information theory in ecology. *General Systematics* 3:36-71

McClanahan TR, Muthiga NA, Mangi S (2001) Coral and algal changes after the 1998 coral bleaching: interaction with reef management and herbivores on Kenyan reefs. *Coral Reefs* 19:380-391

McClanahan TR, Obura D (1997) Sedimentation effects on shallow coral communities in Kenya. *Journal of Experimental Marine Biology and Ecology* 209:103-122

Mistri M, Ceccherelli VU (1994) Growth and secondary production of the Mediterranean gorgonian *Paramuricea clavata*. *Marine Ecology Progress Series* 103:291-296

Morton B (1995) The biology and functional morphology of *Pteria brevialata* (Bivalvia: Pterioidea), epizoic on gorgonians in Hong Kong. *Journal of Zoology (London)* 236:223-241

Murray SN, Dixon PS (1992) The Rhodophyta: some aspects of their biology III. *Oceanography and Marine Biology Annual Review* 30:1-148.

Nishihira M, Yamazato K (1974) Human interference with the coral reef community and *Acanthaster* infestation of Okinawa. *Proceeding of Second International Coral Reef Symposium, Brisbane* 2:161-172

Nutting CC (1910a) The Gorgonacea of the Siboga Expedition. III. The Muriceidae. *Siboga-Expeditie Monograph* 13b (Livr. 47) pp. 1-108, pls. 1-22

Nutting CC (1910b) The Gorgonacea of the Siboga Expedition. III. The Plexauridae. *Siboga-Expeditie Monograph* 13b (Livr. 48) pp. 1-20, pls. 1-4

Nutting CC (1910c) The Gorgonacea of the Siboga Expedition. III. The Isidae. *Siboga-Expeditie Monograph* 13b (Livr. 50) pp. 1-23, pls. 1-6

Nutting CC (1910d) The Gorgonacea of the Siboga Expedition. III. The Gorgonellidae. *Siboga-Expeditie Monograph* 13b (Livr. 52) pp. 1-39, pls. 1-11

Nutting CC (1910e) The Gorgonacea of the Siboga Expedition. III. The Gorgonidae. *Siboga-Expeditie Monograph* 13b (Livr. 54) pp. 1-9, pls. 1-3

Nutting CC (1911) The Gorgonacea of the Siboga Expedition. III. The Scleraxonia. *Siboga-Expeditie Monograph* 13b (Livr. 57) pp. 1-60, pls. 1-12

Patterson MR (1991) The effects of flow on polyp-level prey capture in an octocoral, *Alcyonium siderium*. *Biological Bulletin* 180:93-102

Pearson RG (1981) Recovery and recolonization of coral reefs. *Marine Ecology Progress Series* 4:105-122

Pielou EC (1966) Species diversity and pattern-diversity in the study of ecological succession. *Journal of Theoretical Biology* 10:370-383

Randall JE (1974) The effect of fishes on coral reefs. *Proceedings of the Second International Symposium on Coral Reefs* 1:159-166.

Riegl B (1995) Effects of sand deposition on scleractinian and alcyonacean corals. *Marine Biology* 121:517-526

Riegl B, Branch GM (1995) Effects of sediment on the energy budgets of four scleractinian (Bourne 1900) and five alcyonacean (Lamouroux 1816) corals. *Journal of Experimental Marine Biology and Ecology* 186:259-275

Riegl B, Velimirov B (1994) The structure of coral communities at Hurghada in the Northern Red Sea. *Marine Ecology* 15:213-231

Roberts CM, Bohnsack JA, Gell F, Hawkins JP, Goodridge R (2001) Effects of marine reserves on adjacent fisheries. *Science 294*:1920-1923

Robertson BL (1987) Reproductive ecology and canopy structure of *Fucus spiralis* L. *Botanica Marina* 30:475-482

Sale PF (1996) Structures and dynamics of reef fish communities: a biogeographical comparison. *In: Cody ML, Smallwood JA (eds.) Long-term Studies of Vertebrate Communities, Academic Press, San Diego, CA*. pp. 73-97.

Sammarco PW, Coll JC, Barre SL, Willis B (1982) Competitive strategies of soft corals (Coelenterata: Octocorallia): Allelopathic effects on selected scleractinian corals. *Coral Reefs* 1:173-178

Sebens KP (1984) Water flow and coral colony size: Interhabitat comparisons of the octocoral *Alcyonium asiderium. Proceedings of the National Academy of Sciences of the United States of America* 81:5473-5477

Sebens KP, Done TJ (1993) Water flow, growth form and distribution of scleractinian corals: Davies Reef (GBR), Australia. *In Proceedings of 7th International Coral Reef Symposium* 1:557-568

Sebens KP, Johnson AS (1991) Effects of water movement on prey capture and distribution of reef corals. *Hydrobiologia* 226:91-101

Shann EW (1912) Observations on some Alcyonaria from Singapore, with a brief discussion on the classification of the family Nephthyidae. *Proceedings of the Zoological Society, London* 34:505-527

Shannon CE, Weaver W (1948) *The Mathematical Theory of Communication. University of Illinois Press, Urbana.* 117pp.

Slattery M, McClintock JB, Heine JN (1995) Chemical defenses in Antarctic soft corals: evidence for antifouling compounds. *Journal of Experimental Marine Biology and Ecology*. 190(1):61-77

So KY (2005) *Algal-herbivore Interactions in Coastal Communities in Tung Ping Chau, Hong Kong. M. Phil Thesis, The Chinese University of Hong Kong.*

Stiasny G (1935) The Gorgonacea of the Siboga-Expedition. Supplement I. Revision der Plexauridae. *Siboga-Expeditie Monograph.* 13b (Livr. 124) pp. 1-106, pls. 1-7

Stiasny G (1937) The Gorgonacea of the Siboga-Expedition. Revision der Scleraxonia. *Siboga-Expeditie Monograph.* 13b (Livr. 130) pp. 1-138, pls. 1-8

Stimpson W (1855) Descriptions of some of the new marine invertebrate from the Chinese and Japanese seas. *Proceedings of the Academy of National*

Sciences 1855:375-383

Strychar KB, Coates M, Sammarco PW, Piva TJ, Scott PT (2005) Loss of *Symbiodinium* from bleached soft corals *Sarcophyton ehrenbergi, Sinularia* sp. and *Xenia* sp.. *Journal of Experimental Marine Biology and Ecology* 320:159-177

Sullivan KM, Chiappone M (1992) A comparison of belt quadrat and species presence/absence sampling of stony coral (Scleractinia and Milleporina) and sponges for evaluating species patterning on patch reefs of the central Bahamas. *Bulletin of Marine Science* 50:464-488

Tam MC (2006) *Fish Assemblages in Fished and Protected Areas of Tung Ping Chau Marine Park, Hong Kong SAR. M. Phil Thesis, The Chinese University of Hong Kong.*

Thompson TL, Glenn EP (1994) Plaster standards to measure water motion. *Limnology and Oceanography* 39:1768-1779

Tursch B, Tursh A (1982) The soft coral community on a sheltered reef quadrat at Laing Island (Papua New Guinea). *Marine Biology* 68:321-332

Van Ofwegen LP (2000) Status of knowledge of the Indo-Pacific soft coral genus *Sinularia* May, 1898 (Anthozoa: Octocorallia). *Proceedings of the Ninth International Coral Reef Symposium, Bali, Indonesia* 1:167-171

Verseveldt J (1980) A revision of the genus *Sinularia* May (Octocorallia, Alcyonacea). *Zoologische Verhandelingen* 179:1-128

Verseveldt J (1982) A revision of the genus *Sarcophyton* Lesson (Octocorallia, Alcyonacea). *Zoologische Verhandelingen* 192:1-91

Verseveldt J (1983) A revision of the genus *Lobophytum* von Marenzeller (Octocorallia, Alcyonacea). *Zoologische Verhandelingen* 200:1-103

Veron JEN (2000) *Corals of the World. Volume 3. Australian Institute of Marine Science, Townsville, Australia.* 490pp.

Verrill AE (1865) Classification of polyps: (Extract condensed from a synopsis of the Polypi of the North Pacific Exploring Expedition, under Captains Ringgold and Rodgers, U.S.A.). *Proceedings of the Exxes Institute* 4:145-152

Wallace CC (1985) Reproduction, recruitment and fragmentation in nine sympatric species of the coral genus *Acropora*. *Marine Biology* 88:217-233

Watts JCD (1973) Further observations on the hydrology of the Hong Kong territorial waters. *Hong Kong Fishery Bulletin* 3:9-35

Wilsanand V, Wagh AB, Bapuji M (2001) Antifouling activities of octocorals on some marine microfoulers. *Microbios* 104:131-140

Utinomi H (1976a) A review of the Japanese species of Alcyonium, with descriptions of two new species and almost forgotten rare species (Octocorallia, Alcyonacea). *Publication of the Seto Marine Biological Laboratory* 23:191-204

Utinomi H (1976b) Shallow-water octocorals of the Ryukyu Archipelago (Part I). *Sesoko Marine Science Laboratory Technical Report* 4:1-5

Utinomi H (1977a) Shallow-water octocorals of the Ryukyu Archipelago (Part II). *Sesoko Marine Science Laboratory Technical Report* 5:1-11

Utinomi H (1977b) Shallow-water octocorals of the Ryukyu Archipelago (Part III). *Sesoko Marine Science Laboratory Technical Report* 5:13-34

Yoshioka PM (1994) Size-specific life history pattern of a shallow-water gorgonian. *Journal of Experimental Marine Biology and Ecology* 184:111-122

Yoshioka PM, Yoshioka BB (1989) Effects of wave energy, topographic relief and sediment transport on the distribution of shallow-water gorgonians of Puerto Rico. *Coral Reefs* 8:145-152

Zaslow RB, Benayahu Y (1996) Longevity, competence and energetic content in planulae of the soft coral *Heteroxenia fuscescens*. *Journal of Experimental Marine Biology and Ecology* 206:55-68

Zou RL, Scott PJB (1982) The Gorgonacea of Hong Kong. *In: Morton B. (ed.),* *Proceedings of the First International Marine biological Workshop: The Marine Fauna and Flora of Hong Kong and Southern China. Hong Kong University Press, Hong Kong.* pp. 135-159

李楚璞 (1982) 南海軟珊瑚的研究 I. 牙龍灣的軟珊瑚。*熱帶海洋* 1(2):156-169.

李楚璞 (1984) 南海軟珊瑚的研究 II. 西沙群島的豆莢軟珊瑚尋和肉芝軟珊瑚屬。*南海海洋科學集刊* 6:103-119.

李楚璞 (1986) 香港水域的軟珊瑚。*熱帶海洋* 5(4):19-25.

李楚璞 (1991) 南沙群島海區的軟珊瑚 II. 南沙群島及其鄰近海區海洋生物研究論文集 (一)，*海洋出版社*。48-55 頁.

鄒仁林, 陳映霞 (1989) 珊瑚及其藥用。*科學出版社*。63-65 頁.

Appendix: **Detailed description of each study site and the listing of octocoral genera recorded. Occurrence of each octocoral genus is categorized with respect to its frequency of occurrence in all the sites surveyed in this study as follows:**

Very rare: 1 site only
Rare: 1 – 3 sites
Uncommon: 4 – 9 sites
Common: 10 – 14 sites
Dominant: 15 – 20 sites
Abundant: > 20 sites

Site: 1 – Kang Lau Shek

GPS reading: N 22° 32' 446" E 114° 26' 584"

Surveyed water depth: 1.5 – 15 m

Substratum: Layers of sedimentation rocks form a steep slope. Large boulders and rocks are common. Sedimentation and silt layer are thick in deep water region (-13- -15 m CD).

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Cladiella*	Uncommon
	Lobophytum	Abundant
	Sarcophyton	Uncommon
	Sinularia	Abundant
Nephtheidae	*Dendronephthya*	Common
Nidaliidae	*Chironephthya*	Uncommon
Xeniidae	*Elbeenus*	Very rare
	Sansibia	Common
Gorgonians		
Acanthogorgiidae	*Acanthogorgia*	Uncommon
Ellisellidae	*Dichotella*	Rare
	Viminella	Uncommon
Plexauridae	*Astrogorgia*	Uncommon
	Echinogorgia	Abundant
	Echinomuricea	Dominant
	Euplexaura	Common
	Menella	Abundant
	Paraplexaura	Common
Total 7	**17**	

Site: 2 – Lang Guo Shui

GPS reading: N 22° 32' 179" E 114° 26' 333"

Surveyed water depth: 1.5 – 14 m

Substratum: Layers of sedimentation rocks form a gradual slope. Large boulders and rocks are common. A reef flat is found at -14 m CD. Sedimentation and silt layer are thick in deep water region (-13- -15 m CD). High abundance and diversity of octocorals are recorded under the marker buoy of TPCMP.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Cladiella*	Uncommon
	Lobophytum	Abundant
	Sarcophyton	Uncommon
	Sinularia	Abundant
Nephtheidae	*Dendronephthya*	Common
Xeniidae	*Sansibia*	Common
Gorgonians		
Acanthogorgiidae	*Acanthogorgia*	Uncommon
	Anthogorgia	Rare
Ellisellidae	*Ellisella*	Common
	Junceella	Dominant
	Viminella	Abundant
Gorgoniidae	*Leptogorgia*	Rare
Plexauridae	*Astrogorgia*	Uncommon
	Echinogorgia	Abundant
	Echinomuricea	Abundant
	Euplexaura	Common
	Menella	Common
	Paraplexaura	Abundant
Total 7	**18**	

Site: 3 – Lung Lok Shui
GPS reading: N 22° 32' 344" E 114° 25' 631"
Surveyed water depth: 1.5 – 14 m
Substratum: Layers of sedimentation rocks form quite a steep slope near the shore. Large boulders and rocks are common. Sedimentation and silt layer are thick in deep water region (-13- -15 m CD). Substratum in shallow water region (-2- -6 m CD) is highly occupied by macro algae *Sargarssum* spp..

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Cladiella*	Uncommon
	Lobophytum	Abundant
	Sarcophyton	Uncommon
	Sinularia	Abundant
Nephtheidae	*Dendronephthya*	Abundant
Nidaliidae	*Chironephthya*	Uncommon
Xeniidae	*Sansibia*	Common
Gorgonians		
Acanthogorgiidae	*Acanthogorgia*	Uncommon
	Anthogorgia	Rare
Ellisellidae	*Verrucella*	Rare
	Viminella	Rare
Gorgoniidae	*Leptogorgia*	Rare
Plexauridae	*Astrogorgia*	Uncommon
	Echinogorgia	Common
	Echinomuricea	Common
	Euplexaura	Common
	Menella	Uncommon
	Paraplexaura	Abundant
Subergorgiidae	*Subergorgia*	Rare
Total 9	19	

Site: 4 – Round Island

GPS reading: N 22° 32' 440" E 114° 19' 937"

Surveyed water depth: 4 – 13 m

Substratum: Mainly composed of rocks, rubbles, and sand.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Gorgonians		
Plexauridae	*Echinogorgia*	Uncommon
	Echinomuricea	Uncommon
	Euplexaura	Uncommon
	Paraplexaura	Uncommon
Total **2**	**5**	

Site: 5 - Port Island

GPS reading: N 22 ° 29' 854" E 114° 21' 697"

Surveyed water depth: 5 – 15 m

Substratum: Big boulders are found near the shore. The substratum is mainly composed of sand. Quite a number of dead gorgonians are observed in the eastern side. Black corals are found in the southern-most tip.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Sinularia*	Common
Clavulariidae	*Carijoa*	Rare
Nephtheidae	*Dendronephthya*	Dominant
	Nephthyigorgia	Uncommon
Gorgonians		
Acanthogorgiidae	*Anthogorgia*	Rare
Plexauridae	*Astrogorgia*	Uncommon
	Echinogorgia	Uncommon
	Echinomuricea	Abundant
	Euplexaura	Common
	Menella	Rare
	Paraplexaura	Uncommon
Ellisellidae	*Dichotella*	Uncommon
	Verrucella	Rare
	Viminella	Uncommon
Total 6	**14**	

Site: 6 – Grass Island

GPS reading: N 22 ° 28' 420" E 114° 22' 266"

Surveyed water depth: 4 – 15.4 m

Substratum: Mainly composed of boulders and rubbles. The hard substratum in the shallow water is mostly occupied by barnacles. Few hard coral colonies are observed. Sandy in deep water region.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Gorgonians		
Acanthogorgiidae	*Acanthogorgia*	Rare
Plexauridae	*Echinomuricea*	Uncommon
	Paraplexaura	Common
Total 3	**4**	

Site: 7 – Kung Chau

GPS reading: N 22 ° 29' 056" E 114° 22' 322"

Surveyed water depth: 1.5 – 12 m

Substratum: Big boulders and bare rocks are found near the shore. Sand is coarse and lots of sea urchins are observed. No hard corals, but few colonies of black corals and ahermatypic coral *Tubastrea* sp. are recorded.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Total 1	**1**	

Site: 8 – Shek Ngau Chau

GPS reading: N 22 ° 28' 608" E 114° 25' 612"

Surveyed water depth: 3 – 18 m

Substratum: Slopes are steep all around the island. Substratum is mainly composed of big boulders and rocks.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Cladiella*	Uncommon
	Lobophytum	Abundant
	Sinularia	Common
Clavulariidae	*Carijoa*	Rare
Nephtheidae	*Dendronephthya*	Dominant
	Scleronephthya	Dominant
Nidaliidae	*Nephthyigorgia*	Rare
Gorgonians		
Acanthogorgiidae	*Anthogorgia*	Uncommon
Ellisellidae	*Junceella*	Rare
Plexauridae	*Echinogorgia*	Uncommon
	Echinomuricea	Uncommon
	Euplexaura	Uncommon
	Paraplexaura	Common
Total 7	**13**	

Site: 9 – Breaker Reef

GPS reading: N 22 ° 27' 657" E 114° 25' 224"

Surveyed water depth: 1.5 – 20 m

Substratum: Substratum is composed of big boulders and rocks. The slope is steeper on western side, with high abundance of octocorals. Sea anemone and urchins are common.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Cladiella*	Uncommon
	Lobophytum	Abundant
	Paraminabea	Rare
	Sinularia	Common
Clavulariidae	*Carijoa*	Rare
Nephtheidae	*Dendronephthya*	Dominant
	Scleronephthya	Dominant
Gorgonians		
Acanthogorgiidae	*Anthogorgia*	Uncommon
Ellisellidae	*Dichotella*	Rare
	Viminella	Rare
Plexauridae	*Astrogorgia*	Uncommon
	Echinogorgia	Uncommon
	Echinomuricea	Common
	Euplexaura	Common
	Menella	Uncommon
	Paraplexaura	Common
Total 6	**16**	

Site: 10 – Wong Mau Chau

GPS reading: N 22° 26' 841" E 114° 23' 732"

Surveyed water depth: 2 – 13 m

Substratum: Big boulders and rocks are the major substrata. Hard coral coverage is quite high.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Cladiella*	Uncommon
	Lobophytum	Dominant
	Sarcophyton	Uncommon
	Sinularia	Common
Clavulariidae	*Carijoa*	Rare
Nephtheidae	*Dendronephthya*	Abundant
Gorgonians		
Ellisellidae	*Dichotella*	Abundant
Plexauridae	*Astrogorgia*	Uncommon
	Echinogorgia	Uncommon
	Echinomuricea	Common
	Euplexaura	Common
	Menella	Uncommon
	Paraplexaura	Common
Total 5	**13**	

Site: 11 – Mai Fun Tsui

GPS reading: N 22° 26' 841" E 114° 23' 732"

Surveyed water depth: 3 – 12 m

Substratum: Big boulders and rocks are the major substratum type. A lot of black corals and ahermatypic corals *Tubastrea* sp. are observed.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Gorgonians		
Acanthogorgiidae	*Acanthogorgia*	Uncommon
Plexauridae	*Paraplexaura*	Uncommon
Total 3	**3**	

Site: 12 – Tuen Tsui

GPS reading: N 22° 26' 187" E 114° 24' 107"

Surveyed water depth: 3 – 13 m

Substratum: Mainly composed of rubbles and sand. A lot of sea urchins are recorded.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Total 1	**1**	

Site: 13 – Lan Tau Pai

GPS reading: N 22 ° 24' 339" E 114° 23' 289"

Surveyed water depth: 2 – 10 m

Substratum: Mainly composed of rocks and rubbles.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Lobophytum*	Common
	Sinularia	Common
Nephtheidae	*Dendronephthya*	Common
Gorgonians		
Gorgoniidae	*Leptogorgia*	Rare
Plexauridae	*Echinomuricea*	Uncommon
	Euplexaura	Uncommon
	Paraplexaura	Abundant
Subergorgiidae	*Subergorgia*	Rare
Total 5	**8**	

Site: 14 – Tsim Chau

GPS reading: N 22 ° 24' 145" E 114° 23' 204"

Surveyed water depth: 3 – 14 m

Substratum: Mainly composed of boulders and rocks.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Lobophytum*	Uncommon
Nephtheidae	*Dendronephthya*	Uncommon
Gorgonians		
Plexauridae	*Echinomuricea*	Uncommon
	Euplexaura	Uncommon
Total 3	**4**	

Site: 15 – Tai Chau

GPS reading: N 22 ° 24' 145" E 114° 23' 204"

Surveyed water depth: 2 – 8 m

Substratum: Mainly composed of rock and rubbles.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Cladiella*	Uncommon
	Lobophytum	Common
	Sinularia	Uncommon
Nephtheidae	*Dendronephthya*	Abundant
Gorgonians		
Plexauridae	*Euplexaura*	Uncommon
	Paraplexaura	Common
Total 3	**6**	

Site: 16 – Conic Island

GPS reading: N 22 ° 21' 784" E 114° 23' 459"

Surveyed water depth: 3 – 14 m

Substratum: Rocky substratum with rubbles.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
Gorgonians		
Plexauridae	*Echinomuricea*	Common
	Euplexaura	Common
Total 2	**3**	

Site: 17 – Pak Lap Tsai

GPS reading: N 22 ° 21' 056" E 114° 22' 080"

Surveyed water depth: 3 – 13 m

Substratum: Sandy substratum in shallow and deep areas.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Sinularia*	Uncommon
Gorgonians		
Plexauridae	*Euplexaura*	Uncommon
Total 2	**2**	

Site: 18 – Wong Nai Chau
GPS reading: N 22 ° 20' 704" E 114° 22' 220"
Surveyed water depth: 2 – 16 m
Substratum: The slope is very steep and rocky.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
Gorgonians		
Plexauridae	*Euplexaura*	Uncommon
Total 2	**2**	

Site: 19 – Kong Tau Pai
GPS reading: N 22 ° 20' 249" E 114° 22' 598"
Surveyed water depth: 2 – 13 m
Substratum: Rocky substratum with many starfish.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Lobophytum*	Uncommon
Nephtheidae	*Dendronephthya*	Common
Total 2	**2**	

Site: 20 – Town Island

GPS reading: N 22 ° 20' 371" E 114° 22' 032"

Surveyed water depth: 1.5 – 12 m

Substratum: Substratum mainly composed of rubbles and sand.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
Total 1	**1**	

Site: 21 – Wang Chau

GPS reading: N 22 ° 19' 834" E 114° 22' 537"

Surveyed water depth: 2 – 8 m

Substratum: Mainly composed of rocks and rubbles.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Gorgonians		
Plexauridae	*Euplexaura*	Uncommon
Total 2	**2**	

Site: 22 – Basalt Island

GPS reading: N 22 ° 18' 789" E 114° 22' 197"

Surveyed water depth: 3 – 14 m

Substratum: Mainly composed of rubbles and sand.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Rare
Total 1	**1**	

Site: 23 – Bluff Island

GPS reading: N 22 ° 18' 856" E 114° 20' 917"

Surveyed water depth: 3 – 12 m

Substratum: Mainly composed of rocks and rubbles.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Sinularia*	Common
Nephtheidae	*Dendronephthya*	Abundant
Total 2	**2**	

Site: 24 – Ma Tsai Pai

GPS reading: N 22 ° 19' 639" E 114° 19' 397"

Surveyed water depth: 2 – 13 m

Substratum: Mainly composed of rubbles and sand.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
Total 1	**1**	

Site: 25 – Unnamed Island

GPS reading: N 22 ° 18' 241" E 114° 19' 407"

Surveyed water depth: 2 – 13 m

Substratum: Mainly composed of sand.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Total 1	**1**	

Site: 26 – Trio Island

GPS reading: N 22 ° 18' 068" E 114° 19' 289"

Surveyed water depth: 3 – 10 m

Substratum: Substratum is composed of rocks and rubbles.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
Gorgonians		
Plexauridae	*Echinomuricea*	Uncommon
	Euplexaura	Uncommon
Total 2	**3**	

Site: 27 – Pak Pai

GPS reading: N 22 ° 18' 543" E 114° 18' 627"

Surveyed water depth: 1.5 – 15 m

Substratum: Mainly composed of rubbles and sand.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Uncommon
Total 1	**1**	

Site: 28a – Ma Wan (North Ninepin)

GPS reading: N 22 ° 16' 318" E 114° 20' 994"

Surveyed water depth: 2 – 16 m

Substratum: Mainly composed of boulders and rocks. Coverage of octocorals is high. Slope is steep

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Abundant
	Scleronephthya	Abundant
Gorgonians		
Plexauridae	*Paraplexaura*	Common
Total 2	**3**	

Site: 28b – Sai Chau Mei (North Ninepin)

GPS reading: N 22 ° 15' 870" E 114° 20' 700"

Surveyed water depth: 2 – 12 m

Substratum: Mainly composed of rocks and rubbles.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
	Scleronephthya	Common
Gorgonians		
Plexauridae	*Paraplexaura*	Common
Total 2	**3**	

Site: 28c – Hoi Tam Hau (North Ninepin)
GPS reading: N 22° 15' 755" E 114° 20' 927"
Surveyed water depth: 2 – 14 m
Substratum: Sheltered area composed of rocks and rubbles.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
	Scleronephthya	Common
Total 1	**2**	

Site: 29a – Kwo Chau Wan (South Ninepin)
GPS reading: N 22° 15' 562" E 114° 21' 032"
Surveyed water depth: 2 – 8 m
Substratum: Sheltered area composed of rocks and rubbles.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
	Scleronephthya	Common
Total 1	**2**	

Site: 29b – Tai Chau Mei (South Ninepin)

GPS reading: N 22 ° 15' 337" E 114° 20' 794"

Surveyed water depth: 2 – 8 m

Substratum: Shallow area with a good hard coral and seaweed community. No octocorals are found.

Site: 29c – Stone Wall (South Ninepin)

GPS reading: N 22 ° 15' 290" E 114° 21' 181"

Surveyed water depth: 2 – 17 m

Substratum: A stony and nearly vertical wall, with a lot of sponges growing on it.

Family	Genus	Occurrence
Soft Corals		
Nephtheidae	*Dendronephthya*	Common
Gorgonians		
Acanthogorgiidae	*Acanthogorgia*	Uncommon
	Anthogorgia	Uncommon
Plexauridae	*Astrogorgia*	Uncommon
	Echinomuricea	Uncommon
	Euplexaura	Common
	Menella	Uncommon
	Paraplexaura	Common
Total 3	**8**	

Site: 30 – Lung Shuen Pai (East Ninepin)

GPS reading: N 22v 15' 897" E 114° 22' 659"

Surveyed water depth: 3 – 20 m

Substratum: Mainly composed of big boulders and rock, with steep slope. A good octocoral community with about 60% coverage.

Family	Genus	Occurrence
Soft Corals		
Alcyoniidae	*Paraminabea*	Rare
Clavulariidae	*Carijoa*	Rare
Nephtheidae	*Dendronephthya*	Dominant
	Scleronephthya	Dominant
Nidaliidae	*Nephthyigorgia*	Rare
Gorgonians		
Acanthogorgiidae	*Acanthogorgia*	Uncommon
	Anthogorgia	Uncommon
Plexauridae	*Astrogorgia*	Uncommon
	Echinomuricea	Common
	Euplexaura	Common
	Paraplexaura	Common
Total 6	**11**	