Jewels of the Deep Sea - Precious Corals

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Introduction

Precious Corals belong to the Family Coralliidae (Anthozoa: Octocorallia) and are well-known for their red or pink skeletons that have been used since antiquity for ornament, medicine, talismans and currency. In Okinawa, they are found living at depths from 200 to about 300m, but in northern Japan they are found in shallower waters, generally about 150m deep.

We have been keeping and displaying several local species of Coralliidae since the opening of the Okinawa Churaumi Aquarium on November 1, 2002 (Nonaka et al., 2006). One of the most difficult groups of coral to keep, we have thus far succeeded in keeping individuals in captivity for only about two years. Nevertheless, we can gather valuable data from living precious corals being kept in a tank.

Although many people are familiar with the word “coral”, there are relatively few people who have ever seen coral alive. Even fewer people have seen deep-sea species of precious coral alive. Public aquariums can provide an excellent opportunity to introduce living corals from both shallow and deep water to visitors, and to encourage interest in them and other marine creatures too. But, although aquariums can and should serve as educational facilities, it is difficult to get visitors to notice these tranquil, quiet creatures! We have tried and failed to attract attention to precious corals by special signs and lighting, so now we at the Churaumi Aquarium are planning a special exhibit about the relationship of precious coral to cultural anthropology.

What are corals

In the past, the words “coral” and “sango” (coral in Japanese) generally meant jewelry coral to most people, but recently, “coral” has increasingly been understood to refer to “coral reef” corals. Both the precious corals and the reef-building corals belong to phylum Cnidaria, but they are in different taxonomic groups. Most reef-building corals are in the Order Scleractinia of the Subclass Hexacorallia, and most precious corals are in the Order Alcyonacea of the Subclass Octocorallia. Both are members of the Phylum Cnidaria (animals with stinging cells, “cnidae”) which contains four taxonomic Classes: Scyphozoa, Hydrozoa, Cubozoa and finally, Anthozoa, which includes the “sea anemones” and the reef, soft and

precious "corals" being discussed here. Each Class is defined by its life cycle: Scyphozoans and Cubozoans have short-term "polyp" generations (attached to or resting on the substratum) and long-term "medusa" (floating "jellyfish") generations. Hydrozoans have both medusa and polyp generations, but Anthozoans have only the polyp stage. Therefore species in Scyphozoa, Cubozoa and some species in Hydrozoa are all commonly referred to as jellyfish. Anthozoans lack a medusoid stage, and so are generally called corals or sea-anemones. Species in the Class Anthozoa are further differentiated into two Subclasses based on the number of tentacles in their polyps: Octocorallia (having eight tentacles) and Hexacorallia (having six or multiples-of-six tentacles). Uchida (1992) suggested that members of the Hexacorallia, having more varied shapes and numbers of tentacles forming their polyps, are likely not as closely related to each other as are members of the Octocorallia, all of whose polyps have eight pinnate tentacles.

What is the definition of coral?

Both words, "coral" in English and "sango" in Japanese, were originally quite likely referring to the Mediterranean precious coral, an octocoral named *Corallium rubrum*. Wood (1983) indicated that coral is a general term for species which belong to the Phylum Coelenterata (Cnidaria) and have skeletons. In Fig. 1, the red letters indicate the different taxonomic groups which have members considered to be "corals". Almost all are species belonging to the Class Anthozoa, but "Fire corals" and "False precious coral" are in the Class Hydrozoa. As Cairns (2007) explained, it is not surprising that there is no consistent definition of the word "coral", since it is a layman's term that refers to animals in several taxonomic groups. According to his definition, "coral" includes members of seven taxa: Order Scleractinia (hard corals), Order Zoanthidea (in part, the zoanthids known as gold corals), Order Antipatharia (black corals), Subclass Octocorallia (soft corals, gorgonians, red and pink corals, bamboo corals, blue coral, sea pens), and three Families in the Class Hydrozoa, the Stylasteridae (lace corals, stylasters), Hydractiniidae (in part, the longhorn hydrozoans) and Milleporidae (hydrocorals, fire corals).

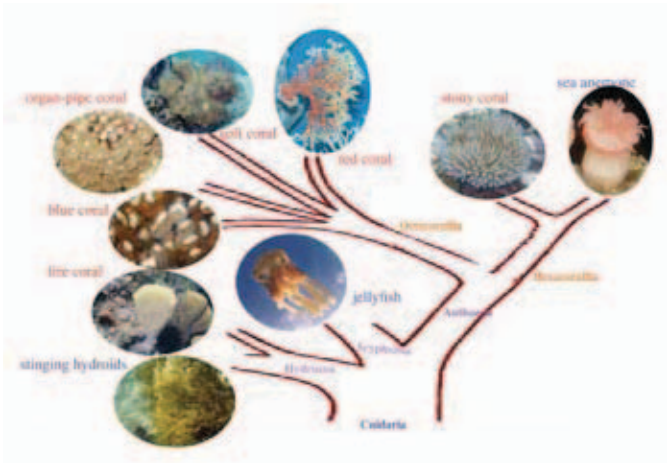

Fig.1:Gene alogical tree of Cnidaria, with"corals" in red

What are the precious corals?

The skeletons (axes, axial skeletons) of some coral species are so hard that they can be beautifully polished for use in sculptures and jewelry. These are the species called "precious corals." In general, the polished products are also called just "coral" or "sango" (in Japanese). Almost all commercial species of precious corals belong to the Subclass Octocorallia, Order Alcyonacea, Family Coralliidae. So far, the

described species include one species from the Mediterranean Sea, three species from Japan, three species from Hawaii, and one unidentified species from Midway. In Hawaii and Mexico, the "black corals" harvested for jewelry are not octocorals but antipatharians, in the Order Antipatharia, in a different Subclass, Hexacorallia. The less well-known "gold corals" include zoanthids with golden skeletons harvested from Hawaii (several species of *Savalia/Gerardia* spp., again in Subclass Hexacorallia), and also the so-called "gold corals" from Alaska, which in fact are several species in Subclass Octocorallia, Family Primnoidae. The "angel corals" too, harvested from shallow waters of the Caribbean, are skeletons of members of the Subclass Octocorallia, likely species in the Family Plexauridae. The skeletons of two Pacific shallow-water octocorals, "blue coral" (*Heliopora coerulea*) and "sponge coral" (*Melithaea ochracea*), have also been worked into beads for necklaces. However, for this document, "precious coral" is a rather narrow term, referring only to members of the octocoral family Coralliidae.

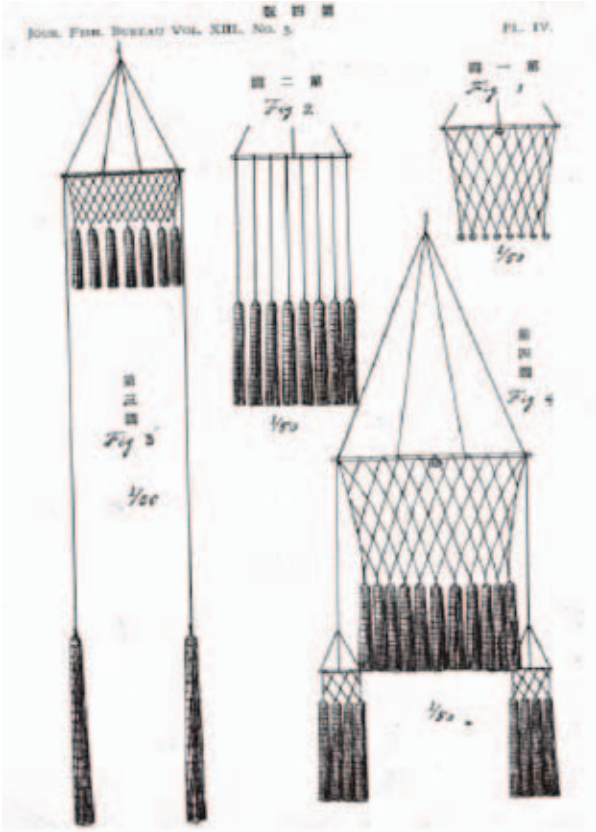

Fig. 2: Primitive coral net (Kitahara, 1903)

History of the coral fishery in Japan

Precious corals have been harvested routinely from the Mediterranean Sea for at least 5,000 years and were taken even as long as 30,000 years ago or more! Products made from *Corallium rubrum* are recorded from an Old Stone Age Monument about 25,000 years old in Germany (Kosuge, 1987), and precious corals and shells were found in a ruins roughly 30,000 years old in Lausanne, Switzerland (Liverino, 1986). Coral products were first imported to Japan via the Silk Road, and coral products are known to have been stored over 1,200 years ago at Nara's Sho-so-in, one of the oldest storage facilities in Japan (Suzuki, 1999b). Thereafter, products of Mediterranean precious coral were distributed in many cities in Japan. During the Edo-era (1603-1867), as they became less expensive, even some daimyos (a kind of governor), samurais and rich dealers could own them. Near the end of the Edo-era, even ordinary people were using coral beads as accessories.

The first record of collecting precious coral in Japan is in 1812, when a fisherman found a precious coral entangled in his net off Muroto, Kochi Prefecture. Reportedly, he gave the Daimyo of Kochi the coral colony he had collected (Shozakai, 1983, Suzuki, 1999a). In 1815, in a book entitled "Nan-ro-shi", or

"Book of the Southern Way", referring to the southern, Kochi area of Japan, reddish pieces of coral were reported found occasionally, if rarely, hung-up on fishing nets (Kosuge, 1987, Suzuki, 1999a). At a store in Kochi City named Tachibana-Ya, there is a receipt from 1835 for the purchase of precious corals. A similar record from 1848, reports a coral colony found stuck on a fishing hook (Kosuge, 1987). Thus, it appears that Kochi fishermen at that time were familiar with precious corals, and very likely recognized their commercial value. In 1938, the Kochi Prefectural government prohibited collection of red corals (Suzuki, 1999a) and tried to conceal information about the corals from the central government (Shozakai, 1983). Perhaps information was hidden by the fishermen because they were afraid of incurring penalties or high taxes. But, Kosuge (1987) suggests that the Kochi government was actually not so strict, because there are some records showing government approval for fishermen to harvest corals. For example, 225g of coral were sold in Kochi in 1835, and the local government asked fishermen for estimates of the fishing boats and nets being used for coral harvesting.

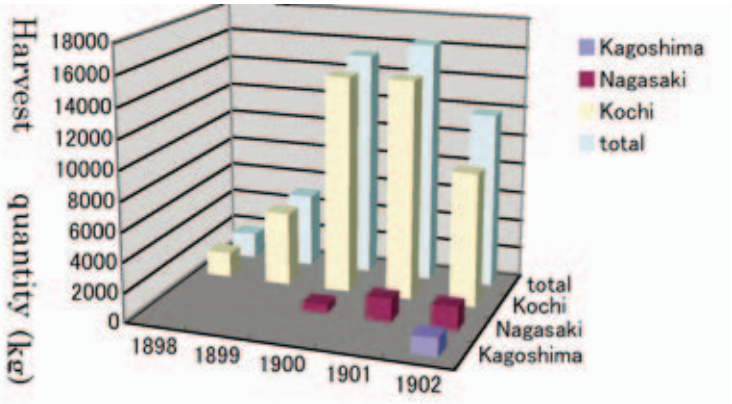

Fig. 3: Initial amounts of coral harvest (data from Kitahara, 1904)

With the arrival of the Meiji-Era (1868-1912), there were no longer any limits on the precious coral fishery. Kosuge (1987) reports that coral harvesting was begun in the Muroto region at Kochi in 1871, but the fishery techniques had been already been developed well before that date. Konojo Ebisuya, a coral fisherman, invented coral nets (Fig. 2) for efficient harvest during the Edo-Era. His invention consisted of a large weight with long nets attached, to be dragged across the sea floor. (He was honored in the scientific name of "white coral", named *Corallium konojoi* by Prof. Kishinouye in 1903a,b.) By then, fishermen were fishing large quantities of precious corals. Kitahara (1904) reported a total of more than 16t of corals collected from coral beds off Kochi, Kagoshima and Nagasaki in 1901 (Fig. 3). Suddenly, Japan went from being an importing country to an exporting country (Fig. 4). Because of overfishing and consequent reduction of harvest in the Mediterranean area, dealers there were forced to import supplies, mostly from Japan.

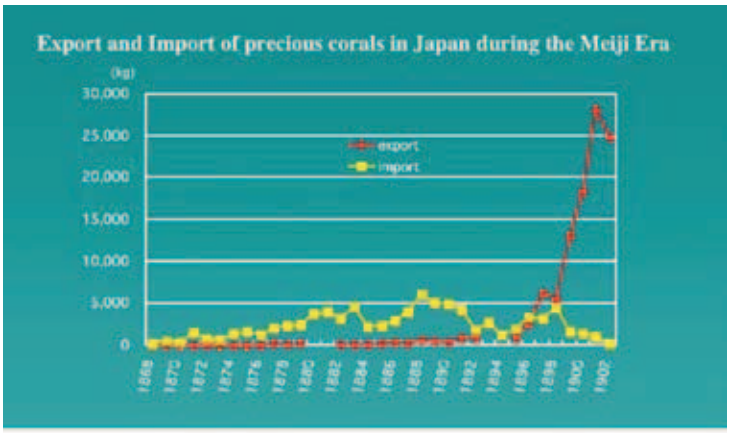

Fig. 4: Export and Import of precious corals in Japan during the Meiji-Era (data from Kitahara, 1904)

The impact of the coral trade could be seen in the many, expensive, tile-roofed houses built in the Kochi fishing villages, because the corals were worth so much money. Although the

prices seemed unbelievably high to the fishermen, dealers in the big city sold the coral at even higher prices. One interesting episode was reported in the Kochi Newspaper by Shozakai, 1983: the captain of a large ship transporting rice met a fisherman with his small boat filled with recently harvested coral of excellent quality. Knowing the extremely high value of coral, the captain made an offer to the fisherman to trade a boatload of rice for his boatload of coral. The fisherman accepted the proposal, thinking it very favorable to him, even too high, and as soon as he had exchanged his coral for a boatload of rice, fled to his home port. Meanwhile, the captain waited in vain for the fisherman to return to get the remaining rice, meaning his entire shipload, due him. The fisherman did not return, thinking that "the boatload" referred just to his small fishing boat, and so the captain thereafter also fled, with the corals and remaining rice, to his own port, Muroto. This story illustrates the incredible price difference between coral in a fishing boat and coral eventually sold in the city market in those days. Even though selling their catch at a fraction of the ultimate price, the corals still gave the fishermen a get-rich-quick opportunity, and they took many risks to collect them. Many coral boats were sunk by typhoons (Kosuge, 1987). He reports that in just the western area of Kochi, 125 fishermen died in 1909. He also reports that in the Dan-jo Islands, Nagasaki, 300 fishermen died in 1895; 10 fishermen died, 209 were missing and 155 boats sank in 1905; 119 fishermen died, 615 were missing and 173 boats sank in 1906; and 64 men died and 30 boats were missing in 1914.

Despite these numerous accidents, the fishery did not cease, instead it grew! It spread to Izu, the Bonins (Ogasawara Archipelago) and even eventually to Okinawa. In 1924, 10 fishing boats obtained permission to harvest coral in Okinawa Prefecture. Fishermen collected corals off the southern coast (Chinen) in 1937, perhaps the first record of a coral fishery in Okinawa. A coral bed was also found offshore the island of Yonaguni, the most western island in Okinawa Prefecture (and Japan). After World War II, the discovery of a huge coral fishing ground at Miyako Island, Okinawa brought general awareness of the coral fishery in the Prefecture (Kosuge, 1987). Beds of momo-iro-sango (*Corallium elatius*) were found in the Ogasawara Archipelago (the Bonin Islands south of Tokyo) in 1918, and some harvesting has continued there ever since, except when interrupted during war-time (Kosuge, 1987). One of the largest coral grounds in the Pacific was found around Midway Is. by a Japanese fishing ship from Fukushima Prefecture in 1965. Thereafter, not only Japanese but also Chinese ships came to Midway to harvest coral.

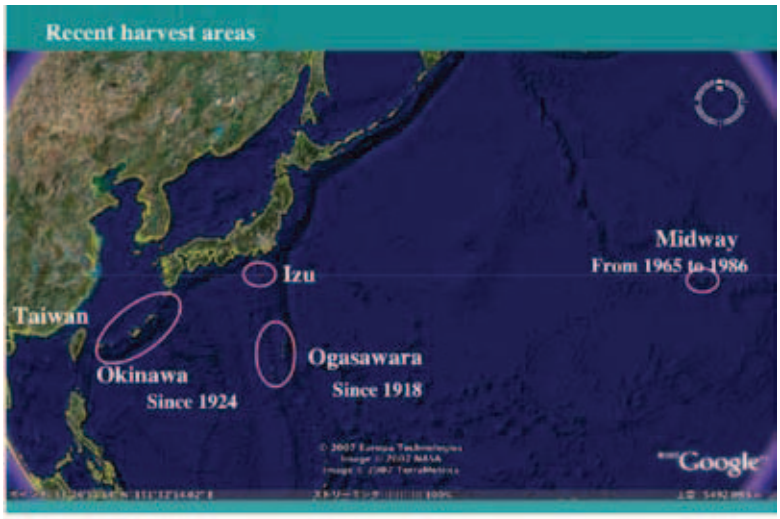

Fig. 5: Modern coral fishing areas around Japan

In the early days, fishermen used a "coral net," a kind of dredge, to harvest corals. Consisting of long nets attached to a weight, this coral net would be dragged across the bottom, entangling all benthic animals in its path. Because of this destructive method, not just organisms but entire ecosystems were damaged or destroyed. As a result the coral harvest declined worldwide, and alternative, less-destructive methods of harvest were increasingly sought, such as by submarine and R,O,V, (remotely-operated vehicle). In 1979, both Kagoshima and Okinawa Prefectures banned harvesting of precious corals by "coral net," permitting collection only by submarine or ROV. In fact, only one company, a big one wealthy enough to have a submarine, now has a permit to collect in Okinawa. In Kochi, however, the traditional coral-net method is still being permitted, with little expectation of government prohibition, because the local fishermen simply cannot afford an ROV or submarine.

Resource conservation of precious corals

Resources of precious corals are known to have been reduced everywhere in the Mediterranean and the Pacific. In the Mediterranean, where remaining precious corals are found living in water shallow enough to be readily observed by SCUBA, there have been many reports about their ecology, reproduction, resources, etc. There are also several reports on precious corals in Hawaii (Grigg, 1974 etc.). But there are almost no reports on precious coral resources in Japan.

The necessary data for resource conservation include such factors as growth rate, age at maturity and reproductive ecology (Table 1).

Table 1 Biological and ecological data of precious corals

area		**Mediterranean**	**Hawaii**	**Japan**
species		***C. rubrum***	***C. secundum***	***P. japonicum***
growth rate	length	0.2-2cm/yr. (Marchal et al., 2004)	0.9cm/yr. (Grigg, 1976)	0.3mm/yr. ?(Grigg, 1974)
	diameter	0.24-1.32mm/yr. (Marchal et al., 2004)	no data	no data
sex		separate (Vighi, 1972)	separate (Grigg, 1976)	no data
maturity		7-10yrs (Torrents et al., 2006)	13yrs (Grigg, 1976)	no data
reproduction style		brooder (Lacaze-Duthiers, 1864 etc.)	spawner (Grigg, 1993)	no data

Information from the Mediterranean species, *Corallium rubrum*, indicates they can grow 0.2-2 cm in a year, reach reproductive maturity 7-10 years after attachment, and are dioecious (sexes are separate) brooders. Vighi (1972) reported they reproduce from July to October. Colonies of a Hawaiian species, *C. secundum*, can grow 0.9 cm per year in length (Grigg, 1976), can mature in about 13 years (Grigg, 1976) or 12-13 years (Grigg, 1993), and are dioecious spawners (Grigg, 1976). But there is only one report about growth in Japanese species. Grigg (1974) briefly mentioned, from a personal communication of observations of tagged colonies of *Paracorallium japonicum* recovered off Japan, that colony growth was 0.3 mm/ year. Kishinouye (1904a) reported only that gonads were more developed in March than in

September, without any further details.

We are now researching the precious coral resource in Okinawa Prefecture. We hope to obtain instructive data to analyze for the purpose of precious coral conservation.

Taxonomic studies of Japanese precious corals

When we started our precious coral conservation research we soon found it imperative to study their taxonomy. The last taxonomic studies of Japanese precious corals were published more than 100 years ago by Kishinouye (1904b). More than five decades later, in a study of Hawaiian species, Bayer (1956) devised a taxonomic key to all known Pacific species, including the ones described from Japan. As our observations and our collections continue to improve with use of an ROV, we are finding that the Japanese fauna needs much more study. For example, according to our recent observations, fishermen in Okinawa are using the same name "Shiro-Sango" for what may be two different species with white axes; one with rounded branches and thick coenenchyme, and one with thin sharp branches and thin coenenchyme (see Nonaka et al., 2006; figs 12-14). Kishinouye (1903a,b) gave the name "Shiro-Sango" to *C. konojoi*, which is certainly the one with "rounded" branches. The "thin sharp one" is likely a still-undescribed species, new to science.

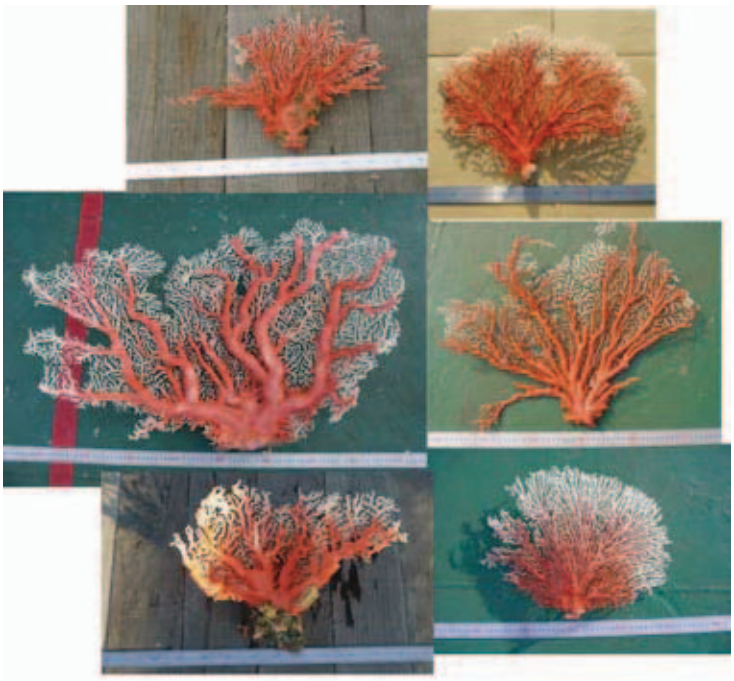

Fig. 6: Variation of *Corallium elatius*

Likewise, colonies of the so-called "Momoiro-Sango", *C. elatius*, seem to have two branching morphologies, one with stout and one with slender branches (Fig. 6), or they too may turn out to be different species. (In general, branching pattern is an important character for identification in octocorals, but it is also important to consider the size, shape and arrangement of polyps, the thickness and color of living surface tissues, the shape and size and color of sclerites, and habitat data.)

Of the corals we have collected in Okinawa, our specimens of "Aka-Sango", *Paracorallium japonicum*, seem to most closely resemble the described northern species. However, upon examination of a specimen from Sagami Bay (near Tokyo) identified as *P. japonicum* and preserved at the National Science Museum, we found that it is much larger than the colonies routinely collected in Okinawa, and it is bushy in shape, not planar. The Tokyo specimen is rather old (collected in 1968) and dried, so therefore we were unable to make detailed comparisons of it with our specimens. In the future we want to examine

alcohol-preserved, or better still, fresh specimens from Sagami Bay, to determine if these indeed are two different species. (The original holotype material described and figured by Kishinouye, 1903a, is lost.)

In 2003, Bayer & Cairns suggested a new genus of Coralliidae, which they named *Paracorallium*, and they put "Aka-Sango (*Paracorallium japonicum*)" in this new genus. Their description of the genus is "colonies with autozooids seated in deep pits in the solid axis, pits with prominently beaded margins." But, the Okinawan *Paracorallium japonicum* may in fact belong back in "*Corallium*", because we have not found any "deep pits" in the axis of samples collected here. Indeed, examination of the Sagami Bay *P. japonicum* also revealed no deep pits, so we are also calling into question the validity of the genus *Paracorallium.*

To further our studies, we are now adding DNA analysis to our repertoire of taxonomic techniques.

Taxonomy of Indo-Pacific species of Coralliidae

In the Indo-Pacific, there are 25 known species in the family Coralliidae. So far in the studies on this family, the most important characters for identification are shape and size of sclerites. We hope our future DNA studies will help to reveal so-far difficult to determine taxonomic relationships in the family. In the section below, their known taxonomic characters (according to Bayer, 1956) are summarized, species by species, and the original descriptions in the literature have been translated and condensed. All figures are copies of the original published illustrations, reprinted here with permission of the publishers. We hope this compilation of the scattered literature contributes to helping identify precious corals from Japanese waters in the future.

The precious corals known from Japanese waters are presented first, in a group arranged alphabetically by genus and species, followed by the group from Hawaii, also arranged alphabetically, and finally a group formed by the rest of the known Indo-Pacific species, again arranged in alphabetical order.

Precious Corals from Japanese Waters

(Depth ranges reported include those from both the early literature and our recent collection data from Okinawa.)

Corallium boshuensis Kishinouye, 1903 (Figs. 7-9)

Corallium boshuensis Kishinouye, 1903a: 624; Kishinouye, 1903b: 104; Kishinouye, 1904a: 23, pl.3, fig. 4; pl.7, fig.2; pl.8, fig.20; (in Japanese); Kishinouye, 1904b: 22, pl.3, fig. 4; pl.7, fig.2; pl.8, fig.20; Kukenthal, 1924: 51.

Corallium boshuense,-- Bayer, 1956: 75 (in key); Pasternak, 1981: 43.

Colony form: Colony finely branched in one plane. Terminal twigs sharply pointed. Main branches laterally compressed when viewed in cross-section.

Coenenchyme: Coenenchyme thin, light yellow in color with small granulated furrows on the surface.

Polyps: Contracted autozooids prominent, cylindrical, with eight radial grooves, taller than wide. Distributed on one side only on twigs, rare on the stem, not in clusters.

Axis: Axis smooth, without striation or pits on the surface. Many large burrows of some commensal animal on the front side of the axis. Burrows about 30mm in length, some of them buried within axis. Axis entirely cream-white in color.

Sclerites: Five kinds of sclerites: 8-radiate, cruciform, long-warty spindles, double clubs and irregular forms, 8-radiates most numerous. Large irregular forms may be fused sclerites.

Distribution: Japan, 550 m(?).

Remarks

Only one specimen, recorded from Chiba Pref., from perhaps approximately 600m deep. Colony about 200 mm in height, about 300 mm in width and 20 mm in diameter near holdfast. Coenenchyme lost basally, a feature sometimes seen in mature colonies, suggesting this was a mature colony at time of collection.

Closely resembles *C. sulcatum*, possibly a synonym. The two species can be distinguished in color, branching and coenenchyme thickness, but sclerites are similar. Type specimen described by Kishinouye is missing. Specimen number NSMT-CoR951 labeled "*Corallium boshuensis*" preserved at the National Science Museum in Tokyo is actually a specimen of *C. konojoi* (personal observation).

Fig. 7: Whole colony of *Corallum boshuensis*. (from Kishinouye, 1904)

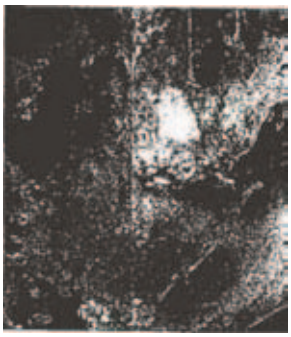

Fig. 8: Surface detail. (from Kishinouye, 1904).

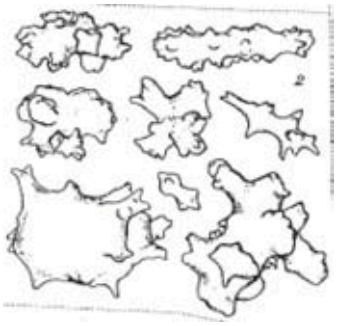

Fig. 9: Sclerites. (from Kishinouye, 1904)

Corallium elatius (Ridley, 1882) (Figs.10-14)

Pleurocorallium secundum var. *elatior* Ridley, 1882: 228, pl.9, figs.6-11

Corallium elatior,-- Kishinouye, 1903a: 625; Kishinouye, 1903b: 104 (in Japanese).

Corallium elatius,--Kishinouye, 1904a:25, pl.1, fig.3; pl.3, figs.1,2; pl.7, fig.6; pl.8, figs.7-15; (in Japanese); Kishinouye, 1904b: 24, pl.1, figs.3; pl.3, figs.1,2; pl.7, fig.6; pl.8, figs.7-15; Kukenthal, 1924: 49; Bayer, 1956: 76 (in key).

Corallium sp.1,--Nonaka et al., 2006: 1823, figs.9-11.

Colony form: Colony branches in one plane, more or less recurved, some branches anastomosing. Terminal branches very fine.

Coenenchyme: Coenenchyme thick and firm, with fine projections on the surface. Scarlet or vermilion in color, but near the free end of growing branches light red or colorless. Sometimes all light-yellow variation.

Polyps: Autozooids arranged in about four rows and generally on one face of the colony only. Large, 1.5 to 2.0 mm in diameter, sub-hemispherical.

Axis: Axis finely striated. Normally red to pink in color with a white center, rarely all white with a yellowish center. (Kishinouye (1903) described small pits in the axis generally beneath every polyp, but our specimens of what may be this species lack this feature. The specimen he observed is unfortunately missing.)

Sclerites: Three kinds of sclerites: 6-radiates, 7-radiates and double clubs, the 7-radiate form rare. 8-radiates not present. Autozooids with many small 6-radiates. No spindles in autozooid verrucae.

Distribution: Japan, 50-330 m.

Remarks

Ridley (1882) recorded this species as a subspecies of *C. secundum* named *Pleurocorallium secundum elatior*, but Kishinouye (1903) redescribed it as a distinct species of *Corallium*. This species can grow to an enormous size. Kishinouye (1904a) described some specimens of about one meter in height, 20kg in weight.

Fig. 10: Colony, axis and sclerites of *Corallium elatius*. (from Ridley, 1882)

Fig. 11: Terminal branch.
(from Kishinouye, 1904)

Fig. 12: Colony of Corallium elatius.
(from Kishinouye, 1904)

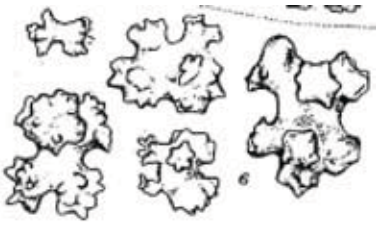

Fig. 13: Sclerites.
(from Kishinouye, 1904)

Fig. 14: Detail of surface.
(from Kishinouye, 1904)

Corallium konojoi Kishinouye, 1903 (Figs.15, 16)

Corallium konojoi Kishinouye, 1903a: 625; Kishinouye, 1903b: 105; Kishinouye, 1904a: 27, pl.1, fig. 4; pl.7, fig.5; pl.8, figs.16,17(in Japanese); Kishinouye, 1904b: 26, pl.1, fig. 4; pl.7, fig.5; pl.8, figs.16,17; Kukenthal, 1924: 50; Bayer, 1956: 76 (in key); Nonaka et al., 2006: 1824, figs.6-8.

Colony form: Colony sparingly branched, generally growing in one plane. Branches often anastomosing, branch tips blunt and rounded.

Coenenchyme: Coenenchyme thick and firm, surface smooth. Yellowish to reddish in color, becoming lighter in color towards the holdfast.

Polyps: Autozooids unevenly distributed on one face of branches, crowded on prominences and at the tips. Autozooids clustered in groups. Autozooids large, 2-3 mm in diameter, a little elevated.

Axis: Axis weakly striated, milky white in color with pinkish center.

Sclerites: Four kinds of sclerites: 8-radiate, 6-radiate, 7-radiate and double clubs. Crosses very rare. 6-radiates, 0.09mm in length, most abundant. 8-radiates not common. Autozooids have 8-radiates, 6-radiates and small irregular forms.

Distribution: Japan, 50-250 m.

Remarks

Colonies about 300 mm in height and width. Axis a beautiful white, but there is little demand. The species name honors the fisherman, Konojo Yebisuya, who in 1836 invented a net for collecting corals and began harvesting them for commercial purposes.

Unfortunately the type specimen Kishinouye described has been lost.

Fig. 15: Whole colony of *Corallium konojoi*. (from Kishinouye, 1904)

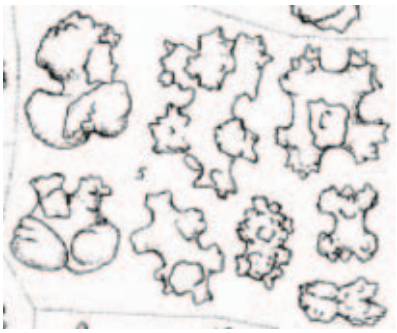

Fig. 16: Sclerites. (from Kishinouye, 1904)

Corallium pusillum Kishinouye, 1904 (Figs. 17-19)

Corallium pusillum Kishinouye, 1904a: 29, pl.5, figs.3,4; pl,7, fig.4; Kishinouye,1904b: 27, pl.5, figs.3,4; pl,7, fig.4; Kukenthal, 1924: 50; Bayer, 1956: 76 (in key).

Colony form: Colony is dichotomously branched in one plane, which is more or less recurved. Colony width exceeds height. Terminal branches rounded in section.

Coenenchyme: Coenenchyme thick and firm, granulated on the surface. Many commensal polychaetes on one surface, their burrows with I or T-shaped openings. Main stem orangeish to yellow-orange but branchlets becoming grayish yellow.

Polyps: Large, hemispherical autozooids, 1.5 mm high and in diameter, distributed on one surface of the branches only, becoming more abundant on the terminal twigs, sometimes making clusters.

Axis: Surface rough with fine grooves. Commensal burrows sometimes are shallow hollows. Axis white and partly pink.

Sclerites: Three kinds of sclerites: 8-radiates, crosses and double clubs, 8-radiates and double clubs abundant. Autozooids with 8-radiates, rods with irregular projections. Sclerites the largest reported in Japanese *Corallium*, about 0.06-0.09 mm long.

Distribution: Japan.

Remarks

Specimen from Izu-Ohshima Island 70 mm high, 210 mm wide and 15 mm in diameter near the holdfast, but may not represent maximum size. The only type-specimen was lost, and no further specimens have been found since.

Fig. 17: Whole colony of *Corallum pusillum*. (from Kishinouye, 1904)

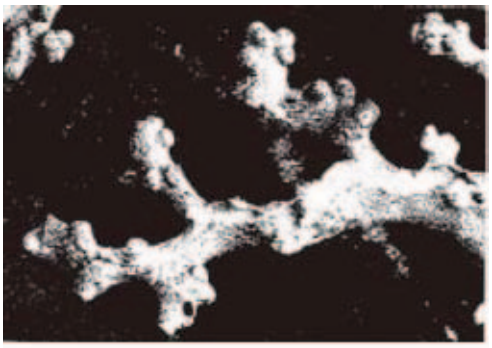

Fig. 18: Tip of colony. (from Kishinouye, 1904)

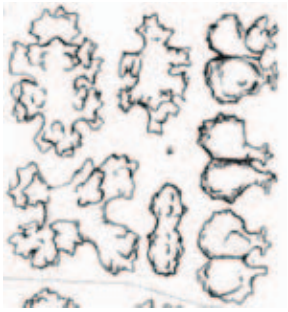

Fig. 19: Sclerites. (from Kishinouye, 1904)

Corallium sulcatum Kishinouye, 1903 (Figs. 20-22)

Corallium sulcatum Kishinouye, 1903a: 624; Kishinouye, 1903b: 104; Kishinouye, 1904a: 24, pl.4, figs.1,2; pl.7, fig.3; pl.8, fig.19; Kishinouye, 1904b: 23, pl.4, figs.1,2; pl.7, fig.3; pl.8, fig.19; Kukenthal, 1924: 52; Bayer, 1956: 75 (in key).

Colony form: Colony branched in one plane, some branches anastomosing. Terminal twigs are slender and sharp.

Coenenchyme: Coenenchyme thin. Small spines distributed in longitudinal rows on the coenenchyme. Light red, twigs yellow.

Polyps: Verrucae of autozooids are cylindrical, with eight conspicuous grooves, on one surface of colony,

numerous on terminal twigs, fewer on stem. Autozooids about 0.9-0.18 mm in height, 0.9 mm in diameter. Siphonozooids rather projecting.

Axis: Axis smooth, rounded in section. Many shallow longitudinal grooves with prickly margins on one surface of the branches. On smaller branches these grooves become cavities, quite similar to the burrows found in *C. boshuensis.* Axis variegated, with lighter and darker pinkish areas.

Sclerites: Five kinds of sclerites: 8-radiates, crosses, double club, rods with some projections and many irregular forms. 8-radiates most abundant.

Distribution: Japan, 180-550 m(?).

Remarks

A fine specimen, about 300 mm in height, 230 mm in width and 23 mm in basal diameter, collected from 180-550 m off Chiba Pref. (depth data not exact). Only two specimens known, both subsequently lost. This species resembles *P. japonicum* and *C. boshuensis*, especially the latter, but differs in several features, including color, grooved branches, etc.

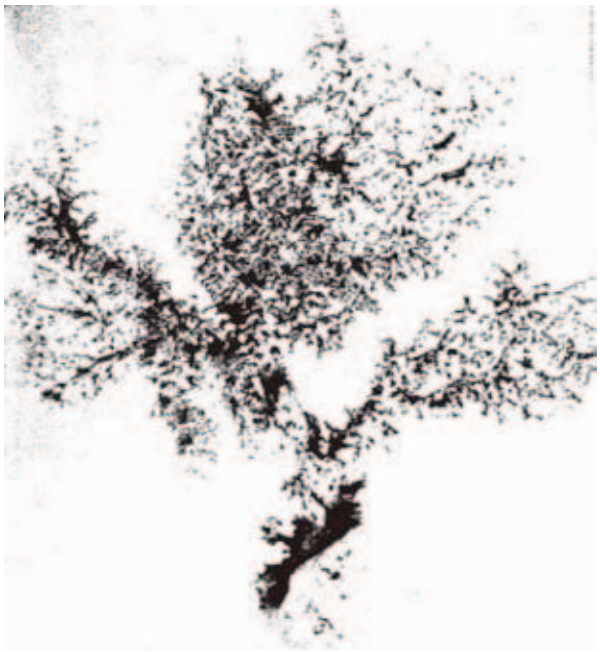

Fig. 20: Whole colony of *Corallum sulcatum*. (from Kishinouye, 1904)

Fig. 21: Branch of colony. (from Kishinouye, 1904)

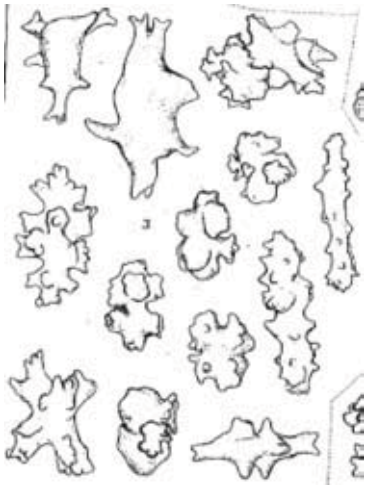

Fig. 22: Sclerites. (from Kishinouye, 1904)

Paracorallium inutile (Kishinouye, 1902) (Figs. 23-25)

Pleurocorallium inutile, Kishinouye, 1902: 419

Corallium inutile, -- Kishinouye, 1903a: 626; Kishinouye, 1903b: 105; Kishinouye, 1904a: 28, pl.5, figs.1,2; pl,7, fig.7; pl.8, fig.18; Kishinouye, 1904b: 27, pl.5, figs.1,2; pl,7, fig.7; pl.8, fig.18; Kukenthal, 1924: 48; Bayer, 1956: 76 (in key).

Paracorallium inutile, -- Bayer & Cairns, 2003: 224.

Colony form: Main branches planar, but smaller branches branching in all directions, often anastomosing, net-like.

Coenenchyme: Coenenchyme thin but firm, light red.

Polyps: Autozooids small, 0.8-1.0 mm in diameter, slightly elevated and distributed over all parts of the branches.

Axis: Axis brittle, finely striated. Small but deep pit in axis under autozooids. Axis entirely white, slightly tinged with yellow.

Sclerites: Two kinds of sclerites: 6-radiates and double clubs. 6-radiates few, double clubs predominant in coenenchyme. Double clubs mainly smooth. Autozooids with rod-like six-radiates with small projections.

Distribution: Japan.

Remarks

Specimen described was 120 mm high and wide base of the stem is 21 mm in diameter, collected at Kashiwa-jima Island in Kochi Pref. (depth unknown). Rare and not a beautiful color, therefore without commercial value.

The type-specimen Kishinouye described was lost.

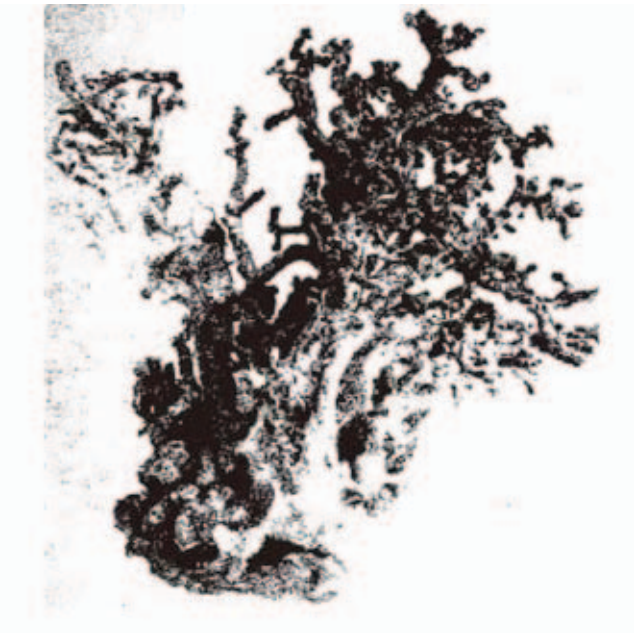

Fig. 23: Whole colony of *Paracorallum inutile*. (from Kishinouye, 1904)

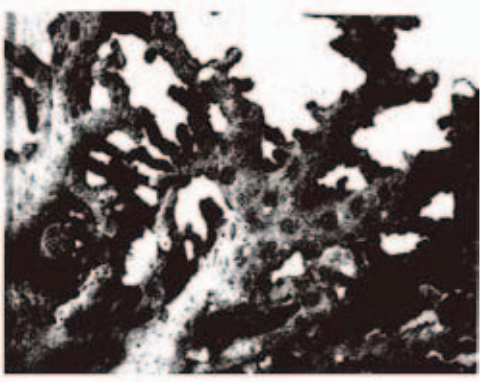

Fig. 24: Branch of colony. (from Kishinouye, 1904)

Fig. 25: Sclerites of *P. inutile*. (from Kishinouye, 1904)

Paracorallium japonicum (Kishinouye, 1903) (Figs. 26-29)

Corallium japonicum Kishinouye, 1903a: 623; Kishinouye, 1903b: 103; Kishinouye, 1904a: 22, pl.1, figs.1,2; pl,2; pl,4, fig.3; pl.7, fig.1; pl.8, figs.1-6; Kishinouye, 1904b: 21, pl.1, figs.1,2; pl,2; pl,4, fig.3; pl.7, fig.1; pl.8, figs.1-6; Kukenthal, 1924: 50; Bayer, 1956: 76 (in key).

Paracorallium japonicum, Bayer & Cairns, 2003: 225; Nonaka et al., 2006: 1823, figs.3-5.

Colony form: Colony abundantly branched in one plane. Short, prickly branchlets grow on one surface and on the sides of the branches.

Coenenchyme: Coenenchyme thin (in Okinawan specimens papillate). Generally dark red but growing tips, pinkish to white.

Polyps: Autozooids small, about 0.7 mm in diameter, and when contracted only a little elevated. Distributed in four or five rows, generally on one surface only.

Axis: Axial surface striated, a small pit in the axis underneath each polyp. In cross section, axis round or oval. Normally dark red in color with white center, Y or X-shaped when viewed in cross section.

Sclerites: Two kinds of sclerites: 8-radiate and crosses. 8-radiates numerous, 0.05 mm long, crosses smaller and fewer. Autozooids almost all 8-radiates.

Distribution: Japan, 100-300 m.

Remarks

The famous coral known as “aka-sango” red coral. Height and width both about 300 mm, base of the stem 120 mm in diameter. Kishinouye (1904a) reported that this species was the most abundant, forming two thirds of the entire coral harvest. Resembling *C. stylasteroides*, but differing in color and distribution of polyps. The type Kishinouye described is lost.

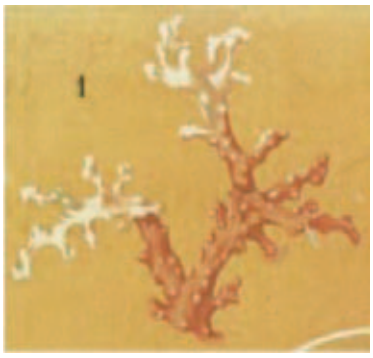

Fig. 26: Tip of colony.(from Kishinouye, 1904)

Fig. 27: Autozooid with tentacles extending. (from Kishinouye, 1904)

Fig. 28: Whole colony of *Paracorallum japonicum*. (from Kishinouye, 1904)
1. Autozooid side. 2. Opposite side. 3. Branch tip.

Fig. 29: *P. japonicum* sclerites.
(from Kishinouye, 1904)

Precions corals from Hawaiian waters

Corallium abyssale Bayer, 1956 (Figs. 30-32)

Corallium abyssale Bayer, 1956: 76, figs.4,5a, 7a-d.

Colony form: Colony branched in one plane in an asymmetrically dichotomous manner, alternate branches dominating to produce a zigzag, sympodial main stem but twigs in upper part of colony branch symmetrically and quite regularly.

Coenenchyme: Coenenchyme of the type extremely thin and rubbed off in places. Surface of coenenchyme with scattered, prominent papillae smaller than the wart-like siphonozooids. Specimen preserved in alcohol pale brown in color, probably discolored, “pink” when fresh. according to original field label.

Polyps: Autozooids very widely separated and few, essentially biserial although an occasional individual out of line. Verrucae 2 mm in height, cylindrical, with eight longitudinal grooves in the distal half, corresponding to the septal insertions. Siphonozooids low, wart-like protuberances in groups around the autozooids.

Axis: Axis solid, round, and smooth, 4 mm in diameter at the lowest point, tapering to 2.5 mm at the top. Pale pink with center somewhat darker.

Sclerites: Three kinds of sclerites in the coenenchyme: stubby crosses and 8-radiates often coarse and clumsy-looking; double clubs with wide, depressed, weakly sculptured heads and short handles with radiating processes. Sclerites of the autozooid verrucae long, blunt rods 0.12-0.13 mm long in addition to the forms found in the coenenchyme proper. In the oral disk and pharyngeal region spiny rodlets that appear to be derived from the 8-radiate type. Sclerites colorless.

Distribution: Hawaii, 1830-2400 m.

Remarks

C. abyssale does not closely resemble any other known species of the genus, although it is like *C. sulcatum* and several other species in having tall sulcate verrucae with long blunt rods.

Fig. 30: Tip of branch of *Corallinm abyssale*. (from Bayer, 1956)

Fig. 31: Detail of polyps. (from Bayer, 1956)

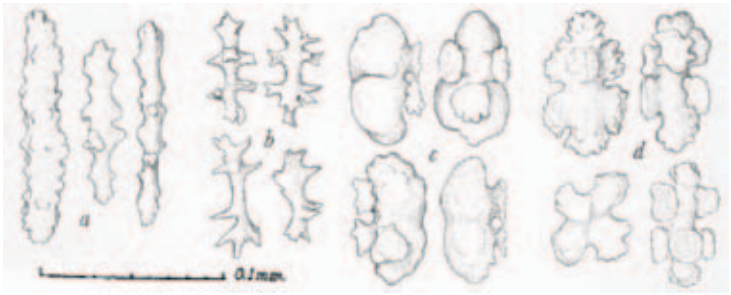

Fig. 32: Sclerites. (from Bayer, 1956)
a. From tentacles. b. From pharynx. c. Double-clubs from coenenchyme. d. Crosses and 8-radiates from coenenchyme.

Corallium kishinouyei Bayer, 1996 (Figs.33-35)

Corallium kishinouyei Bayer, 1996: 218, figs.11-19.

Colony form: Colony sparingly branched in one plane, openly dichotomous or lateral, the smaller terminal branchlets more or less clavate. The stoutest main branch nearly round, 7.2 mm in diameter. Terminal branchlets about 4 mm in diameter, with a tendency to flattening in the plane of branching.

Coenenchyme: Colonies initially distinctly yellowish white but the yellowish tint soon faded in alcohol.

Polyps: Autozooids situated biserially and directed slightly toward one face of the colony (the "front"), with occasional individuals also on the front face roughly between bilateral pairs, becoming more generally scattered on the stoutest branches. Retracted to form low, moundlike verrucae about 3 mm in diameter and at most 1mm in height, the orifices with marginal lobes not necessarily as many as 8 but depending upon the degree of contraction. Numerous small, bluntly conical papillae less than 0.5 mm in diameter, each with

an apical pore, cover the surface of the coenenchyme around and between the autozooids, interpreted as siphonozooids but not confirmed by histological examination.

Axis: Axis longitudinally striated but no deep, smooth pits beneath the autozooids. Depressions in the axis accommodating the autozooids are confined to apical regions, where they are irregular and do not have smooth bottoms nor prominent beaded margins.

Sclerites: Coenenchymal sclerites predominantly 8-radiates from about 0.05 mm up to 0.13 mm in length; 6-radiates present also, and 7-radiates uncommon; crosses present, and a few irregular forms. The tentacles of autozooids slender, bluntly pointed rods up to about 0.09 mm in length, derived from the predominant 8-radiate form. Sclerites colorless, those of the larger branches predominantly opaque white, those of the terminal branches glass-clear.

Distribution: Hawaii, 1145 m.

Remarks

Sclerites are the largest of any known species. Species named in honor Dr. Kamakichi Kishinouye who studied many marine animals, and pioneered scientific study of precious corals in Japan.

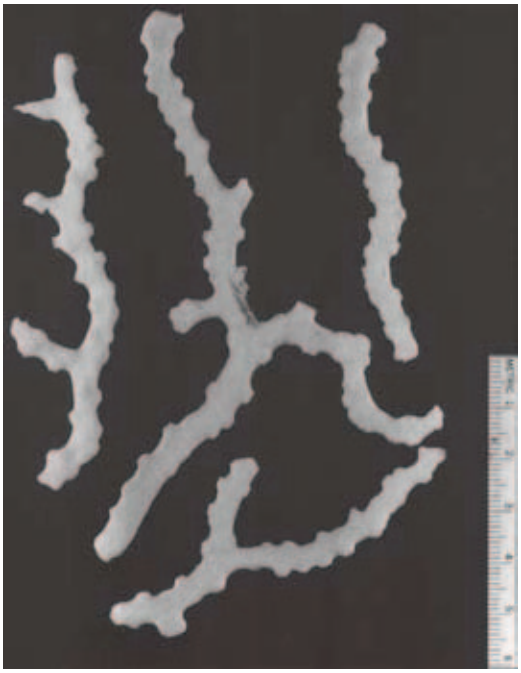

Fig. 33: Branches of colony of *Corallium Kishinouyei*. (from Bayer, 1996)

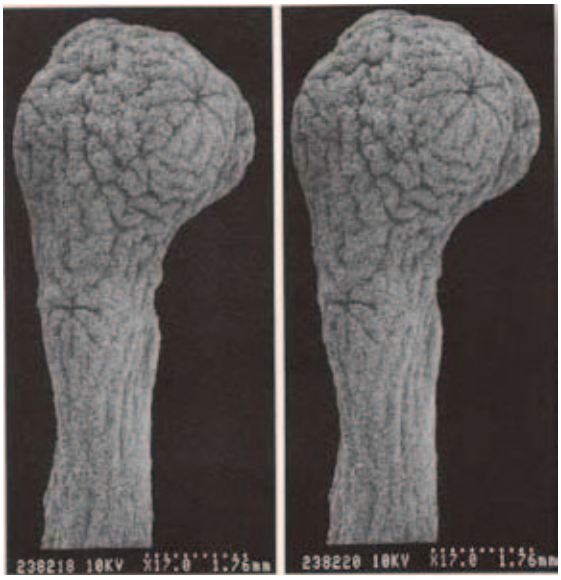

Fig. 34: Tip of branch; stereo pair. (from Bayer, 1996)

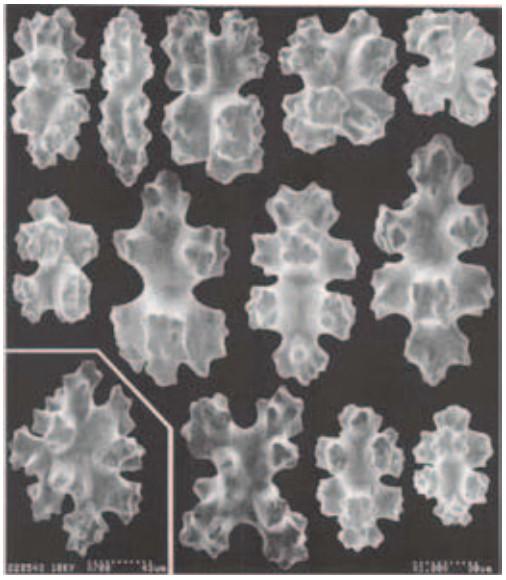

Fig. 35: Sclerites. (from Bayer, 1996)

Corallium laauense Bayer, 1956 (Figs.36, 37)

Corallium laauense Bayer, 1956: 78, figs.5e-f, 7h-j.

Colony form: Colony with some terminal twigs giving off lateral branchlets in one plane.

Coenenchyme: Coenenchyme longitudinally costate, bearing small, conical papillae. Sometimes the coenenchyme extending as a thin, membranous expansion along the two edges of the twigs, where the margins of opposite sides may recurve and join to form closed tunnels. White or faintly pink.

Polyps: Autozooids distributed on two sides and one face of the branches, forming cylindrical, longitudinally-grooved verrucae about 1mm tall. Siphonozooids appearing as small warts with an apical pore, near the autozooid bases.

Axis: Axis is practically round, with broad, longitudinal grooves in the largest parts preserved. White.

Sclerites: Two kinds of coenenchymal sclerites, crosses and 8-radiates. Spinose rods, up to 0.145 mm long in the autozooid verrucae. Small rods in the pharyngeal region and oral disk. Sclerites colorless.

Distribution: Hawaii, 365-584 m.

Remarks

In the form of its calyces and its finely divided branching, *C. laauense* resembles *C. sulcatum*, but the latter has double clubs and massive, irregular forms among its sclerites.

Fig. 36: Tip of branch.(from Bayer, 1956)

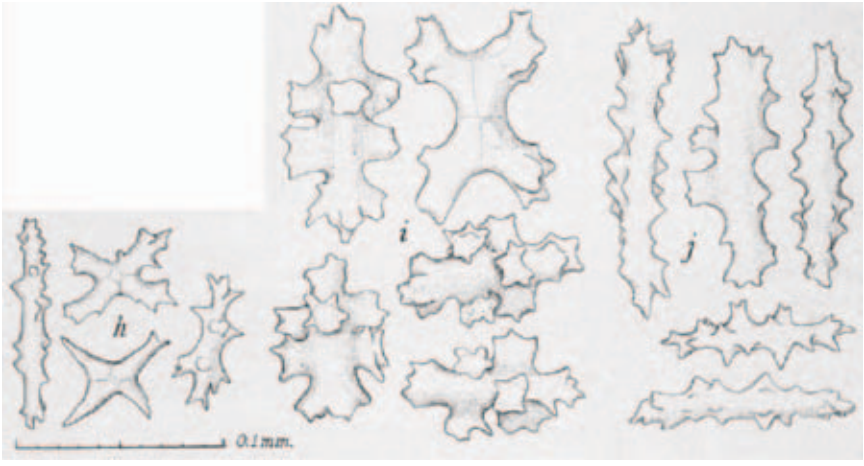

Fig. 37: Sclerites. (from Bayer, 1956) h. Pharyngeals. i. Coenenchymal 8-radiates and crosses. j. Tentacle scales.

Corallium niveum Bayer, 1956 (Figs.38, 39)

Corallium niveum Bayer, 1956: 84, figs. 5g, 8h-k.

Colony form: Colonies irregularly branched in one plane, the major branches often diverging strongly from near the base. The branches stout, the largest ones 5-10 mm in diameter at the base, tapering to about 2mm toward the clavate tips. Small twigs arise from the front of the colonies, each ending in a recurved cluster of polyps directed toward the base of the colony.

Coenenchyme: The surface of the coenenchyme finely wrinkled or corrugated, but no papillae. White.

Polyps: Autozooids form rather large, hemispherical verrucae with 8-rayed orifices, clustered in groups occurring almost exclusively on one face of the colony. Each twig tip ends in a cluster of autozooids and thus assumes a clavate form. The siphonozooids are inconspicuous, appearing as simple pores in the thick coenenchyme.

Axis: Axis solid, round, or oval, and longitudinally grooved. No pitting beneath autozooids. White.

Sclerites: Sclerites of both verrucae and coenenchyme 6-, 7-, and 8-radiates, crosses and double clubs. In the pharyngeal region and oral disk of the polyps small spiny rods and crosses. Sclerites colorless.

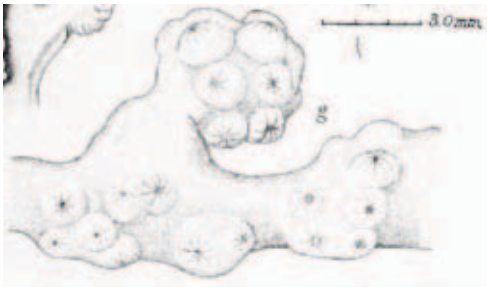

Fig. 38: *Corallium niveum* detail of polyps. (from Bayer, 1956)

Distribution: Hawaii, 232-282 m.

Remarks

C. niveum is related to *C. pusillum* from Japan, which differs in lacking 6- and 7-radiate sclerites and in color (orange).

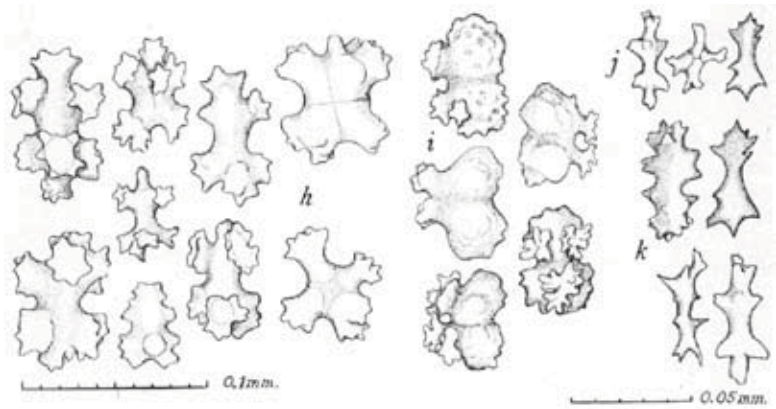

Fig. 39: Sclerites. (from Bayer, 1956) h. Crosses, 6-, 7-, and 8-radiates from coenenchyme. i. Double-clubs from coenenchyme. j. From pharynx. k. From pharynx (0.05mm scale).

Corallium porcellanum Pasternak, 1981 (Fig.40)

Corallium porcellanum Pasternak, 1981: 43, fig.2.

Colony form: Speimens injured during dredging, only numerous fragments of twigs available, about 50 mm long, 3.6 mm maximum diameter. Branching in one plane. Twigs compressed in section, 2.1 mm by 1mm in diameter.

Coenenchyme: Coenenchyme white to yellow-white.

Polyps: Autozooids laterally arranged in double lines, with 4-5 autozooids in bundles on terminal twigs, 5-6 polyps in 30 mm of each row, at nearly equal intervals. Verrucae of autozooids low and wide, up to 2 mm in diameter at the base, 8 radial grooves not reaching summit. Siphonozooids not verrucae-shaped, with small opening only, some concentrated on the base of autozooids, but others scattered on one surface of the colony.

Axis: Axis of main stem is solid, rounded in cross-section, but twigs are brittle, compressed. Surface of the stem with precision longitudinal lines, rough to the touch. Twigs are comparatively soft, 1mm thick in lateral direction. Deep pits absent beneath the autozooids. Axis white or slightly transparent and reminiscent of quality porcelain.

Sclerites: Sclerites of coenenchyme and autozooids mostly 8-radiate, decorating several mounds and conical projections. Size variable, but less than 0.08 mm in length. 6- and 7-radiate and compressed crosses few. Double-club sclerites absent. Sclerites colorless, transparent.

Distribution: Hawaii, (Marcus-Necker; 13˚27'.4N, 173˚27'.3W) 1213-1292 m.

Remarks

Sclerites of *C. porcellanum* similar to those of *P. japonicum* mostly, but distinguished from *japonicum* by lack of axial pits. Distinguised from *C. laauense* by wide autozooid verrucae, and sclerites, predominantly 8-radiates. Similar to *C. niveum* in size of autozooids, but autozooids of *C. porcellanum* mainly in double rows, and without double clubs.

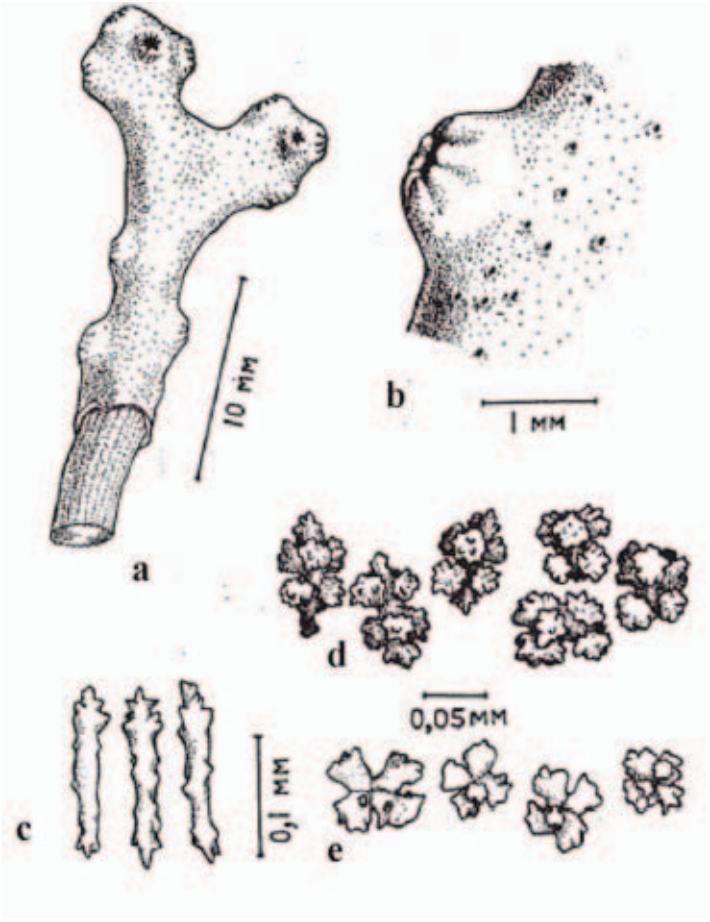

Fig. 40: *Corallium porcellanum.*
(from Pasternak, 1981)
a. Tip of branch.
b. Detail of polyps.
c. Sclerites from tentacles.
d. Sclerites (6-, and 8-radiates) from coenenchyme.
e. Crosses from coenenchyme.

Corallium regale Bayer, 1956 (Figs.41,42)

Corallium regale Bayer, 1956: 77, figs.5c,7e-g; Pasternak, 1981: 43.

Colony form: Specimen only one branch with a few short twigs, insufficient to show the pattern of branching. Branching probably in one plane, as indicated by the twigs originating from the sides of the branch, and furthermore probably pinnate.

Coenenchyme: Surface not papillate, although surface irregular. Coenenchyme moderately thick, and in places expanded from the sides of the branches as recurved flaps supported by thin, calcareous outgrowths of the axis, forming tunnels inhabited by commensal polychaetes.

Polyps: Autozooids along two sides and one face, leaving one face bare, forming tall, cylindrical verrucae 1.5-2.0 mm in height and 1.5 mm in diameter, 8-lobed and grooved toward the distal ends.
Siphonozooids small pores, sometimes in small, wart-like protuberances, some distributed on bases of autozooids and some dispersed on the coenenchyme.

Axis: Axis solid and rounded in section, surface smooth. Pink in color.

Sclerites: Three kinds of sclerites in both verrucae and coenenchyme: 6-, 7-, and 8-radiates, a few crosses, and double clubs with rudely sculptured heads. The 6-radiates usually short, often with the radii much reduced, 7-radiates the usual form, quite uncommon, 8-radiates also usual form, common.

Autozooid verrucae with long, irregular rods 0.09-0.12 mm in length. Small, spinose rodlets in the oral disk and pharyngeal region. Sclerites pale pink by reflected light.

Distribution: Hawaii, 365-723 m.

Remarks

C. regale is most closely related to *C. sulcatum* and *C. imperiale*, but differs from both in having the peculiar, almost spherical 6-radiates found also in *C. maderense* and *C. tricolor* of the Atlantic.

Of all the Hawaiian precious corals, *C. regale* has the best color and might be of commercial value if it could be harvested in quantity.

Fig. 41: *Corallium regale,* tip of branch. (from Bayer, 1956)

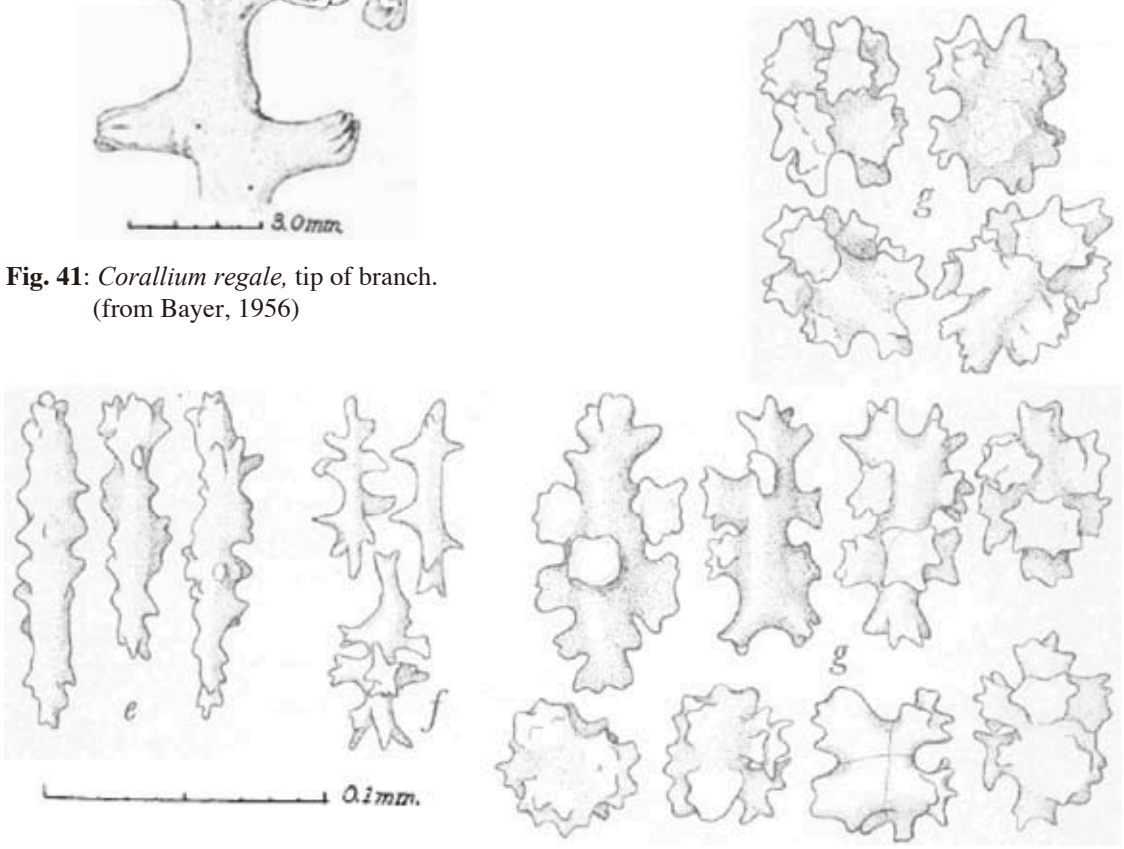

Fig. 42: Sclerites. (from Bayer, 1956)
e. From tentacles. f. From pharynx. g. 6-, 7-, and 8-radiates, double-clubs from coenenchyme.

Corallium secundum Dana, 1846 (Figs. 43-46)

Corallium secundum Dana, 1846: 641, pl.60, figs.1; Kishinouye, 1904a: pl.6; Kukenthal, 1924: 49; Bayer, 1956: 80, figs.5d,6d-e,8a-d.

Pleurocorallium secundum,-- Ridley, 1882: 224, Pl.9, figs.6-11; Wright & Studer, 1889: 186.

Colony form: Colonies planar. With small, slender, prickle-like twigs occurring only on one surface of the colony.

Coenenchyme: Coenenchyme closely papillate on all sides of the branches, but more densely on "front". Coenenchyme and autozooids salmon pink.

Polyps: Autozooid verrucae evenly distributed, not clustered in groups, restricted to short twigs on one side of the colony. Groups of two or three at twig tips. Siphonozooids form small verrucae near the autozooid bases.

Axis: Axis longitudinally striated, somewhat flattened at right angles to the major plane of branching. Pale pink, often almost white, sometimes with a darker center.

Sclerites: Four kinds of sclerites in coenenchyme, mainly double clubs, large, well-formed 8-radiates, present but not common, 6- and 7-radiates comparatively rare. Tentacles of autozooids with small 8-radiates, small spiny rods and crosses in pharyngeal region. No long spindles in autozooids. Sclerites pink by reflected light.

Distribution: Hawaii, 231-564 m.

Remarks

In 1965, Japanese fishermen discovered a huge bed of *C. secundum* at depths of 400 m on the Milwaukee Banks (Koko Seamount), about 750 km northwest of Midway Island (Grigg, 1974). This is the first record of precious coral harvesting in Hawaii. This species was collected as the main fishery species called "angel-skin coral" or "pink coral" in Hawaii.

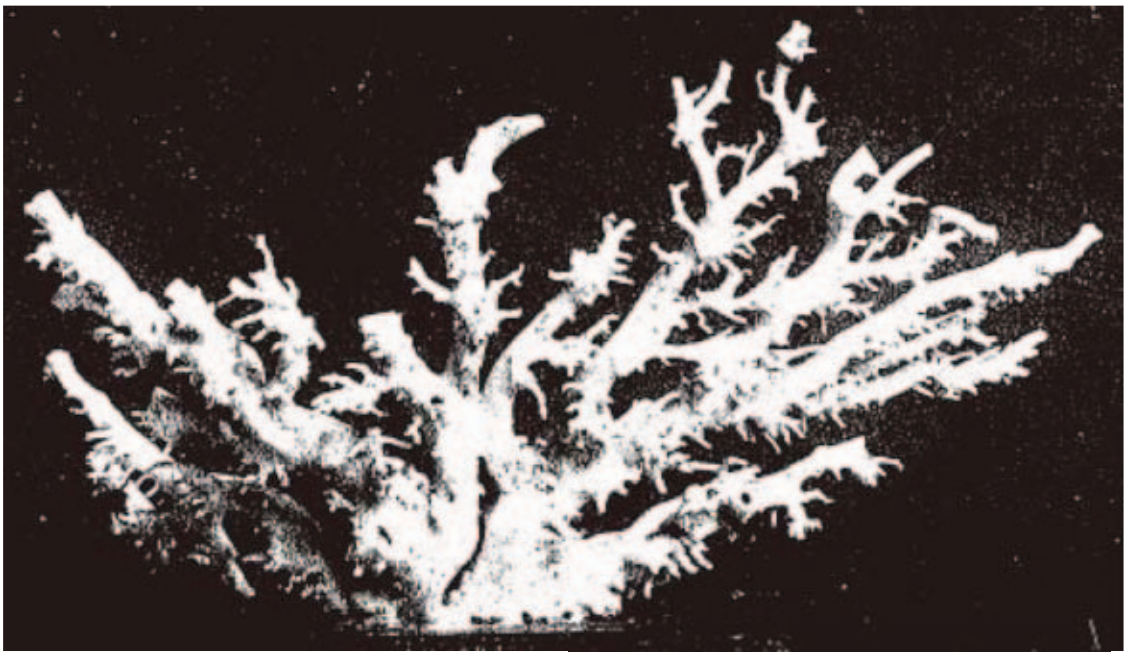

Fig. 43: Whole colony of *Corallum secundum*. (from Kishinouye, 1904)

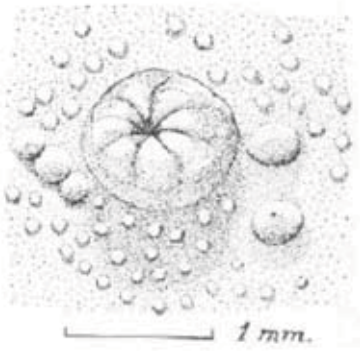

Fig. 44: Detail of polyps. (from Bayer, 1956)

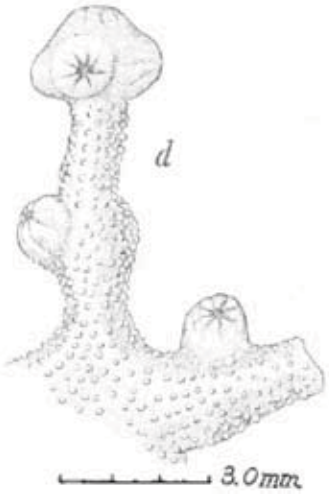

Fig. 45: Tip of branch. (from Bayer, 1956)

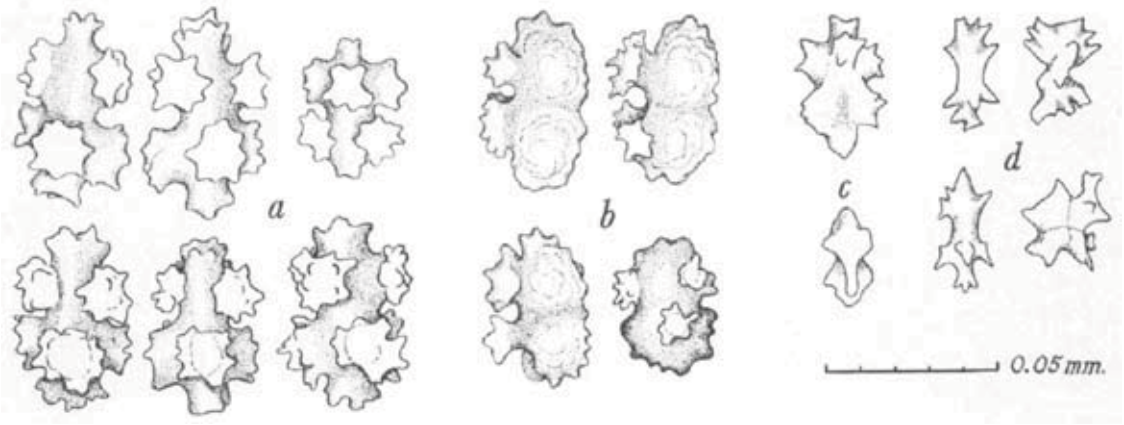

Fig. 46: Sclerites. (from Bayer, 1956)
a. 8-radiates from coenenchyme. b. Double-clubs from coenenchyme. c. From tentacles. d. From pharynx.

Paracorallium tortuosum (Bayer, 1956) (Figs. 47, 48)

Corallium tortuosum Bayer, 1956: 82, figs.5b, 6c, 8e-g.

Paracorallium salomonense tortuosum.-- Bayer, 1993: 16, Pls.10,14-16.

Paracorallium tortuosum.-- Bayer & Cairns, 2003: 225.

Colony form: Colonies irregularly branched, but showing definite tendency to remain in one plane. Largest specimens about 7.5 cm high. Although branching mainly in one plane, twigs here and there grow out in various directions. The branches twisted and tortuous with numerous swellings, cysts, tunnels and other deformities caused by the many infesting epizooic and commensal animals.

Coenenchyme: Coenenchyme exceedingly thin with few sclerites, except between the longitudinal cortical solenia, each of which follows a groove in the axis. It therefore appears to have lines of sclerites running through it longitudinally. Pale pink or salmon pink in color, the region surrounding the autozooids darker.

Polyps: Autozooids raised areas on the trunk and branches; each set in a depression surrounded by a raised rim. Rim usually highest above and open toward the base of the colony, so that the calycular margin forms a projecting shelf over the zooid. They do not form projecting verrucae, but retract flush across the calycular pit, and have the usual 8-rayed orifice at center. Siphonozooids occur as tiny verrucae between the lines of sclerites in the coenenchyme, i.e., along the solenia, especially based from the autozooids.

Axis: Axis round or oval in cross section, about 10 mm in diameter and longitudinally grooved; the smaller branches basically round in cross section but more or less distorted by the autozooid calyces which indent the solid axis. The calyces usually have the best developed rims, and since two are often opposed at the twigs tips, a cross section of the axis there assumes a roughly x-shaped outline. Pinkish. The projecting calycular rims strongly beaded and often darker in color than the surrounding areas.

Sclerites: Two types of sclerites, the same in both coenenchyme and verrucae: 8-radiates and numerous crosses. In the pharyngeal region and oral disk of the anthocodiae minute, irregular rodlets and crosses. Sclerites pink.

Distribution: Hawaii, 168-408 m.

Remarks

All specimens of *P. tortuosum* are infested with a small zoanthid which pits and distorts the axis. The depressions caused by the zoanthid are distinguishable from those formed by the polyps of the *Paracorallium* itself by their larger size and lack of raised, beaded margin. The coral is also host to a polynoid polychaete, to which the tunnels and cavities in the axis are due. One specimen has in the main

stem some chambers filled with a sponge, which may either be directly responsible for the cavities or merely occupying space left by some other inhabitant. *P. inutile* is similarly infested with actinians but, the axis is not affected.

P. stylasteroids is very similar in general appearance to *P. tortuosum*, but lacks the numerous cross sclerites so conspicuous in the Hawaiian material.

P. tortuosum appears to be the most abundant precious coral in Hawaiian waters but, due to its small size and usually deformed axis, it probably has no commercial possibilities. Bayer (1993) treated *P. tortuosum* as a subspecies of *P. salomonense* but later as a seperated species pending discovery of more materials for comparisons. (Bayer and Cairns, 2003)

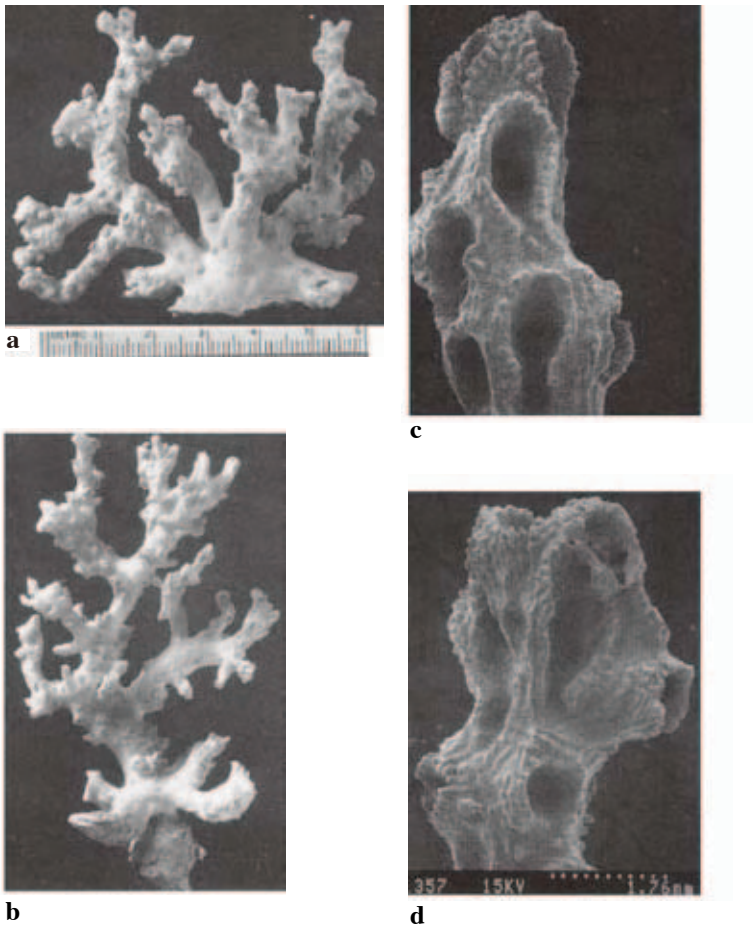

Fig. 47: *Paracorallium tortuosum*. (from Bayer, 1993)
a,b Whole colonies. c,d Axis of branchlet.

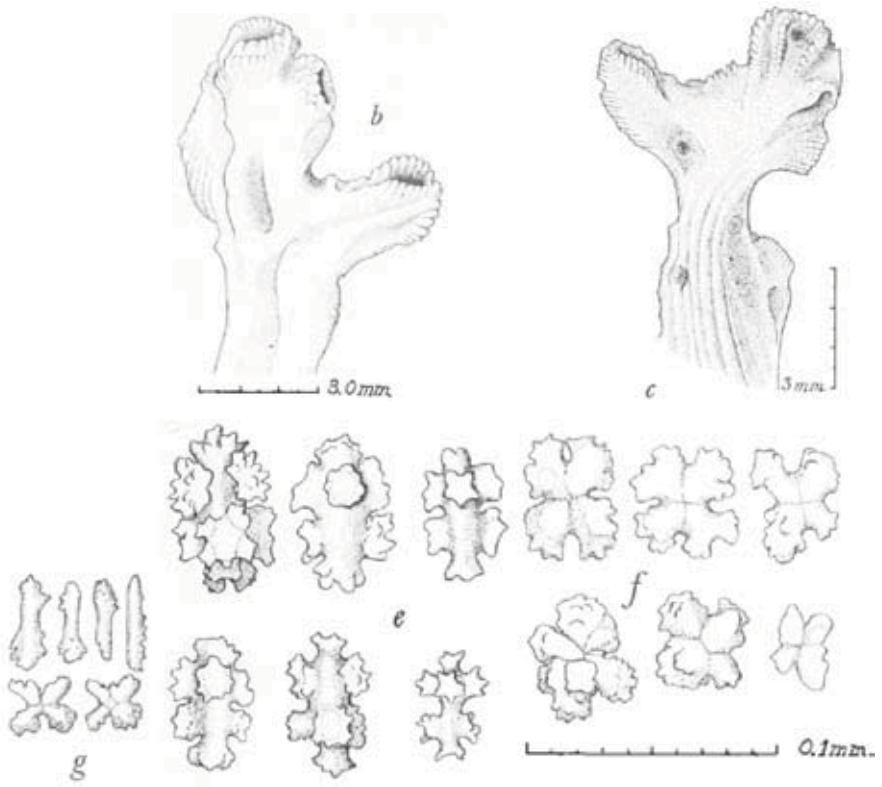

Fig. 48:
Paracorallium tortuosum.
(from Bayer, 1956)
b,c Tip of branches.
e. Coenenchymal sclerites (8-radiates)
f. Coenenchymal crosses.
g. Pharyngeal sclerites.

Precious Corals from other Indo-Pacific areas

(Descriptions were condensed from the original publications)

Corallium borneense Bayer, 1950 (Fig. 49)

Corallium borneense Bayer, 1950: 59, fig.1; Bayer, 1956: 76 (in key).

Colony form: Branches on all sides of the stem, projecting at right angles or inclined a little upward. Large branches irregularly subdivided into thick, clavate twigs bearing at their ends clusters of several autozooids. Small branches mostly simple and of about the same caliber as the secondary twigs of the large branches. Type specimen 5.5cm in height, possibly only a branch of a large colony.

Coenenchyme: Coenenchyme highly colored, being nearest to Ridgway's “salmon” and the verrucae darker, approximating “flame scarlet.”

Polyps: Autozooids are low verrucae about 2 mm in diameter, very few on the main stem, but numerous on the branches. Twigs and branches with autozooids in groups, No predominance of autozooids on any one side. Siphonozooids small warts with simple orifices, often of a lighter color than the surrounding coenenchyme, situated around the bases of the autozooids.

Axis: Axis obscurely striated, round except at the twig tips, X- or Y-shaped in cross section. The main axis is about 9 mm in diameter near the base, decreasing to 3.5 mm at the top. About 15 mm from the base there is a round hole 3 mm in diameter leading to a cavity within the stem; at the base of a branch 6mm above the first hole there is a small but deep pit not connected with the axial cavity. These deformities were probably caused by a polychaete commensal. The white axis has a pink center.

Sclerites: Four kinds of sclerites in both coenenchyme and autozooids, predominant sclerite the double club. Less common are the radiate forms with 6-, 7-, or 8-radiate sclerites, such as the malformed 8-radiate, and simple crosses. Small rods with conical processes occur only in the autozooids; this form may be derived from the multi-radiate type by suppression of the rays.

Distribution: Borneo, 534 m.

Remarks

Those with rather large, dome-like verrucae often clustered in groups and also not set into the axis (e.g., *C. konojoi*). The manner of branching is similar in appearance to *C. konojoi*. Microscopically the latter differs greatly in the predominance of 6-radiates, the more irregular double clubs, and the presence of autozooids only on one surface of the colony.

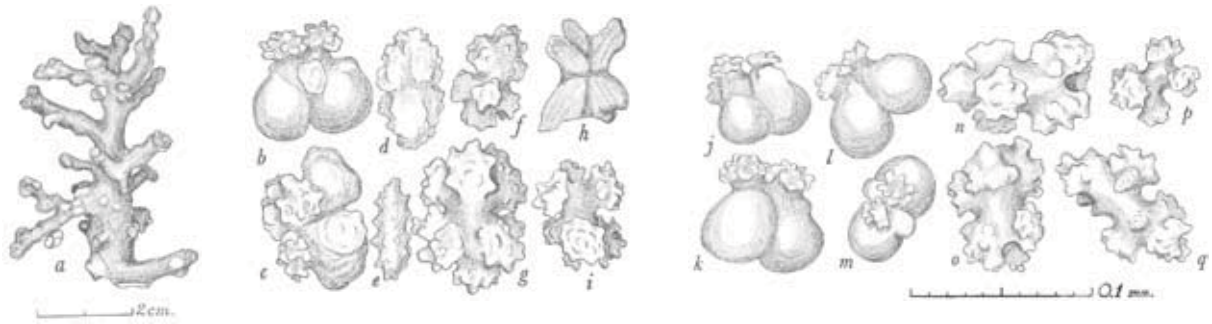

Fig. 49: *Corallium borneense*. (from Bayer, 1950) a. Whole colony. b-i. Sclerites from autozooid verrucae. j-q. Sclerites from coenenhcyme.

Corallium ducale Bayer, 1955 (Fig. 50)

*Corallium ducal*e Bayer, 1955: 210, Pls.1; Bayer, 1956: 75 (in key).

Colony form: Colony spread in one plane, openly branched laterally and dichotomously. Branches round or slightly compressed at right angles to the plane of branching, the largest nearly 10 mm in diameter. Terminal twigs 1.5-2.0 mm in diameter.

Coenenchyme: Coenenchyme of the "back" face of the colony wrinkled by an anastomosing reticulum of narrow ridges marking the presence of the solenial system, sinuous grooves present on the coenenchyme between the autozooids. Colony dark pink in alcohol.

Polyps: Autozooids restricted to one face of the colony, their calyces short cylindrical or blunt conical, distinctly 8-ribbed. Tentacles fully retractile and none exsert in preservation. Verrucae of autozooids 1.5 mm or less in height, and up to 2.0 mm in diameter at the base, more or less tapering apically. Siphonozooids small, hemispherical or irregular calyces near the autozooids.

Axis: Axis faintly striated; in the terminal portions with low surface irregularities and distinct granulation. The axis is of a richer and deeper color than the coenenchyme.

Sclerites: Four kinds of sclerites in the coenenchyme: abundant double clubs derived from radiate forms by asymmetrical development of two radii, measuring 0.060-0.085 mm in length, and 6-, 7-, and 8-radiates up to 0.1 mm in length, some of which may show a considerable subdivision of the radii or are otherwise misshapen. Sclerites in the pharyngeal region and oral disk: crosses, massive, irregular bodies and slender spinous rods in the pharyngeal region and oral disk, and abundant stouter rods in the tentacles.

Distribution: East-Pacific Mexico.

Remarks

The massive, irregular sclerites of *C. ducale* resemble those of *C. boshuensis* and *C. sulcatum*, but *C. ducale* differs widely from both those species in its open, lateral dichotomous plan of ramification, lower autozooid calyces, and presence of both 6- and 7-radiates as well as the usual 8-radiate forms.

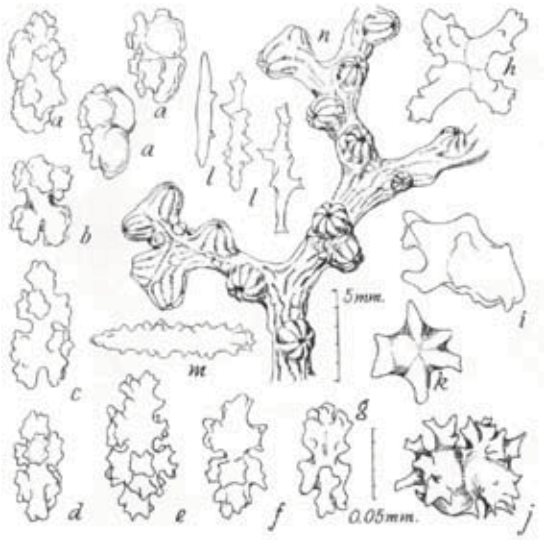

Fig. 50: *Corallium ducale*. (from Bayer, 1955)
a. Double-club sclerites. b. 6-radiate sclerite.
c. 7-radiate sclerite. d. 8-radiate sclerite
e-g. Irregular radiates. h. Cross sclerites.
i-k. Irregular sclerites.
l. Sclerites from oral disk and pharynx.
m. Sclerite from tentacle. n. Tip of branch.

Corallium halmaheirense Hickson, 1907 (Figs. 51-53)

Corallium halmaheirense Hickson, 1907: 6, figs.5,6,9; Kukenthal, 1924: 51; Bayer, 1956: 76, (in key).

Colony form: Only broken parts are preserved, suggesting branching mainly in one plane. Sample 15 mm in height and axis diameter 2.25 mm. with four lateral branches ranging from 5-8 mm length with two small branches on one face about 3 mm in length.

Coenenchyme: Coenenchyme orange-red and much darker than axis. Distortion of growth due to commensal polychaete worm.

Polyps: Verrucae of autozooids conical in shape, very prominent, 2-3 mm in height, and marked externally by eight deep longitudinal grooves. Not all turned in the same direction but nevertheless tend to turn towards "anterior" surface of the colony.
Between verrucae of autozooids a number of minute white specks visible, certainly siphonozooids.

Axis: Main axis half-moon shaped in section, very pale pink, almost white, but with an eccentrics darker pink core.

Sclerites: Coenenchyme with numerous crowded sclerites of the 8-radiate type 0.06-0.07 mm long.
Sclerites of verrucae of autozooids flattened spindles or rods (about 0.09 x 0.015 mm) with many tubercles.

Distribution: Celebes Sea, 1089 m.

Remarks

A characteristic feature of this species seems to be many of the terminal branchlets terminate in a pair of opposite verrucae so that these branchlets have the shape of a capital T. It is difficult to separate from *C. sulcatum*, *C. tricolor* and *C. maderense,* but in *C. sulcatum*, the sclerites are of three kinds, six-radiates, seven-radiates and double clubs. In *C. tricolor* and *C. maderense*, there are three forms of sclerites in the cortex, double clubs being the most numerous. Sclerites of *C. halmaheirense* very similar in form and shape to the sclerites of *C. reginae* but decidedly smaller.

Fig. 51: Branchlet of *Corallium halmaheirense*. (from Hickson, 1907)
a. Tunnel containing a commensal polychaete.
b and c. Typical T-shape terminal branch.

Fig. 52: Detail of polyps. (from Hickson, 1907)

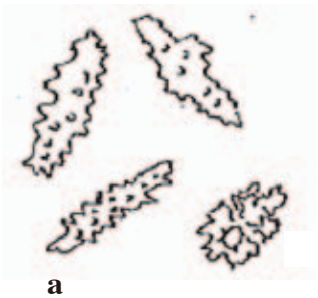

Fig. 53: Sclerites. (from Hickson, 1907)
a. 8-radiate from coenenchyme.
Others from autozooids.

Corallium imperiale Bayer, 1955 (Fig. 54)

Corallium imperiale Bayer, 1955: 209, Pls.2c-h; Bayer, 1956: 75, 76 (in key).

Colony form: Colony large, spread in one plane, abundantly branched in a subpinnate fashion. Main branches practically circular in cross section, about 5mm in diameter; end twigs slender, about 1.5mm in diameter.

Coenenchyme: Coenenchyme with a predominantly longitudinal and parallel system of narrow ridges, here and there densely anastomosing cross-connections marking the presence of the coenenchymal solenial network. One face ("back") of colony bare. Both coenenchyme and axis a rich pink in color.

Polyps: Autozooids restricted to one face of the colony, their calyces tall, cylindrical, 8-ribbed; the tentacles fully retractile, but in preservation may remain exsert. The calyces about 2.5 mm tall, up to 3 mm if the tentacles not fully retracted, and 1.5 mm in diameter. Siphonozooids forming small, irregular verrucae between the autozooids.

Axis: Axis very weakly and obscurely striated, rich pink.

Sclerites: Two kinds of sclerites predominant in the general coenenchyme and autozooids: 8-radiates and double clubs. Double clubs very abundant; averaging 0.05-0.06 mm in length. Typical 8-radiates to 0.08-0.09 mm long, and occasional atypical examples 0.1 mm. Crosses not uncommon. In the distal part of the autozooids a few rods 0.10-0.11 mm in length may be found, and this type of sclerite is the predominant one in the tentacles. Small 8-radiate and irregularly spinous rods also occur in the tentacles, where the sclerites are irregularly packed, extending as points into the bases of the pinnules.

Distribution: East- Pacific Mexico southwest of Guadalupe Is.

Remarks

Corallium imperiale seems to be closely allied to *C. boshuensis* and *C. sulcatum*, but differs from both in the absence of massive, irregular sclerites and the predominance of double clubs rather than 8-radiates. *C. impteriale* differs further from *C. sulcatum* in its less profuse branching and more prominent autozooids, and from *C. boshuensis* in its lack of compression of the branches and its rich pink color.

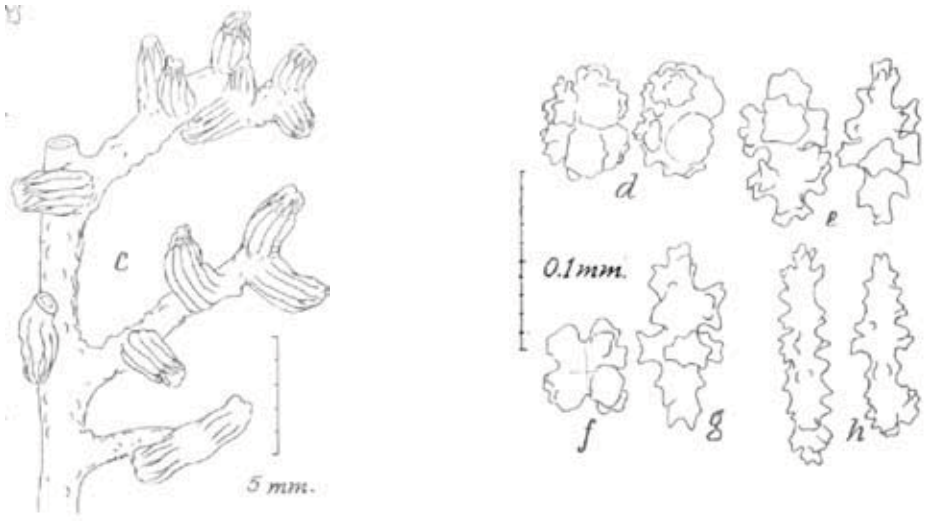

Fig. 54: *Corallium imperiale*. (from Bayer, 1955)
c. Tip of branch. d. Sclerites (double-clubs) from coenenchyme. e. Sclerites (8-radiates) from coenenchyme. f. Cross from coenenchyme. g. Atypical sclerite from coenenchyme. h. Sclerites from tentacles.

Corallium reginae Hickson, 1905 (Figs. 55-59)

Corallium reginae Hickson, 1905: 270; Hickson, 1907: 4, figs.1-4,8,10; Kukenthal, 1924: 50; Bayer, 1956: 76 (in key).

Colony form: Colony branching irregularly but principally in one plane.

Specimens considerably broken, 37-80 mm in height, base of attachment 3-6 mm in diameter and the main branches are 4-5 mm in diameter at their bases.

Coenenchyme: Pink.

Polyps: Autozooids situated on one surface only except at branch extremities. Autozooids in retraction forming irregularly scattered hemispherical verrucae projecting about 1.5 m from the surface, about 1.4mm in diameter, scored externally by eight radiating grooves. All the larger branches have few autozooids. Siphonozooids very small, in some cases indicated by minute papillae or tubular pores but usually inconspicuous, numerous, unevenly distributed.

Axis: Axis very hard and takes a polish. In transverse section it shows a pale central spot and one or two white rings arranged concentrically around the center. Color of axis a rather dark pink. Some fistulose places due to the action of a commensal polychaete.

Sclerites: Sclerites very variable in form, the largest 8-radiates about 0.075-0.08 mm in length not exceeding 0.085 mm, the double-club shape comparatively rare. The great majority of sclerites irregular 8-radiates but a considerable number approximating the typical 8-radiate sclerites may be found.

Distribution: Flores Sea, 122 m.

Remarks

Although Hickson first mentioned this new species in 1905, a more complete description is in Hickson 1907.

Fig. 55: A basal fragment of a colony of *C. reginae*. (from Hickson, 1907) b. Base of attachment.

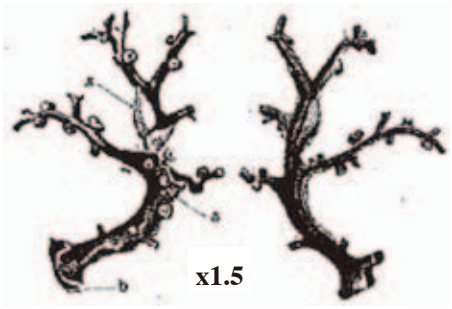

Fig. 56: Whole colony from anterior surface (left) and posterior surface (right). (from Hickson, 1907)

Fig. 57: Detail of polyps. (from Hickson, 1907)

Fig. 58: Sclerites. (from Hickson, 1907)
a. Irregular 8-radiate sclerite from coenenchyme.
b. Double-club from coenenchyme.
c and d. Spindles from autozooid verrucae.

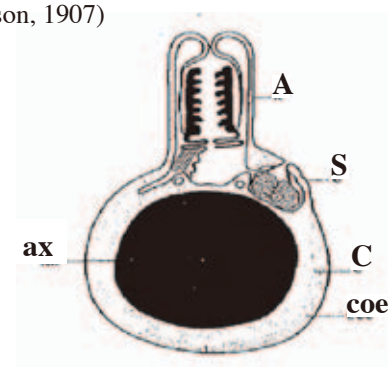

Fig. 59: Diagram of branch.(from Hickson, 1907)
A. Autozooid. S. Siphonozooid bearing the gonads.
C. Canals. coe. coenenchyme. ax. Axis.

Corallium variabile (Thomson & Henderson, 1906) (Figs. 60, 61)

Pleurocorallium variabile Thomson & Henderson, 1906: 24, Pl.1 fig.9. Pl.5 fig.6. Pl.9 fig.13.

Corallium variabile. -- Kukenthal, 1924: 51, Bayer, 1956: 76 (in key).

Colony form: Complete colony form still unknown, only some broken pieces available, the largest one 13.5 cm in height and 6.2 cm in width. Colony very profusely branched in one plane, branches tortuous, with little, if any sign of lateral compression. Branching from the antero-lateral surfaces of the stem, diminishing gradually in thickness towards their tips. Numerous short branchlets on the sides of the large branches and the stem.

Coenenchyme: Coenenchyme thin, creamy white in color, and full of closely packed small sclerites resembling glistening sand grains. Also a few fragments from the same locality rosy-red with a yellowish-brown coenenchyme with the same polyp arrangement and details of sclerites and axis as above.

Polyps: Polyps irregular on the anterior surface of the stem and branches, the salmon pink verrucae a fine contrast to the creamy white of the general coenenchyme and the yellow of the tentacles. Verrucae prominent, almost cylindrical in shape, marked by eight longitudinal ridges, 2.7 mm high. The tentacles about 0.5 mm in length, yellowish in color, and closely covered by small sclerites. With tentacles retracted, the apices of the verrucae resemble eight-rayed stars.

Axis: Axis hard, not easily indented with a knife, solid, almost cylindrical in section in some parts and slightly oval in others. White in color, surface marked by very fine striations, often very faint.

Sclerites: Coenenchymal sclerites two kinds:

(1) 8-radiate sclerites, with a short shaft and terminal tubercles. Several tubercles project at each end of the sclerite at right angles to the shaft. The large tubercles may themselves be covered with smaller tubercles. These sclerites from 0.06-0.08 mm long, and 0.04-0.05 mm in diameter.

(2) Double-clubs consisting of two globes masses somewhat flattened at one end, and at the other end bearingshort processes, variable in shape, with several tubercles. On average 0.06 mm in length, and 0.04 mm in width.

Also a very few rough spiny spindles from 0.06-0.09 mm in length, and 0.02 mm in diameter.

Distribution: Ceylon, 926 m.

Remarks

This species differs from *C. johnsoni*, in being more profusely branched, and in having more prominent and differently arranged verrucae.

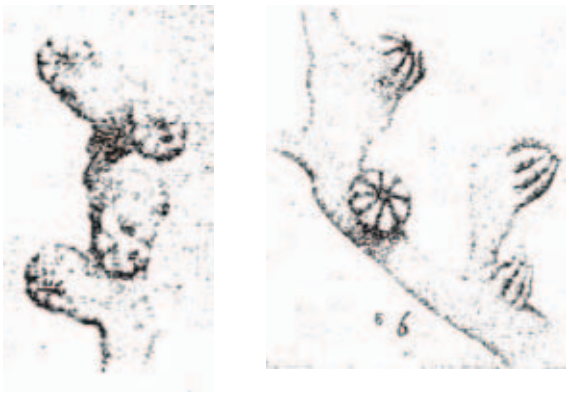

Fig. 60: Detail of polyps.
(from Thomson & Henderson, 1906)

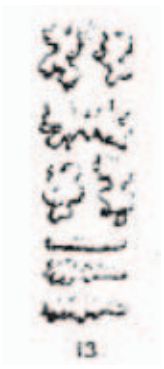

Fig. 61: Sclerites of holotype specimens.
(from Thomson & Henderson, 1906)

Paracorallium nix (Bayer, 1996) (Figs. 62-64)

Corallium nix Bayer, 1996: 213, figs.7-10.

Paracorallium nix.-- Bayer & Cairns, 2003: 225.

Colony form: Specimen only a branch so colony form unknown. Branch sinuously curved, thick, approximately round in cross section, and 6.2 mm in greatest diameter at the base, shape suggesting branching roughly in one plane. Short terminal branchlets produced mostly from two sides in the plane of curvature, but a few small ones arise from the "front" of the branch.

Coenenchyme: Coenenchyme very thin, generally smooth but inconspicuously papillate in areas protected from abrasion, suggesting that elsewhere the minute papillae may either have been rubbed off during collection, or have contracted completely as the result of contact with other objects in the trawl. In conspicuous sinuous longitudinal grooves indicate the location of the principal coenenchymal canals.
Coenenchyme white.

Polyps: Autozooids on all sides of the branch and terminal branchlets, retracted flush within the rim of the axial pits, the bases of the infolded tentacles forming an 8-lobed margin of the closed verrucal apertures. Their distribution most clearly revealed by staining with crystal violet, which stains the structures within the gastric cavities more darkly than the surrounding coenenchyme so that they contrast sharply with the paler cortex as the highly soluble stain dissipates.
Siphonozooids not distinct small verrucae and therefore very difficult to detect, but commonly one in the tapered groove extending from the autozooid, and scattered individuals in the coenenchyme between and around the autozooids.

Axis: The surface of the axis longitudinally grooved, as usual covered with minute axial protuberances ornamented with thorny projections. Axis a distinct rounded pit 0.75 mm wide and 1.05 mm long at the

position of each autozooid, bordered by a beaded rim commonly interrupted where a coelenteric canal passes through to connect with the gastrobascular cavity of the autozooid. White.

Sclerites: Four kinds of coenenchymal sclerites, predominantly short 8-radiates reaching lengths of 0.06-0.07 mm. Very short, wide 6- and 7-radiates 0.04-0.06 mm long, some weakly asymmetrical but not clearly modified as double clubs, the shortest of them forming tuberculate spheroids. Crosses absent or rare. The tentacles contain blunt rods derived from 8-radiates, as shown by numerous intermediate forms.
Sclerites colorless, translucent.

Distribution: New Caledonia, 240 m.

Remarks

There are distinct axial pits with beaded margins in the autozooids of *P. stylasteroides*, *P. salomonense*, and *P. thrinax*. However the sclerites of *P. stylasteroides* are smaller and not so sharply sculptured, and those of *P. salomonense* are both larger and more acutely sculptured. *P. thrinax* differs conspicuously in its small, dichotomously branched uniplanar growth form and its strongly asymmetrical double-club sclerites.

Fig. 62: Whole specimen of *P. nix* from front surface. 5.75cm in height. (from Bayer, 1996)

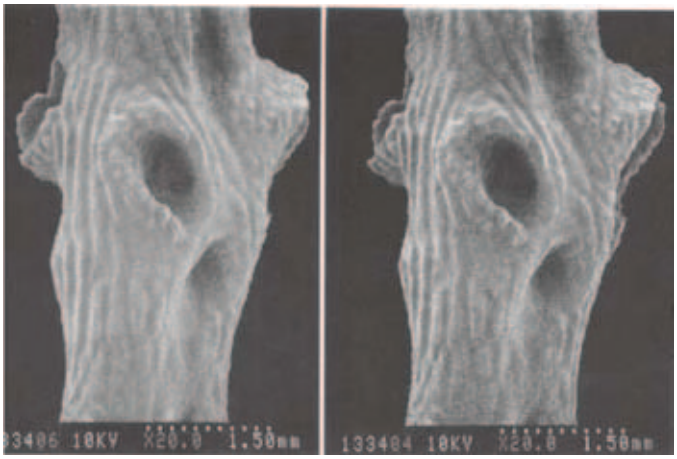

Fig. 63: Axis of branch.(from Bayer, 1996)

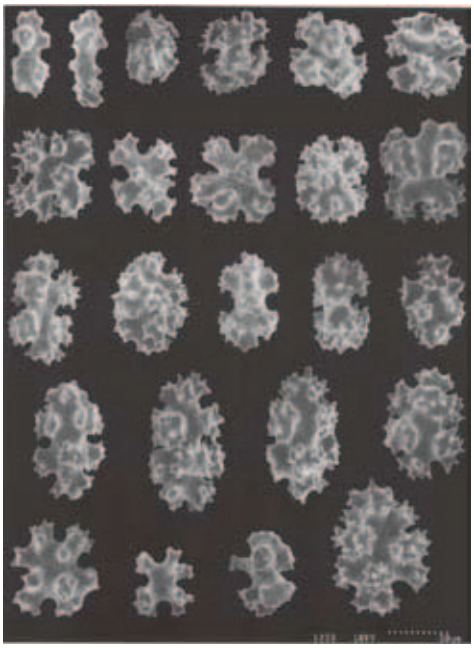

Fig. 64: Sclerites of *P. nix*. (from Bayer, 1996)

Paracorallium salomonense (Thomson & Mackinnon, 1910) (Figs. 65, 66)

Sympodium salomonense Thomson & Mackinnon, 1910: 168, Pls.12,13, figs.11,12,15a,15b.

Corallium salomonense salomonense. -- Bayer, 1993: 15, Pls.10 upper,11,12,13.

Paracorallium salomonense. -- Bayer & Cairns, 2003: 225.

Colony form: Complete colony form still unknown, only some broken pieces available. The short, rounded branches resemble a digitiform massive alcyonacean, therefore Thomson & Mackinnon originally (1910) put this species in the genus *Sympodium* (family Xeniidae).

Coenenchyme: Coenenchyme thin.

Polyps: Autozooids flat or only slightly raised in contracted state, apertures closed by tentacle bases in the form of an 8-rayed star. Siphonozooids scattered, obscure.

Axis: Axis with autozooids seated in distinct pits in the calcareous axis, the apical ones bordered by a distinctly raised, horse-shoe shaped rim.

Sclerites: Two kinds of sclerites: 8-radiates and crosses. Not markedly asymmetrical, having a distinctly thorny aspect with tubercular ornamentation complex and sharp, reaching more than 0.09 mm (largest 0.11 mm) in length by 0.058-0.06 mm in width.

Distribution: Chagos Archipelago, 217-272 m.

Remarks

Skeletal characters agree so closely with those of *P. tortuosum* that Bayer (1993) suggested they be considered representatives of one species, the senior synonym being *salomonense*. However, in view of the wide geographic separation of the type localities of *P. tortuosum* (Hawaii) and *P. salomonense* (Chagos), Bayer & Cairns (2003) treated them as speperate species, pending the discovery of more specimens for comparisons.

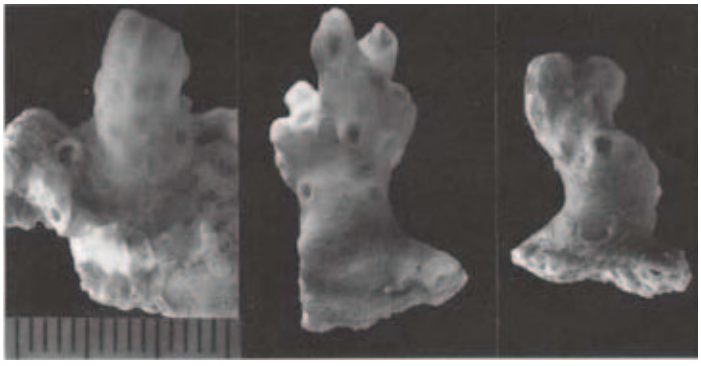

Fig. 65: Whole colony of syntype specimens. (from Bayer, 1993)

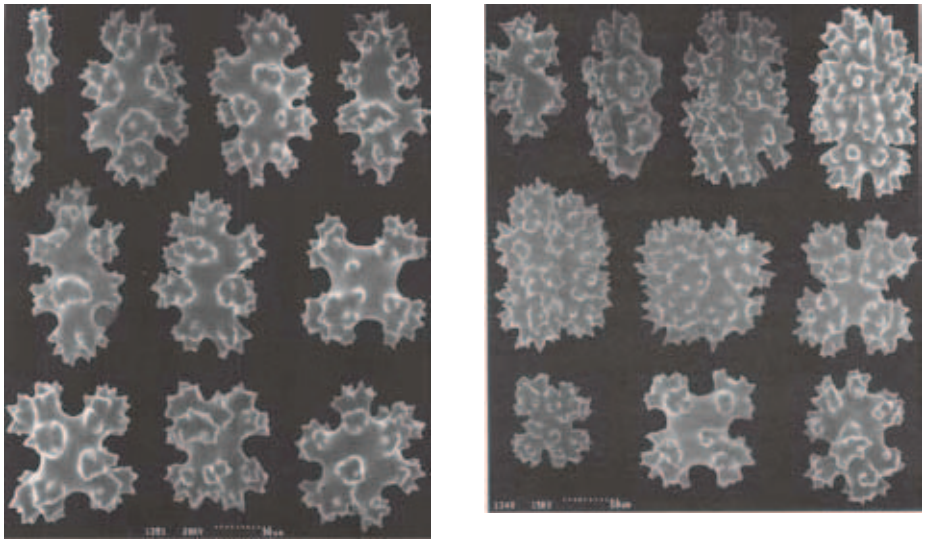

Fig. 66: Some variations of sclerites in *P. salomonense*. (from Bayer, 1993)

Paracorallium stylasteroides (Ridley, 1882) (Figs. 67, 68)

Corallium stylasteroides Ridley, 1982: 225, Pl.9, figs.1-4; Kukenthal, 1924: 48, figs.39,40; Bayer, 1956: 76 (in key); Bayer, 1993: 17, Pl.17.

Paracorallium stylasteroides,-- Bayer & Cairns, 2003: 225.

Colony form: Colony dichotomously branched in one plane, dichotomous, but subject to considerable variation. Branches tortuous, decidedly compressed laterally in the case of all but the peripheral members, arising from the antero-lateral rather than the postero-lateral aspects of the stem or branches from which they may be derived, diminishing gradually in thickness towards the peripheral part. A few small branchlets scattered on sides of the larger branches irregularly, and together with the terminal branchlets, generally subclavate in form, consisting of a slightly contracted basal portion and an enlarged, pointed, and polyhedric terminal portion. “Posterior” aspect of main branches very convex, but that of lesser branches less so. Maximum transverse breadth of the whole colony 135 mm, maximum height 105 mm. Stem stout, irregular in transverse section.

Coenenchyme: Coenenchyme very thin, with minute projecting points (visible only with the aid of a lens) arranged along the axial striae. Color of coenenchyme extremely pale orange.

Polyps: Verrucae of autozooids in the grooves of axis, not projecting beyond their margins, or in slight depressions distributed over all parts of the colony, but most abundantly on the lateral aspects of the main branches, and on the small terminal and lateral projecting branchlets. Peripheral part a pale pink collar, slightly darker than the general crust. The eight valves of autozooids very pale yellow in color. Diameter about 0.75 mm.

Axis: Axis hard, compact. Longitudinal striae on the fine surface, about four to 1 mm. Grooves for autozooids generally with a narrow raised lip on each side; length of grooves 1.5 to 2 mm long (in direction of branches) by about 0.75 mm broad, and about 0.5 mm deep in the center, a smooth-walled hemispherical pit. Axis perforated by a few canals (normal, or due to parasites?) of about 1mm in diameter, which issue distally at various points on the lateral aspects of the branches, the openings being often covered by a curved lamina of hard material. Pure white throughout.

Sclerites: Ridley (1882) described sclerites of coenenchyme as only8-radiates, from 0.053 to 0.058 mm long by 0.035 mm broad (including the tubercles); shaft, excluding tubercles, about 0.02 mm broad. However, Bayer (1993) illustrated three kinds of sclerites prepared from the type: 6-radiates, incomplete double clubs with rough surface, and crosses (rare), all with rather smooth tubercles. Length approximately 0.05 mm, breadth 0.03 mm.

Distribution: Mauritius, 137 m.

Remarks

The present species agrees in the mode of branching in one plane with *C. secundum,* and also in that many of the polyps are borne on small lateral branchlets; but differs from it in having polyps on the posterior as well as the anterior surface, and also in the very pale pinkish color of the coenenchyme (that of *C. secundum* being darker pink), and the pure white of the hard axis (that of *C. secundum* being white and pink). Bayer and Cairns (2003) suggested that when new specimens are discovered, *P. stylasteroides*, *P. nix* (from New Caledonia) and *P. tortuosum* (Hawaii) may be a single variable species.

Fig. 67: *Pacorallium stylasteroides*. (from Ridley, 1882)
1. Whole colony. 2. Detail of autozooids.
3. Part of axis with coenenchyme removed.
4. Sclerites from coenenchyme.

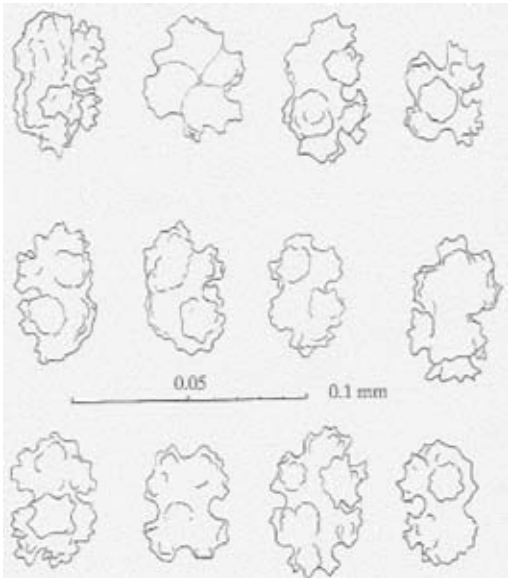

Fig. 68: Sclerites of *P. stylasteroides*.
(from Bayer, 1993)

Paracorallium thrinax (Bayer & Stefani, 1996) (Figs. 69-71)

Corallium thrinax Bayer 1996: 206, figs.1-5.

Paracorallium thrinax Bayer & Cairns, 2003: 224.

Colony form: Specimens small, from 3.7 to 6 cm in height, and between 3 and 6 cm in width. Sparingly branched dichotomously, often with a few short lateral twigs. The holdfast a narrow basal expansion of the trunk. For the most part branching in one plane, but in some colonies a branch may stand at nearly 90 degrees from the plane of the principal fan. No anastomoses. In most cases a short main trunk, oval in cross section, about 0.6 x 1.2 cm in diameter, which bifurcates to produce principal branches approximately round in section, which in turn bifurcate as many as two or three times; a few short, blunt lateral twigs sometimes arise from one or more of the internodes between bifurcations. In some cases, principal branches 2-4 mm in diameter arise directly from the holdfast.

Coenenchyme: Coenenchyme so thin that the axial sculpture is exposed in areas subject to abrasion. The longitudinal axial striations are clearly indicated through the coenenchyme, most clearly toward branch tips where the autozooids are closer together. Colonies preserved in ethanol are white.

Polyps: Autozooids low, inconspicuous verrucae distributed predominantly on one face (the "front") of the colony, with only an occasional stray on the back surface, indistinct unless artificially stained with crystal violet. Tentacles retracted flush with the coenenchyme, their bases forming an 8-lobed margin of the verrucal orifice. Siphonozooids scarce and distributed randomly in the coenenchyme, so inconspicuous that they can be distinguished only by staining with crystal violet.

Axis: The surface of the axis longitudinally grooved and covered with minute tubercles ornamented with thorny projections. At the position of each autozooid, the axis a distinct rounded pit 0.75 mm wide and 1.05 m long bordered by a beaded rim that in some cases is interrupted by a narrow gap for passage of a coelenteric canal. Axis is white.

Sclerites: Four kinds of coenenchymal sclerites. Numerous 6-radiates up to 0.04 mm in length. Some modified as globose double clubs by asymmetrical hypertrophy of two of the rays to form a pair of smooth, spheroidal processes. Surface of the coenenchyme crowded, with the spheroidal processes directed outward. Sclerites intermediate between double clubs and 6-radiates with the hypertrophied rays more or less strongly modified not uncommon. Irregular forms occur but extremely rare. No crosses or 8-radiates observed, and only a single small 7-radiate found in 3 preparations for SEM observations.

Small rods and 6-radiates present in the tentacles, the distal ones decreasing in size to about 0.03 mm.

Sclerites colorless.

Distribution: New Caledonia, 240 m.

Remarks

The colonial form of *P. thrinax* is immediately distinguished from *salomonense*, *inutile* and *nix*. Among those with beaded pits beneath the autozooid, *P. stylasteroides*, *salomonense* and *tortuosum* lack double clubs. *P. inutile* has double clubs of somewhat different outline and only 6-radiates but no 7- and 8-radiates, and differs further in its colonial form, pale pink axis and reddish cortex.

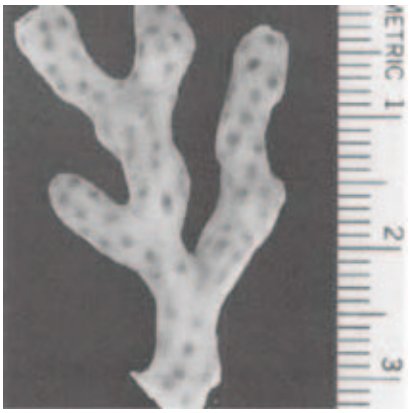

Fig. 69: *P. thrinax,* Whole colony from anterior surface. (from Bayer, 1996)

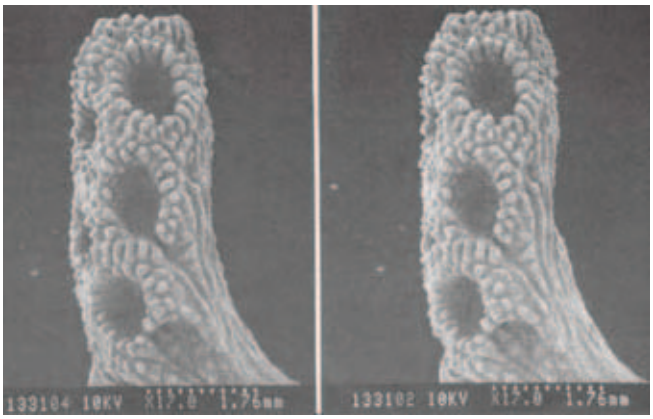

Fig. 70: Axis of branch. (from Bayer, 1996)

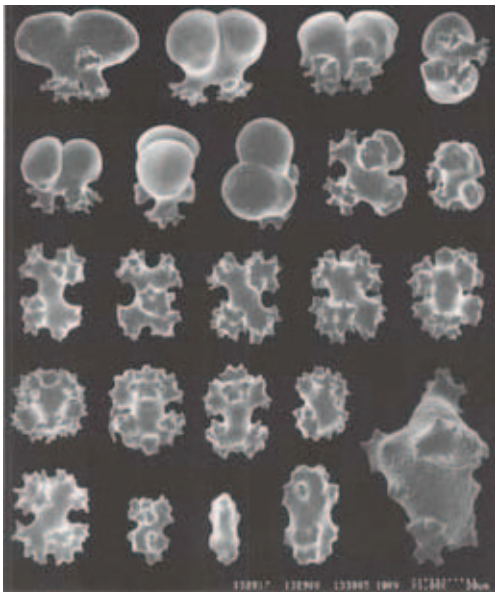

Fig. 71: Sclerites of *P. thrinax*. (from Bayer, 1996)

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References

Bayer, F.M. 1950. A new precious coral from North Borneo. Journal of the Washington Academy of Science 40 (2): 59-61.

Bayer, F.M. 1955. Contributions to the nomenclature, systematics, and morphology of the Octocorallia. Proceedings of the United States National Museum 105: 207-220, plates 1-8.

Bayer, F.M. 1956. Descriptions and redescriptions of the Hawaiian octocorals collected by the U.S. Fish Commission steamer "Albatross" (2. Gorgonacea: Scleraxonia). Pacific Science 10 (1): 67-95.

Bayer, F.M. 1993. Generic reassignment and affinities of *Sympodium salomonense* Thomson and Mackinnon (Coelenterata: Octocorallia). Precious Corals and Octocoral Research 1: 14-19, plates 10-17.

Bayer, F.M. 1996. Three new species of precious coral (Anthozoa: Gorgonacea, genus *Corallium*) from Pacific waters. Proceedings of the Biological Society of Washington 109 (2): 205-228.

Bayer, F.M. and S.D. Cairns. 2003. A new genus of the scleraxonian family Coralliidae (Octocorallia: Gorgonacea) Proceedings of the Biological Society of Washington 116 (1): 222-228.

Cairns, S. D. 2007. Deep-Water Corals: An Overview with special Reference to Diversity and Distribution of Deep- Water Scleractinian Corals. Bull Mar Sci 81(3): 311-322.

Grigg, R.W. 1974. Distribution and abundance of precious corals in Hawaii. Proceedings of the 2nd International Coral Reef Symposium. 2, Great Barrier Reef Committee, Australia, p. 235-340.

Grigg, R.W. 1976. Fishery management of precious and stony corals in Hawaii. Sea Grant Technical Report. UNIHI-SEAGRANT-TR-77-03 HIMB Contribution No. 490. 48pp.

Grigg, R.W. 1993. Precious coral fisheries of Hawaii and the U.S. Pacific Islands - Fisheries of Hawaii and U.S.- associated Pacific Islands. Marine Fisheries Review 55 (2): 50-60

Hickson, S. J. 1905. On a new species of *Corallium* from Timor. Proceedings of the Meeting of Saturday September 30: 268-271.

Hickson, S. J. 1907. Die Alcyoniden der Siboga-Expedition I. Coralliidae. Siboga-Expeditie Monogragh. 13C:1-8, plate 1.

Kitahara, T. 1904. Sango gyogyo chosa hokoku. Suisan Chosa Hokoku 13 (3): 1-24, plates 1-5. (in Japanese)

Kishinouye, K. 1902. Honpou san sango no ichi shinshu Doubutsu Gaku Zasshi 14: 419-420. (in Japanese)

Kishinouye, K. 1903a. Preliminary note on the Coralliidae of Japan. Zoologischer Anzeiger 26 (705): 623-626.

Kishinouye, K. 1903b. Honpou san no sango. Doubutsu Gaku Zasshi 15: 103-106. (in Japanese)

Kishinouye, K. 1904a. Sango no kenkyu. Suisan Chosa Hokoku 14 (1): 1-31, pls. 1-9. (in Japanese)

Kishinouye, K. 1904b. Notes on the natural history of corals. Journal of Imperial Fishery Bureau 14 (1): 1-32, pls. 1-9.

Kosuge, S.1987. The CORALS -Captivating and charming gift from Neptune- Institute of Malacology of Tokyo. Special publication No. 2, 174pp. (in Japanese)

Kukenthal, W. 1924. Gorgonaria. Das Tierreich 47: i-xxviii + 1- 478, 209 figs. Berlin and Leipzig, Walter de Gruyter and Co.

Uchida H. 1992. Hexacorallia. In: Guide to seashore animals of Japan with color pictures and keys. 1: 118-120. (in Japanese)

Vighi M. 1972. Etude sur la reproduction du *Corallium rubrum* (L.) Vie Milieu 23 (1.A): 21-32

Lacaze-Duthiers, H.D. 1864. On the formation of coral (*Corallium rubrum*). Quarterly Journal science 1: 614-623.

Liverino, B. 1986. The CORALS -Cultural Tourist Itineraries in the south of Italy- Industrial History Series. Analisi Co. Ltd, Rome, Italy, 200pp.

Marschal C., J. Garrabou, J.G. Harmelin and M. Pichon. 2004. A new method for measuring growth and age in the precious red coral *Corallium rubrum* (L.). Coral Reefs 23: 423-432.

Nonaka M., K. Muzik and S. Uchida. 2006 Culture, Study and Display of Precious Corals. Proceedings of the 10th International Coral Reef Symposium., Japanese Coral Reef Society, Japan: 1821-1831.

Pasternak, F.A. 1981. Alcyonacea and Gorgonacea. In: Kuznetsov, A.P. and A.N. Mironov [Eds.], Benthos of the submarine mountains Marcus-Necker and adjacent Pacific regions. Moscow: Akademiya Nauk: 40-55.

Ridley, S.O. 1882. On the arrangement of the Coralliidae, with descriptions of new or rare species. Proceedings of the Zoological Society of London: 221-233, plate 9.

Shozakai K. 1983. Sango no umi. The Kochi Newspaper. (in Japanese)

Suzuki K. 1999a. SANGO. Cultural history of tools and human-beings, No.91. University of Housei Press, Tokyo, 362pp. (in Japanese)

Suzuki K. 1999b. About the corals preserved in Syo-so-in. Syo-so-in Sango Cho-sa Houkokusyo, 31-39. (in Japanese)

Tsounis G., S. Rossi, M. Aranguren, J-M. Gili and W. Arntz. 2006. Effects of spatial variability and colony size on the reproductive output and gonadal development cycle of the Mediterranean red coral (*Corallium rubrum* L.). Marine Biology 148: 513-527.

Wood E. M. 1983. Corals of the World. T.F.H. Publications, Inc., Ltd. 256pp.