

Chapter

Distribution of coral reefs

Coral reefs are characterized by its beautiful spectacle, where tropical fishes swim around on colorful corals in crystal-clear waters shining in emerald blue. This wonderland is created, taking long-long period, by innumerable living organisms that inhabits on the reefs as their home. Japanese Archipelago stretches long from southwest to northeast resulting to have well developed coral reefs at south and non-reefal coral communities at higher latitudes. These habitats express various different characteristics which never disinterests us. This chapter introduces such characteristics in coral fauna and geological formation of coral reefs including non-reefal coral communities in Japan, and further takes a close look on the wonderland of organisms on the reefs.

7-1 Hermatypic corals of Japan

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1 Introduction

There are ~800 species and ~110 genera of hermatypic (zooxanthellate) corals, mostly within the Order Scleractinia. In addition to members of this order, zooxanthellate corals include single monospecific genera of Order Coenothecalia and Order Stolonifera, plus ~10 species of the single genus of Order Milleporina. Scleractinian corals are widely distributed from tropical to boreal regions, whereas the other three groups are mostly restricted to low-latitude coral reef environments.

The taxonomy and biogeography of Japanese coral fauna have been clarified by extensive, intensive field studies by Veron (1992, 2000). Only a general account of corals of Japanese waters will be given here, concentrating mainly on species from coral reef areas. We follow the taxonomic classifications of Veron (1992, 2000) and Nishihira and Veron (1995). For more details, please refer to these publications.

2 High species diversity and biogeographic distribution

Japanese seas range from sub-tropical to temperate regions. The south-western half of the total area includes the Ryukyu Islands. The Ryukyu Islands are further divided into three major groups of islands, the South Ryukyus (the Yaeyama and Miyako islands), the Middle Ryukyus (the Okinawa and Amami islands), and the North Ryukyus (the Tokara Archipelago). Especially in the South and Middle Ryukyus, there are well developed coral reefs that support high coral species diversity. Although coral reefs are not developed in the area north of the Satsunan Islands, towards the central Japanese mainland, well-developed coral communities are observed in these areas. Further north, from the Izu Peninsula to Tateyama in Tokyo Bay, only low diversity

coral communities occur. Coral communities in these three areas may be called coral reef communities, non-reefal communities, and outlying communities (Veron, 2000).

Although Japanese coral fauna has not been fully elucidated, ~380 species are estimated to occur in the Yaeyama Archipelago, ~340 in the Okinawa Islands, ~220 in the Amami Archipelago, ~150 in the area from Tanegashima Island to Shikoku Island, ~100 from Kyushu Island to the Kii Peninsula in middle Japan, and ~25-40 species in the Izu Peninsula and Tokyo Bay areas. Veron (2000) added ~35 species to the Japanese fauna. Including these species, the total number of Japanese corals may be estimated at ~415 species for coral reef areas (from the Yaeyama Archipelago to the Amami Archipelago), ~200 species for non-reefal communities (from Tanegashima to the Kii Peninsula), and ~55 species for outlying coral communities (from Izu Peninsula to Tokyo Bay).

This species richness may change, depending on future field studies in various areas or following future taxonomic reviews. At present, we may say that the Japanese coral fauna consists of ~415 scleractinian species belonging to 78 genera, plus ~10 species of three non-scleractinian genera. These figures show that despite their high latitudes, Japanese waters support a high diversity of coral fauna. Of 78 scleractinian genera, 28 are mono-specific, while nine genera include more than 10 species. The genus *Acropora* is most speciose (82 species), followed by *Montipora* (38), *Porites* (25), *Favia* (16) and *Fungia* (15).

Japanese corals show a distinct latitudinal pattern to their biogeographic distribution. Species richness is highest in the coral reef areas of the Ryukyu Islands, and it decreases in a northward direction. In the Ryukyu Islands, the southernmost Yaeyama Archipelago support the richest fauna. This observed high species richness may be attributed to their location and geography.

The Ryukyus consist of many islands scattered over a wide area, far from the mainland coast of China, and thus clear of turbid terrestrial waters. In the South and Middle Ryukyus, relatively large islands are found, with rivers and long, irregular coastlines that create diverse habitats in shallow coastal waters. Northward reductions in coral biodiversity occur through the gradual differential disappearance of low-latitude species, not by displacement of tropical fauna with subtropical and temperate coral species. The northward latitudinal decrease in coral species' richness through the Ryukyu Islands and along the Pacific coast of the Japanese mainland occurs in parallel with a negative gradient in surface sea water temperatures (upstream to downstream in the north-flowing Kuroshio Current). The Kuroshio Current is considered to be the most important factor producing the high species richness of Japanese coral fauna.

3 Characteristic corals

Wide-ranging distributions (from the Ryukyu Islands to the central Japanese mainland) are known for ~45 species of coral, while ~230 species are restricted to coral reef areas. *Acropora tanegashimensis* (Photo. 1) and four other species occur only in non-reefal temperate waters. About 130 species have been reported from non-reefal to coral reef areas, but are not known to occur in temperate outlying communities. *Alveopora japonica*, *Acropora japonica* and *Acropora pruinosa* have not been identified from coral reef areas.

Some species have interesting distributions, including discontinuous distributions in some wide-ranging species. *Catalaphyllia jardinei* (Photo. 2) is found in temperate Japan and tropical areas, yet it has not been identified around the Ryukyu Islands. *Porites heronensis* has been reported from Australian waters and the Japanese mainland, but not from the Ryukyu Islands.

Currently, corals thought to be endemic to Japan include *Euphyllia paraglabrescens* (Photo. 3), *Acropora tanegashimensis* (both endemic to Tanegashima Island) and *Porites okinawensis*. *Alveopora japonica* has been reported from the Japanese mainland and Korean waters, but not from the Ryukyu Islands.

Among those corals that have been reported as being restricted to Japanese waters are many species that have been identified in the more southern seas, such



Photo. 1. *Acropora tanegashimensis* (Tanegashima Is., Kagoshima).



Photo. 2. *Catalaphyllia jardinei* (Kushimoto, Wakayama).



Photo. 3. *Euphyllia paraglabrescens* (Tanegashima Is., Kagoshima).

as around the Philippines. *Boninastrea boninensis*, once thought to be endemic to the Ogasawara Islands, is now recognized as being widely distributed in the Philippines. *Leptoseris amitoriensis* (Photo. 4) has been regarded, in the past, as endemic to Iriomote Island, but is now known



Photo 4. *Leptoseris amitoriensis* (Photo by H. Yokochi, Iriomote Is., Okinawa).



Photo 5. *Goniopora cellulosa* (Tanegashima Is., Kagoshima).



Photo 6. *Goniastrea deformis* (Shirahama, Wakayama).

to be distributed across a wide range of locations to the south of Japan. In Philippine field surveys, Licuanan and Capilli (2003) found *Goniopora cellulosa* (Photo. 5), *Goniastrea deformis* (Photo. 6), and *Hydnophora bonsai*, which had all previously been reported only around the Amami Archipelago and northern non-reefal areas

of Japan. *Madracis kirbyi* had been reported from the Ogasawara Islands, but subsequently was also found in the Ryukyu Islands. It is likely that more range extensions will occur with further species identification in the Ryukyu Islands. As these examples illustrate, it is safe to say that other species will be added to the Japanese coral fauna inventory in the future.

4 Further studies

Japanese coral fauna has been clarified by a series of studies conducted at certain localities by Veron (1992, 2000) and by others, but further intensive fieldwork at other locations is needed if the area's biodiversity and biogeography are to be understood. For example, further detailed study has shown that *Madracis asanoi* does not harbor zooxanthellae; therefore, the species should not be listed amongst Japan's zooxanthellate coral fauna. In the Ryukyu Islands, unexpectedly abundant populations of *Heterocyathus aequicostatus* (Photo. 7) have been observed growing on soft bottoms at >10 m depth. Close examination of the reef flat off Iriomote Island revealed the world's smallest sessile colonial zooxanthellate coral, *Stylaraea punctata* (Photo. 8). In this way, future detailed studies are expected to add more species to the catalogue of Japanese fauna. In addition, future detailed taxonomic and systematic studies may change the rational treatment of species. Veron (2000) tentatively established many new species, or split single species in two.

Corals have been identified using traditional methodologies based on skeletal morphology, as well as by the morphological characteristics of their soft tissues, using ecological, behavioral, and reproductive features. Modern genetic approaches have also proved useful for species recognition and for gauging variations within and between local populations. Many species show discontinuous geographical distributions and/or local variations in key morphological characters. Comparative studies of corals between different habitats (coral reef areas and the Japanese mainland, or the Ryukyu Islands and other tropical coral reef areas) are likely to be productive in this regard.

Insufficient field studies have been conducted in the Ryukyu Islands, especially in the Miyako and Amami Archipelago. Particularly necessary are studies of *Acropora*, *Montipora*, and species that are difficult to identify. Field studies of coral communities off the

Japanese mainland have mostly concentrated on the Pacific coast. Extensive studies are needed in areas along the coast of the Sea of Japan. Information about this coral fauna is quite limited, but in terms of coral species, the coastline of the Sea of Japan appears less rich than that of the Pacific coast.

5 Importance of diversified habitat

Corals are vulnerable to various disturbance agents, and coral communities, especially in coral reef areas, have been seriously damaged. Coral communities may be degraded through mass predation, bleaching, and environmental destruction. Since the early 1970s, mass mortality of corals has been caused by intermittent outbreak populations of the crown-of-thorns starfish, *Acanthaster planci*. Outbreaks of this starfish remain a localized threat to coral communities. The 1998 mass bleaching events have so far been the most wide-ranging disturbance for corals and coral reefs in Japan. Red soil runoff, derived from erosion of terrestrial development sites, causes continuous environmental pollution. Many local coral communities have disappeared owing to nearby local construction work.

In many places, a drastic decrease in living coral coverage has occurred. While, in general, this trend continues, some places do show signs of recovery. There is no information about the number of species that have become locally extinct or vanished entirely from Japanese waters. Special attention should be focussed on rare species, those species that are restricted to a particular habitat, and species with low growth rates and/or low reproductive potential.

Diversified habitats occur repeatedly, due to the complex coastal and underwater geomorphology. Wave exposure and turbidity conditions change with other environmental gradients from the tip of a cape to a bay bottom, or from windward to leeward locations. Light and water movement vary with depth, and substrates may change from rocks to mud. All of these abiotic factors are important for coral distribution. For the long-lasting maintenance of coral diversity, it is important to maintain this variety of habitats in a healthy condition, free from pollution and mechanical disturbance. *Oulastrea crispata*, *Pseudosiderastrea tayamai*, *Heteropsammia cochlea*, *Heterocyathus aequicostatus*, *Diaseris distorta* (Photo. 9), and *D. fragilis* inhabit muddy or sandy



Photo. 7. *Heterocyathus aequicostatus* (Okinawa Is., Okinawa).



Photo. 8. *Stylaraea punctata* (Iriomote Is., Okinawa).



Photo. 9. *Diaseris distorta* (Okinawa Is., Okinawa).

bottoms. Minimization of environmental disturbance and legal protection of various habitats is important if the high diversity of Japanese coral fauna is to be saved. This is fundamental for the conservation of coral reef communities, as well as for that of the many organisms that are directly or indirectly dependent on corals and coral communities.