A Preliminary Investigation of the Coral Reef at the Southern Coast of Ishigaki Island, Ryukyus

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The authors studied the zonation of the living corals on a fringing reef at Ōhama, the southern coast of Ishigaki Island, Yaeyama Group, Ryūkyūs. The purpose of this investigation was to obtain the relation of the coral zonation to the reef morphology in the reef flats. Genus or/and species, life form, colony size and coverage of corals were examined in quadrat method (a rectangle of 1.0×1.5 m^2) at intervals of 5 m or 10 m along a section established perpendicular to shore line, almost regardless of morphology. For the taxonomy of corals, the authors referred to papers of Eguchi (1934), Wells (1954 and 1956) or Vaughan and Wells (1943).

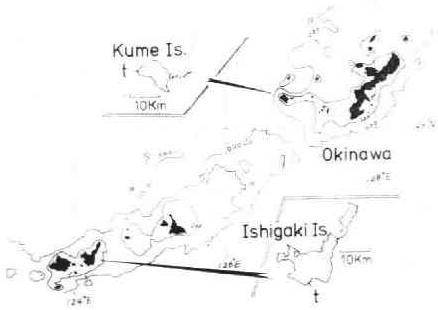

Fig. 1 Index map of the study area

There are many ecological studies on the coral reefs of Ryūkyū Islands (*e.g.* Hirata *et al.* 1971, Yamazato *et al.* 1974 and 1976 or Horikosni *et al.* 1974). Nevertheless, this report must be valuable, because there are few investigations on the coral zonation corresponding to the minute coral reef morphology.

In this report some results of this survey are discussed and compared with the coral zonation of the emerged Holocene reefs at the western coast of Kume Island, Okinawa Group, Ryūkyūs, on which the authors examined in 1977.

1 Coral reef morphology

Ishigaki Island locates from 120°04′E to 124°20′E and from 24°20′E to 24° 37′N, lying about 400 km west-southwest of Naha in Okinawa Island, and it is

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surrounded with coral reefs. The study reef, near 124°12E and 24°20'N, is a fringing reef with a moat less than 2 m in depth and about 600 m in width, which, therefore, is called pseudo-barrier.

The profile from barrier to coast may be morphologically divided into reef crest moat, sea-level platform, high tide platform, wave cut ramp and sand dune (Fig. 2). There are many coral pinnacles in the moat. The reef crest and the bottom of the moat are constructed with Holocene coral limestone and living corals. The landward part of the moat bottom, the sealevel platform, the high tide platform and the wave cut ramp are composed with Pleistocene coral limestone primarily of nodular coralline algae (Ryūkyū Limestone) and their surfaces are marine erosional.

All the tops of the reef crest, the sea-level platform and the coral pinnacles nearly accord with mean sea level, but a few parts of the reef crest are slightly higher than mean sea level. This fact is very significant in discussing the relation of the sea level to the reef formation. On Amami Islands there are only few coral reefs that have grown up to the mean sea level.

In the moat are frequently observed micro-atolls on the top of some coral pinnacles which consist mainly of the colonies of massive or foliaceous corals, such as *Porites* or *Pavona*. At the time of relatively lower sea level, living corals on the top of a pinnacle decay or die, while ones on its flank spread out. The latter grows upward at the time of relatively higher sea level. In this way the growth zone of a pinnacle forms a ring. By the repetition of such growth a micro-atoll is formed.

The high tide platform is grown by patches of *Septifer* (*Mytilisepta*) *virgatus* (Wiegmann).

The landward limit of *Limonium Wrightii* O. Kunze on the top of the high tide platform corresponds to the shore line at mean high tide.

In comparison with the smooth surface of sea-level platform, the surface of high tide platform is very rough and serrated, and a small nip or slight knick point is seen between both platform surfaces. Such appearances show that high tide platform is in the process of destruction, and a former sea level may be estimated by the level of the top of this platform. Up-rush slope or wave cut ramp at the rear of high tide platform is covered with coral fragments, and on it there are small shrubberies in places. It is an emerged surface too. Its coral fragments consist primarily of massive *Cyphastrea*, foliaceous *Pavona* or branching *Montipora*. They coincide in sort with corals in the moat.

At the back of the wave cut ramp there is a small sand dune covering a low Pleistocene terrace.

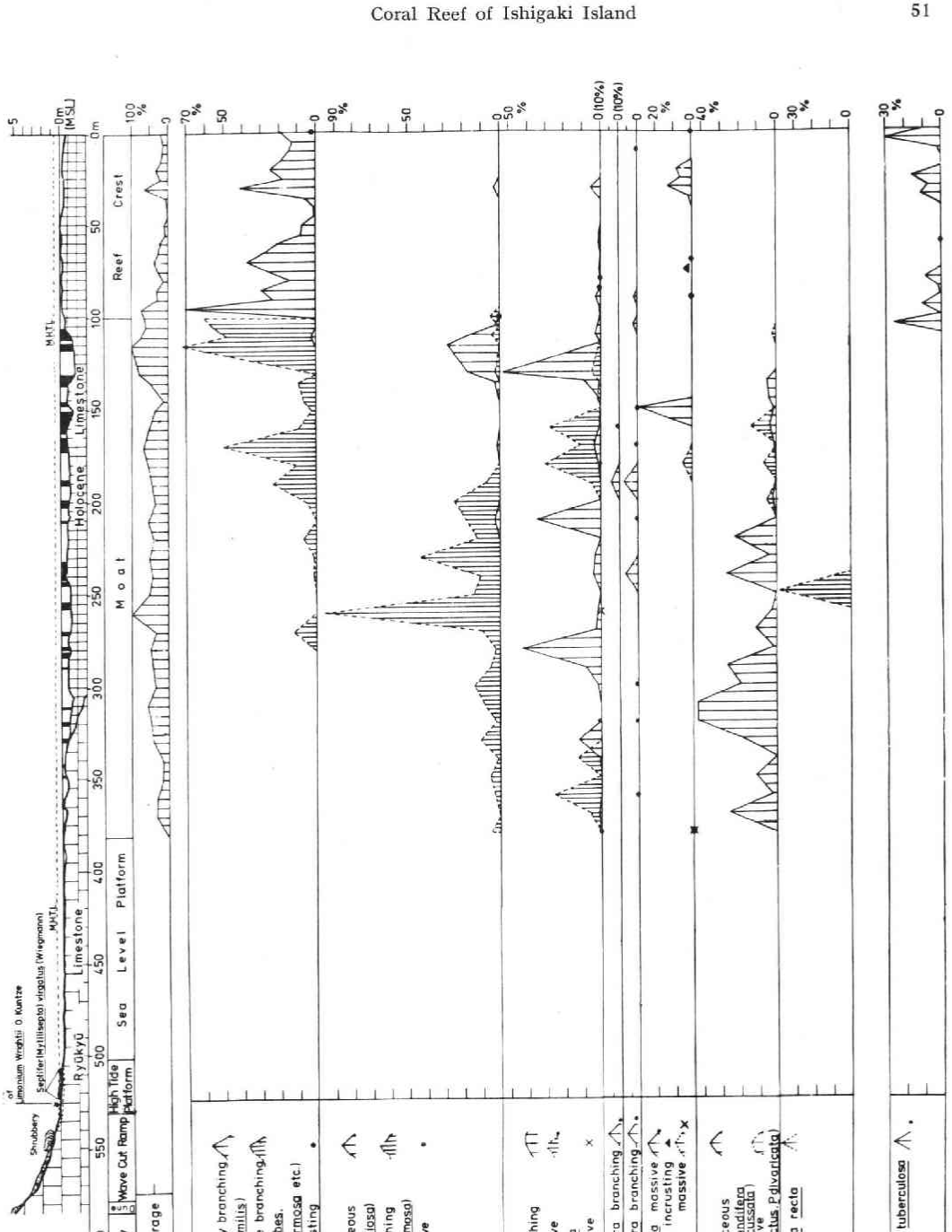

Fig. 2 Coral reef morphology and coral zonation at Ōhama, southern coast of Ishigaki Island.
This figure represents a genus or life form list of the transect corals and a summary of their abundance, distribution, and pattern.
The abundance of Scleractinian corals and Zoanthidea are plotted with percentage as a function of distance from the barrier.

2 Coral zonation

The coral coverage and the coral zonation along a section are shown in Fig. 2. Living corals occur on the reef seaward from 380 m point. A few corals are seen on its landward slope, but many corals live in the moat and unroundish coral fragments are scattered here and there. Corals grow most vigorously and densely at coral pinnacles in the moat.

Lithothamnion sp. is distributed from 75 m point to 300 m. *Marginopora vertebralis* Q. et G. inhabits in heap from 200 m point to 300 m. On the sea-level platform, living corals are not seen and seaweeds cover them in places.

Corals on this transect are *Acropora, Montipora, Porites, Goniopora, Seriatopora, Pocillopora, Goniastrea, Favia, Favites, Pavona* or *Symphyllia* in genus, and they are classified into stubby branching type, fragile branching type, incrusting type, massive type or foliaceous type in life form.

Near the transect, in addition, *Cyphastrea microphthalma, Leptoria phyrgia, Fungia scutaria, Millepora* sp. and *Stylophora pistillata* are seen. Yamazato *et al.* (in Horikoshi *et al.* 1974) described *Anacropora* in Kabira bay of this island. This coral was not found in the coral sea of Ryūkyū Islands till their description.

The coral zonation of this reef is characterized as follows:

(1) *Seriatopora, Stylophora, Pocillopora* and other smaller corals are commonly distributed throughout the moat but they can't stand a high rank because of their small size and their tendency to settle separately each other.

On the contrary, the distributions of *Acorpora, Montipora,* and *Pavona* are generally limited to each peculiar zone, because of their tendency to aggregate in the mode of thickets. The abundance of the latter is much larger than the former's as shown in Fig. 2.

(2) Each genus has each peculiar pattern of the distribution in life form. Namely, it is recognized that a regional differentiation in species corresponds to the coral reef morphology. On *Acropora,* stubby branching and incrusting species (*A. humilis* etc.) are observed on the reef crest, and fragile branching species (*A. hebes, A. formosa* etc.) are distributed in the moat. On *Montipora,* foliaceous species (*M. foliosa*) and massive species are seen at the seaward part of the moat and there are branching species (*M. ramosa*) at its landward part. On *Pavona,* massive species (*P. cactus* and *P. divaricata*) are seen at the seaward half of the moat, and foliaceous species (*P. frondifera* and *P. decussata*) are distributed at the landward half of the moat.

(3) The most principal species on the reef crest is stubby branching *Acropora* (*A. humilis*). *Palythoa tuberculosa* (Esper), although not Scleractinian coral but Zoanthidea, is distributed only in the reef crest.

(4) The moat is divided into two zones: a seaward zone near the reef crest and

a landward zone. The former is the zone of fragile branching *Acropora* and the-latter is the zone of foliaceous *Pavona* and branching *Montipora*.

(5) *Porites* lives in the whole moat.

3 Comparison with the coral zonation at the western coast of Kume Island

The authors (1977) studied the coral zonation of an emerged reef flat at the western coast (locating 126°43'E and 26°22'N) of Kume Island, Ryūkyūs. Its coral reef had been formed at the age of a higher sea level than the present level. By applying the radiocarbon age of a coral collected at a neighboring coast (Ōshiro and Takayasu 1977), the age of this higher sea level was estimated about 4000 years ago, while Konishi *et al.* (1974) obtained 2100±300 yr BP from the Holocene raised coral reef limestone at an elevation of 5 m above mean low tide off Kitahara by the Th–230 growth method. It is obscure whether the difference of these dates shows the formative period or occurs from each dating method.

In comparison of two cases at the southern Ishigaki Island and at the western Kume Island, some similar features are recognized on the coral zonation. Similar regional differentiation in species or in life form corresponding to coral reef morphology is recognized at both. At both reef crests, stubby branching *Acropora* is excellent and *Goniastrea* is seen. Tabular *Acropora* and *Cyphastrea* which are distributed at the crest of the western Kume Island are not seen at the top of the reef crest of the southern Ishigaki Island. However, at the present study the authors could not enough observed the seaward slope of the reef crest. The moat of the western Kume Island is the zone of fragile branching *Acropora*, and there were very few *Montipora ramosa*, *Pavona frondifera* and *Pavona decussata* which are prevalent in the moat of Ishigaki transect.

4 Summary

The relation of the coral zonation to the coral reef morphology at Ōhama, the southern coast of Ishigaki Island, are summarized as follows:

(1) This reef consists of reef crest, most with many coral pinnacles, sea-level platform, high tide platform.

(2) All the tops of the reef crest, the coral pinnacles in the moat and the sea-level platform nearly accord with mean sea level.

(3) It is recognized that a regional differentiation of corals in species or in life form corresponds to the coral reef morphology.

(4) The most principal species on the reef crest is stubby branching *Acropora*.

(5) The moat is characterized into two zones: a seaward zone of fragile

branching *Acropora* and a landward zone of foliaceous *Pavona* and branching *Montipora*.

(6) In comparison of the present study with the case of an emerged reef at the western coast of Kume Island, some similar features on the coral zonation are observed. While Kume Island has the Holocene emerged coral reef around an elevation of 2 m above mean sea level, Ishigaki Island holds its equivalent at mean sea level and lower.

Our present study is limited only to one profile. Accordingly, further investigation on many cases and various areas should be expected. However, such a survey about the coral zonation at the front of a barrier and the bottom of a moat invites more troublesome, harder physical work. And so it is necessary to facilitate the research method for a future study. The method used in this study was very incomplete from the view point of statistical ecology. So on the base of this preliminary study the authors intend to study the coral zonation by reasonable methods in the near future. In general, the coral diversity values at the flank of a coral pinnacle are higher than its top. And few corals and a great deal of bioclastics occupy the moat bottom among coral pinnacles. A coral pinnacle must be recognized as a unit when the coral zonation is examined.

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Photo 1 Ōhama coast chosen for the field study. The reef crest and the pinnacles in the moat are recognized in the sea. The shorter the distance from the reef crest gets, the higher the density of pinnacles becomes.

Photo 2 A quadrat of 1×1.5 m^2 placed on the landward part of the reef crest at low tide time. Green or light brown *Acropora humilis* (Dana) and light yellow *Palythoa tuberculosa* (Esper) occur here.

Photo 3 *Acropora humilis* (Dana) on the landward part of the reef crest.

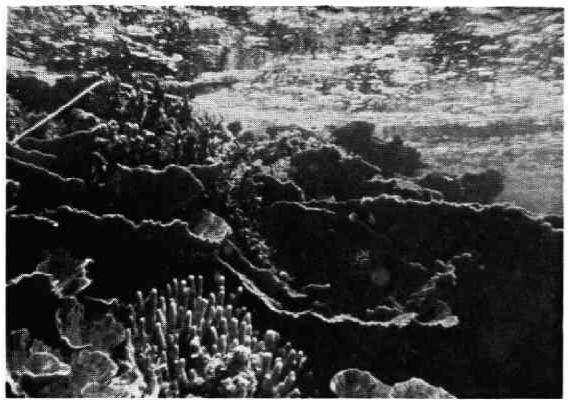

Photo 4 *Monitpora foliosa* (Pallas) and ramose *Porites* behind the reef crest. *Montipora foliosa* looks like cabbage.

Photo 5 *Acropora arbuscula* (Dana) ? The color of these colonies is tan.

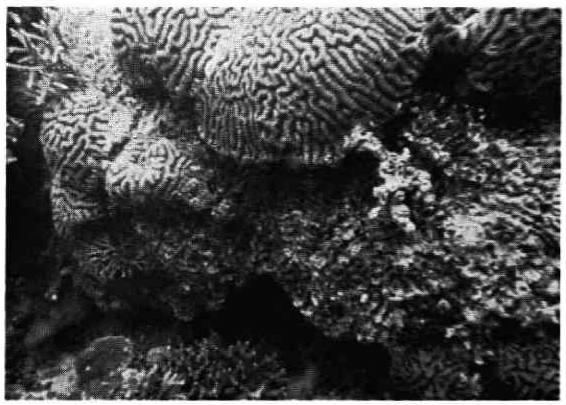

Photo 6 *Symphyllia recta* (Dana). These colonies are light brown. This pinnacle is composed primarily of these brain corals. In the left flank *Seriatopora hystrix* Dana shows an spray-like colony. This color is orange.

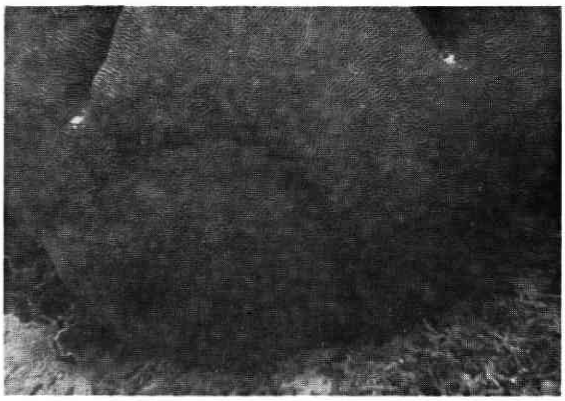

Photo 7 *Leptoria phrygia* (Ellis et Solander). The color of this colony is light brown. This colony builds up a micro-atoll by itself.

Photo 8 In the middle part *Cyphastrea* sp. is seen.

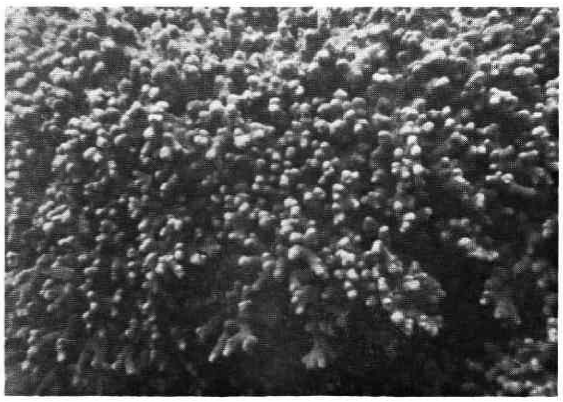

Photo 9 Ramose *Porites* pinnacle.

Photo 10 *Montipora ramosa* Bernard bush.

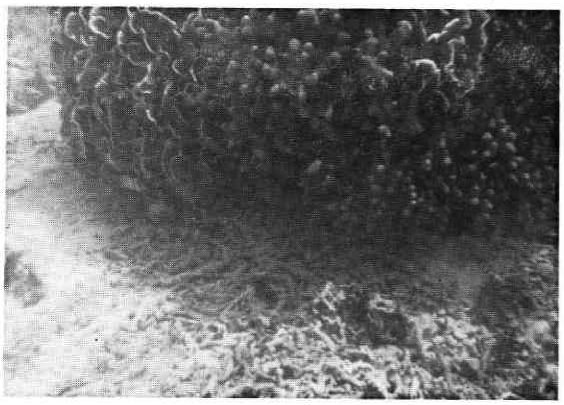

Photo 11 The colonies of the left side are foliaceous *Pavona*, the ones of the center are yellow ramose *Porites*, and the ones of the right are grey ramose *Porites*. These colonies make up the coral pinnacle with a micro-atoll. On the bottom of the moat many coral fragments and other bioclastics are deposited with less than 1 m thick.

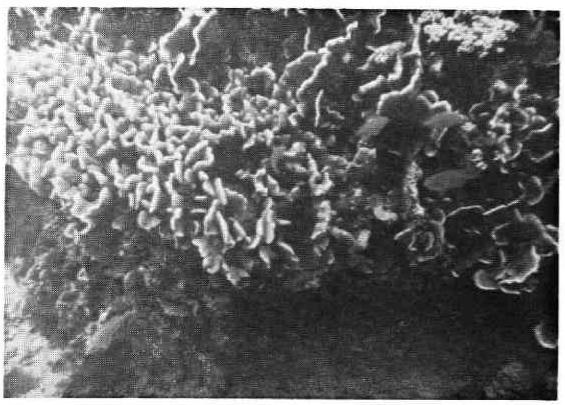

Photo 12 This coral pinnacle consists mainly of *Pavona decussata* Dana, *Pavona frondifera* Lamarck.

Photo 13 Similar to photos 1, 2, and 3, this photograph was taken from above the water. These micro-atolls are composed of *Pavona*, *Porites*, or other brain and ramose colonies.

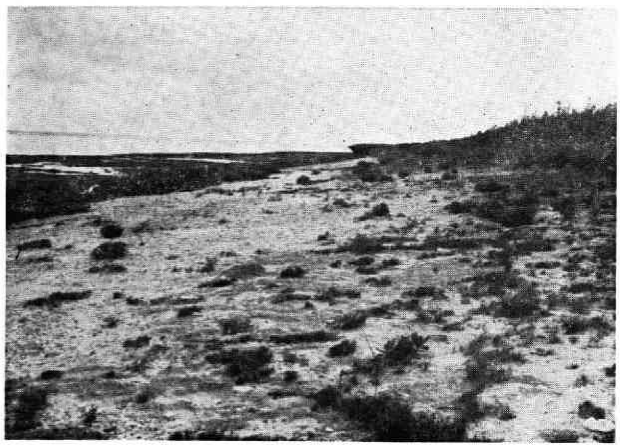

Photo 14 Sea-level and high tide platforms are seen in the left background. Wave cut ramp (Pleistocene coral limestone composed primarily of nodular coralline algae) is shown in the center. Dune covering Pleistocene terrace lies in the right background.

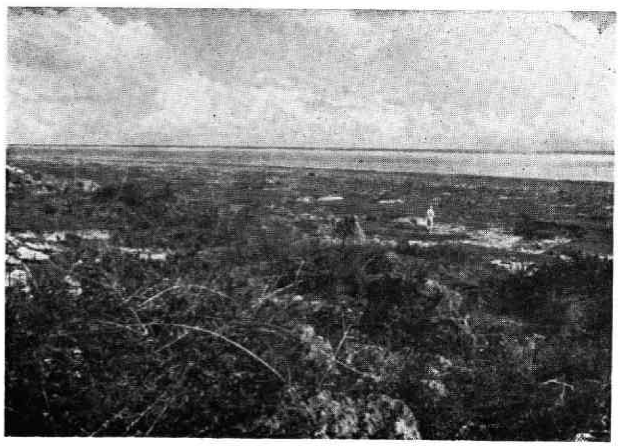

Photo 15 The landscape of the study area from the dune. The long barrier runs near the horizon.