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The tropical coral reef as a biotope

by

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The tropical coral reef as a biotope

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On few marine habitats is there such a voluminous literature as on tropical coral reefs. However, most studies have been concerned with very well defined problems, primarily with the laws of growth of reefs and with theories which explain the origin of coral reefs and coral islands through the combination of biological and geological factors.

Only recently has there been concern with detailed studies of the living habits of coral polyps, of their nutrition, and of their dependence on different environmental conditions. Similarly, the various ecological zones of which the coral reef is composed have only been clearly defined in recent times and confirmed through faunistic studies. Here may be cited the works on fishes of a Pacific atoll by Harry (1953) and on the mollusks by Morrison (1954), works which confirm the validity of the reef zones distinguished by Tracey, Cloud and Emery (1955).

In contrast, for other groups of animals, the only statements at our disposal are those found scattered in the systematic and faunistic literature, together with the individual observations of various naturalists. No comprehensive summary seems to have been made as yet. Until recently, literally nothing was known about the microfauna of tropical coral reefs; indeed, it was not even known whether a microfauna could find the appropriate conditions essential for life in the environment of the coral reef.

I had the opportunity to study coral reefs in the Red Sea and the Maldivé Archipelago (Indian Ocean) during the "Xarifa-Expedition 1957/1958."^{1/} Moreover the microfauna was the focus of the research; thirty samples from coral biotopes were collected in the Red Sea and 84 samples in the Maldives. The systematic study, by various specialists, of the assembled material has not yet been completed; therefore, a complete faunal list cannot be presented, and the following remarks must be considered as preliminary results, and they will have to be completed and enlarged after the conclusion of the systematic studies.

In the Maldivé Archipelago the reefs and coral islands are always assembled in atolls and, like a string of pearls, enclose a lagoon 40-60 m. in depth. Channels cross the reef at many places and link the lagoon with the open sea. In addition, small reefs, which grow up from the lagoon floor without having any connection with the encircling reef, are found in many places.

^{1/} At this point I would like to thank Dr. Hans Hass, as whose guest I was able to work for seven months on the ship "Xarifa".

One must, therefore, distinguish between outer reef and lagoon reef. The outer reef is exposed to the breakers of the open ocean. A steep slope reaches up from the depths of the sea to a ledge, five to ten meters below the surface, which extends landwards as a reef terrace. Then the reef rises up to low tide level and there forms a characteristic zone under the influence of the heavy surf. Here calcareous algae of the group of Lithothamnion find especially favorable living conditions, coating the coral that grows there with a crimson red layer and also forming reef limestone themselves. From this Lithothamnion-zone a flat reef platform extends landward, situated just below low tide level and overgrown with small corals of various species, with alcyonarians, zoantharians and algae. Helipora is also found here at low tide level.

The conditions described above were encountered on the reef of Hitadu Island, Addu Atoll, Maldives. In front of some other atoll islets, such a reef flat is lacking, but there is either a zone of sand stretching between the islet shore and the reef, or a zone of detached coral boulders.

A zone of sand separates the lagoon shore from the lagoon reef. The lagoon reef itself rises in pinnacles just to low tide level and is composed of many different species of corals. Here especially are found the branching, brittle forms.

Thus we can distinguish between different reef zones, which are characterized by different water depths and different influences from wave action. The analysis of the microfauna--as far as carried out--shows, however, only surprisingly insignificant variation between the individual reef zones: Exposed outer reef, protected lagoon reef, and the blocks of coral growing at depths of 10-30 m. exhibit a very closely similar fauna. Among the free-living nematodes a few species can be found which particularly prefer the flat coral biotope lying near low tide level; and it is likely that additional species with more specialized requirements will be found when the systematic study of the other groups is also completed, but the uniform character of the coral fauna is so striking, that individual differentiations can only play a subordinate role.

Such an ecological situation is in contrast with the conditions on sandy and soft sea bottoms, where both the force of the water movement and related with it the particle-size distribution and nature of the sediments, and the depth of water, have a great influence on the microfauna, so that one hardly expects to find any common species among the representatives of the microfaunas of an exposed beach and the sea bottom of a protected bay.

On the contrary, all of the coral zones investigated are inhabited by quite a uniform microfauna, and separation into particular biocoenoses does not appear justified, at least not now, because special character species which could identify the particular zones are lacking.

We shall now attempt to compare the microfauna of the coral heads with the fauna of other marine environments, since the considerable uniformity between coral fauna and "phytalfauna", the fauna which inhabits algae, hydroid colonies, and bryozoan colonies, is striking.

Thirty-six species of free-living marine nematodes were found on coral heads in the Red Sea (Gerlach, 1958). Of these, four species were new to science; most of the remainder had been collected previously by other authors in the Mediterranean Sea, Red Sea or Indian Ocean, and there among algae. The study of the nematode fauna of coral samples from the Maldives is leading to similar results, and Herr Dr. G. Hartmann (of Hamburg; oral communication), who is studying the ostracods of my collection, has come to the same conclusion.

On the lagoon reef of Welingandu Island, Rasdu Atoll, Maldives, I had the opportunity to make a series of 18 samples of the different species of corals occurring there, for their microfauna. This demonstrated again that the free-living marine nematode fauna shows no variation--is entirely the same--whether it inhabits branching corals such as Stylophora, Pocillopora and Psammocora or massive, globular heads such as Porites, Favites, and Leptoria. Further, it also showed that the same nematode fauna occurs on corals which have died off and on which a crust of calcareous algae and other forms has developed. And finally, samples from Alcyonaria and the calcareous green alga Halimeda are not different from samples collected from living coral.

Only quantitative differences can be established, and these are closely related to the capacity of the coral polyps to secrete mucus. Upon irritation, the epidermis of the coral polyp secretes mucus, in which foreign objects fallen on the surface and small organisms become entangled; they are, together with the mucus, carried by ciliary movement to the edge of the coral head, and they fall to the bottom. There are corals, mainly those of the genus Acropora, which secrete mucus in great quantities. The sparsest microfauna is found on the heads of this species, and I have studied a series of Acropora samples usually without finding any associated fauna. In contrast, the richly populated corals such as Seriatopora, Pocillopora and Stylophora produce a distinctly smaller amount of mucus. Beyond this, whether this may also depend on the possibly different efficiency of the nematocysts of the corals is not yet known.

Therefore, I would characterize the nematode fauna, and probably the entire microfauna of coral heads as "phytal fauna" and include the coral reef among the "phytal" biocoenoses. The population density is great on dead corals which are overgrown with algae; in contrast, on living corals it is generally smaller. The coral reef thus represents an environment which apparently provides less favorable living conditions for the microfauna than does an abundant growth of red algae.

Of course, as stated above, the systematic work on the collected material is not yet completed, and it is possible that in the other animal groups of the microfauna, representatives will be found which are typical of the coral reef and do not occur in algal zones. An as yet unidentified aberrant copepod with a wormlike body, which apparently lives only on coral, mainly Pocillopora, certainly belongs here. These animals could be observed as they crawled about on the surface of the coral and slashed at the tissues of the polyps with the sharp claws of the first pair of legs. Here the point to be considered is that this is a form which has become particularly adapted to a mode of life

parasitic on coral. /Dr. Gerlach has kindly informed me in a letter that since publication of the original report, this form has been described by A. G. Humes (Kieler Meeresforsch., 16: 229-235, 1960) as a member of the new genus Xarifa of the new family Xarifiidae.--AJK/

No relations could be found with the fauna of the interstices of the sand. To be sure we found Ingolfiella litoralis Hansen, a slender isopod 2 mm in length, of which only a single specimen was previously known from coral from the Gulf of Siam. Ingolfiella ruffoi Siewing lives in coastal ground water, other species live in fresh ground water in the Balkan region, that means also in the interstices of the sand, but the conclusion that the representatives of the genus Ingolfiella could be considered as typical members of the interstitial fauna cannot yet be drawn, because one species, Ingolfiella bathybia Hansen, is known from soft sediments of the deep sea. The individual species of the genus therefore differ greatly with regard to ecology.

The macrofauna living on coral reefs in the Maldives may be divided into four groups according to the mode of feeding:

I. Suspension feeders are the group most abundant on living coral heads. Some of these animals, insofar as they feed on zooplankton, represent direct competition for food with the corals; others, mainly pelecypods and sponges, feed on phytoplankton and fine seston, which are not utilized by the corals.

Specialized adaptations to the existing environmental conditions are found among the forms which prefer to occupy the living part of the coral head. Thus, here are found not only the true boring forms, such as the boring mussel, Lithodomus, but also bivalves, including oysters, gastropods (Leptoconchus, /Dr. Gerlach has kindly informed me in a letter that the original identification was in error and that the form has since been identified as Magilopsis lamarcki Deshayes by Dr. R. T. Abbott, Academy of Natural Sciences of Philadelphia.--AJK/ Vermetus), barnacles (Pyrgoma), and decapod crustacea (Hapalocarcinus, Cryptochirus), which allow themselves to be surrounded by the growing coral and thus gain protection from predators.

Sessile animals, which also occur in hard bottom communities, colonize the dead base of the coral head: alcyonarians (Lobophytum, Sinularia, Cespitularia), zoantharians (Palythoa), sponges, tunicates, and bryozoans.

II. Detritus feeders and small predators occur, but are not excessively abundant in comparison with their numbers in algal zones and benthic communities. Detritus occurs on the coral reef only in relatively small amounts. Where the bottom is not covered with coral, small areas of pure calcareous sand are found. The floor of the atoll lagoon, under 30-40 m of water, is covered with calcareous sand which is also comparatively poor in organic debris. Only on the dead bases of the corals is there an algal growth worthy of mention as a food source for the microfauna. Representatives of the microfauna are mainly copepods, amphipods, isopods, tanaidaceans, ostracods, polychaetes, and nematodes.

To the group of detritus feeders and small predators belong a few brachyuran crabs and a few shrimps, which regularly live among the branches of the branching corals. Grazing gastropods are not common. An as yet unidentified holothurian sweeps with its tentacles the surface of all the dead coral heads. Serpent stars also occur regularly and are to be placed in this group of detritus feeders and small predators.

A number of coral fishes seek their food among the coral heads. Some are specialists, with elongate, pincer-like snouts, such as, according to the identifications by Herr Dr. Klausewitz (of Frankfurt), Forcipiger, Gomphosus, and Oxymonacanthus, and in addition many chaetodontids, acanthuriids, and pomacentrids. Living directly in the coral heads are small fishes of the genera Gobiodon and Caracanthus. Chromis and Dascyllus, in contrast, use the branched corals as habitat and refuge, but seek their food in the plankton above the coral heads.

III. Predators have the smallest food sources on the coral heads and correspondingly are not abundant. Among the crustaceans, stomatopods and alpheidids may be listed here, as well as predatory gastropods, polychaetes, and sea stars.

Whether nudibranchs and pycnogonids feed directly on the tissues of the coral polyps has not yet been determined. This could be observed in the case of one aberrant copepod Xarifa.

IV. Finally, fishes of the genus Kyphosus and above all parrot fishes (Scaridae) must be mentioned as the last group. With their strong jaws they bite off entire pieces of coral colonies and swallow with them the fauna living on them.

If we now ask which animals of the macrofauna stand in close ecological relation with the living coral reef as environment, an obvious case is that of the parrot fishes, which feed on pieces of coral, and that of those suspension feeders which let themselves become enclosed by the coral. To what extent the numerous "coral fishes" are adapted to the particular environmental conditions of the reef, or whether they also occur in comparable places where coral does not form the biotope, still remains open. The crabs of the genus Trapezia appear to prefer the coral biotope; whether this also is true of the other invertebrates found on the reef remains to be tested.

The aim of this investigation was to determine the place of the tropical coral reefs in the framework of marine environments. The opinion of Stephenson (1958) that the coral reef corresponds to the sublittoral algal region in the temperate zone was confirmed. The investigation of the microfauna shows especially that the coral reef can be included among the "phytal" environments. The common elements in the fauna of the coral reef and in algal regions are many, by contrast the forms especially adapted to life in close relation with corals are few, and it would not be quite justified to contrast at the same level the coral reef with the benthic and phytal biotopes.

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