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THE PRESENCE OF SCLERACTINIAN CORALS AND THEIR MEANS OF ADAPTING TO A MUDDY ENVIRONMENT : THE "GAIL BANK"

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ABSTRACT

Some forty species of scleractinian corals live in a particular, very muddy, environment situated in the south-western lagoon of New Caledonia between 25 and 30 metres' depth.
The seabed is caracterised by the topography of ridges valleys and bumps and appears to be formed of accumulated mollusc shells, scleractinian skeletons and fine particles. The presence on the soft bottom of these various hard substrata allows the scleractinian larvae to establish themselves. In order to survive, these corals have developed various growth strategies which are designed to offset some unfavourable factors such as hypersedimentation and the species' sinking they become heavier as they grow. The majority of the corals found on this site are species with well-developed polyps that are able to reject sedimentary particles. The other species survive by growing, probably very rapidly, vertically or horizontally, or else by increasing their area of contact with the sediment, accompanied by an abundant secretion of mucus.
Lastly, a few species are present because they have found a hard support that is raised higher than the surrounding bottom.

GEOMORPHOLOGICAL DESCRIPTION

The "Gail bank" (1) is a very muddy zone of the south-western lagoon of New Caledonia. Its originality lies in the fact that its specific feature is the presence of relatively well-developed coral communities that have adapted themselves in unusual ways to this unfavourable environment. It is situated between latitudes 22°20' and 22°25' South and longitudes 166°35' and 166°45' East. Its boundary on the North and North-East are the inshore water of three bays into which the "Pirogues", "Plum", "la Coulée", and "N'Go" rivers flow: these rivers, and particularly the "Pirogues" river, carry lateritic material which is deposited in the lagoon (figure 1). To the West and South-West, the "Gail bank" extends as far as the coral cays "Kae", "Nakae" and "Tarety". Average depth is 30m. The bottom relief comprises three types of structure (figure 2) :

- a succession of ridges and valleys following no precise direction, between which there are differences of level of 2 to 4 metres (about 70% of the area),
- small hills with gentle slopes, reaching 6 to 10m in height (about 20% of the area),
- flat zones (about 10% of the area).

The origin of this relief is not known. In an endeavour to ascertain it, a cut about 1m deep was made in the side of a hill, near the summit, using a suction sampler (figure 3). The material thus extracted was composed, in volume, of the following : 50% oyster shells, 25% scleractinian coral skeletons , 25% various types of coarse and some fine particles. Furthermore, it is clear that the sessile life is concentrated on the highest parts of the ridges and hills ; it includes algae (Chlorophyceae), sponges, Actiniaria, Scleractinia with modified growth forms, Alcyonaria, a few Gorgonacea, worms, molluscs (mostly Isognomon and Crassostrea oysters) and Ascidia. Among the scleractinian corals fluorescent specimens are much more numerous here than anywhere else (Catala, 1958, 1964; Magnier 1979).
In the present stage of our knowledge, to which it is hoped to add soon (1), the following hypothesis regarding the origin of these formations may be generated. The ridges could be progressive accumulations of coral structures that first settled on the hard substratum formed by oyster shells, although the speed of growth of the corals would have been barely rapid enough to offset the sedimentation and sinking into the sediment. The ridges and the hills might be the result of successive accumulations of communities of bivalves in clusters, while the valleys and the flat parts would represent areas where the communities were less dense.

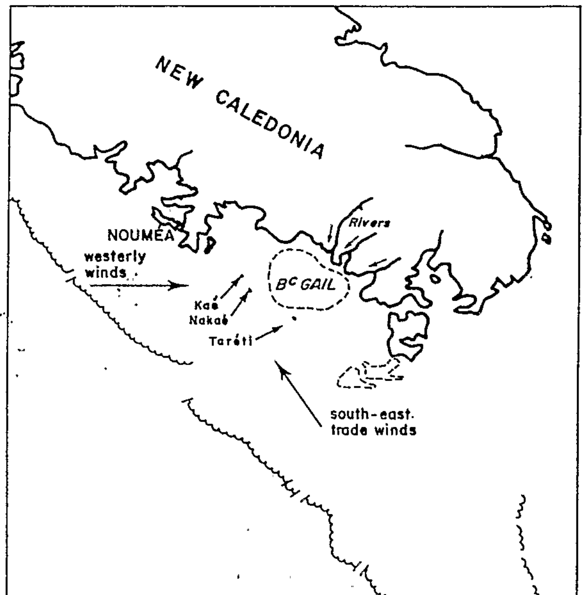

Fig.1 : Location of "Banc Gail" in the south-west lagoon of New Caledonia.

(1) This bank has been dedicated to René GAIL, an ORSTOM marine biologist who lost his life while diving.

(1) There is a project for making digging 3 m deep.

ADAPTATION OF SCLERACTINIAN CORALS TO A MUDDY ENVIRONMENT

Light is an essential factor to coral growth. Despite surface layers of brackish water, hypersedimentation and temporary turbidity on the bottom resulting from heavy rainfall, the light intensity is always sufficient to allow normal calcification. Indeed, at the height of the rainy season, on 28 March 1988 at 11.0 a.m., when the sky was quite clear, the Secchi disk's disappearance was recorded at - 19 m., despite all the unfavourable factors mentioned above.

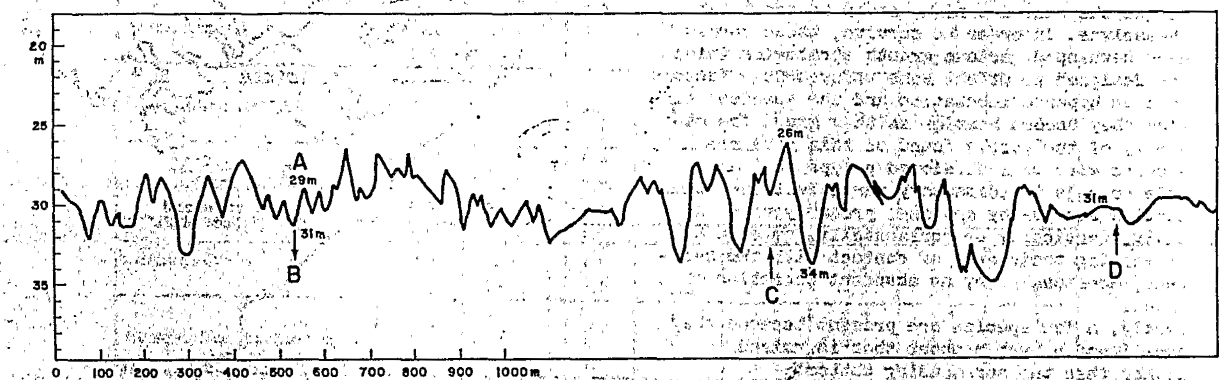

Fig.2 : "Banc Gail" seabed mapping : A = ridge, B = valley, C = small hill, D = flat zones

The following day, when the layer of brackish water had dispersed, the Secchi disk disappeared at -25m. Joannot (1983) quotes figures ranging between 12 and 18 m for the depth at which the Secchi disk's disappearance was recorded at the same site. The fluctuation of the different surface layers is explained by the strong winds prevailling in the area : south-east trade winds and seasonal winds from the west which can give rise to waves with two metres amplitudes. The currents also play an important role in dispersing these surface layers of water. However, despite the amplitude of the waves, they have no effect on the bottom 30m below, where only tidal currents, which do not exceed one knot, are recorded. The presence of algae such as Caulerpa and Halimeda confirms that the light intensity is sufficient for hermatypic corals. As regards hypersedimentation, Joannot (1983) measured the seston weight in $g.m^{-2}$. day^{-1} and gives figures ranging between 11 and 18 g.

The fact that there is relatively good penetration of light thus enables many hermatypic corals to live here. The present record shows some forty different species. However there are two other requirements that must be met if they are to become established and to grow. First, a hard substratum is necessary for most species towards the end of the larval stage. We have indicated above that such substrata are abundant, in the form of oyster shells (Isognomon and Crassostrea) and coral rubble. About 25% of the corals collected show primary supports formed of oyster shells (figure 4). Many oysters subsequently establish themselves on these corals. The other scleractinian are found established on coral rubble derived from other species of madrepore (figure 5), or sometimes belonging to the same spectacular effects of building in stacks (figure 6). Some free species need no hard support (Trachyphyllia geoffroyi, Catalaphyllia jardinei, Cynarina lacrymalis, Fungia sp., Diaseris distorta). The second requirement is that each of the species present has had to develop an individual strategy to counteract both subsidence in the mud and hypersedimentation.

SCLERACTINIAN CORAL ADAPTATIVE STRATEGIES

(a) Most of the species present on this site have very well-developed polyps capable of removing any sediment received : Goniopora, Euphyllia, Catalaphyllia, Plerogyra, Caulastrea, Blastomussa, Cynarina, Trachyphyllia, Fungia, Scolymia, Lobophyllia (figure 7).

(b) Some of the species seem to have very rapid growth, and thus form colonies in successive layers. Sometimes more than twenty layers can be seen underneath the living part of the colony (Porites, Cyphastrea, Favidae).

(c) Yet others grow horizontally, forming a thin plate of large surface area just above the sediment, which has the effect of preventing colonies' sinking into the sediment. On the other hand, horizontal growth has the drawback of exposing the colonies to a maximum of sedimentary particles. To protect themselves, certain species produce an abundant secretion of mucus, which cleans the colonies (Mycedium, Favidae) (figure 8). Others, after initial horizontal growth, construct colonies in the form of a rising bowl (Pachyseris, Leptoseris). The sediments accumulate in the bottom of the bowl, while growth continues round the rim (figure 9). But sometimes the flat colonies are simply tilted. These colonies seem to "tolerate" the burial of one edges of their; growth then continues on the opposite side (Pachyseris, Montipora) (figure 10).

(d) Some Favidae with the usual solid, round shape grow here by constantly enlarging the surface of the upper living part, thus acquiring a very wide-spread cone shape which slows burial into the sediment (figure 11).

(e) Leptoseris gardineri grows vertically and forms thin strips more or less sloping downward so that the sedimentary slides off. The Acropora (3 species) develop, as elsewhere, both vertically and horizontally. A large proportion of the particles passes between their branches, the remainder being cleaned off by their polyps.

(f) Scolymia vitiensis grows to lengths of 30 to 40 cm, of which only the living part, one to two cm thick, emerges from the mud. Growth continues above the sediment as the rest of the colony is buried.

Fig. 3 - Underlying substratum of dead oyster shells.

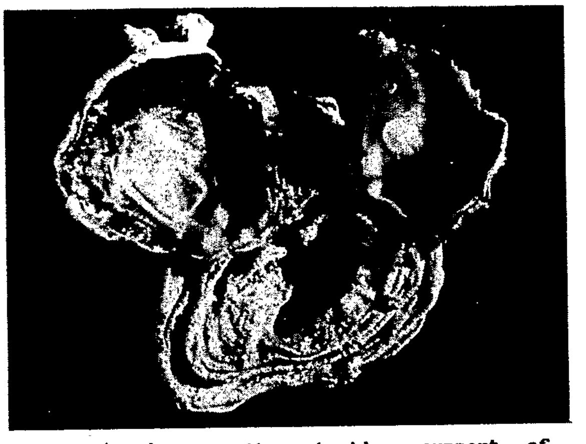

Fig. 4 - *Porites sp.* the starting support of the colony is an oyster shells.

Fig. 5 - *Scolymia vitiensis* : the starting support is a coral debris.

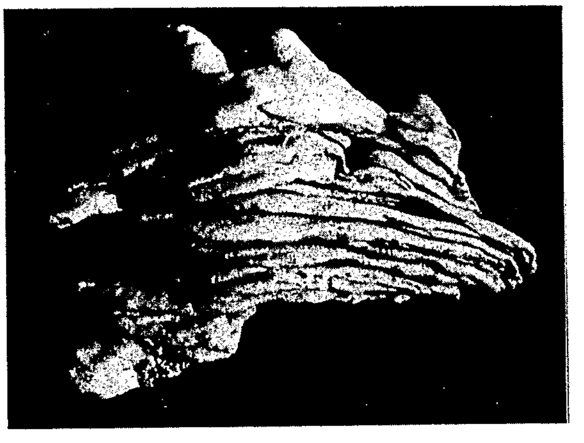

Fig. 6 - *Porites sp.* these stacks suggest fast growth rates.

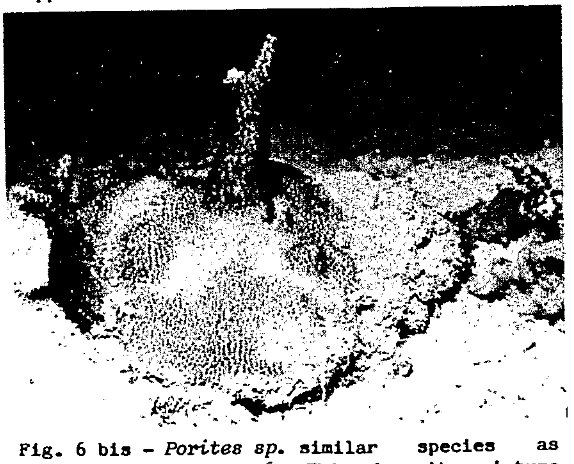

Fig. 6 bis - *Porites sp.* similar species as indicated on figure 6. This in situ picture shows that colony suffers from hyper-sedimenta - tion (pale necrosed zones) which may explain fast growth rate.

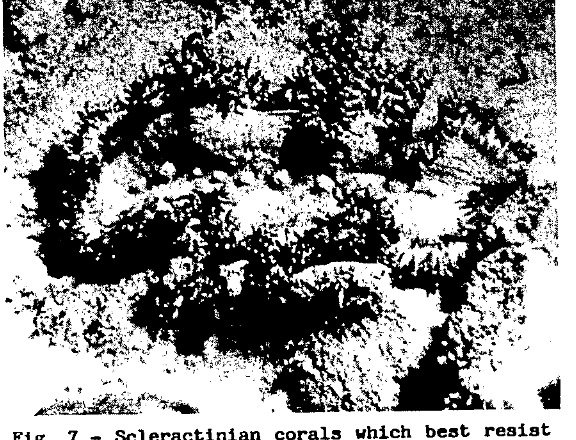

Fig. 7 - Scleractinian corals which best resist to siltation and hyper-sedimentation present well developed polyps such as here *Catalaphyllia jardinei*.

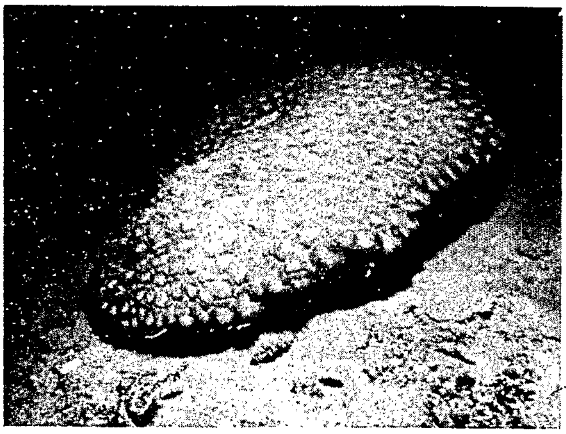

Fig. 8 - Favidae : this species produces an abundant mucus to eliminate suspended particules

Fig. 9 - Growth continues on the outer edge of this *Pachyseris speciosa,* whereas particules accumulate in the bottom of the cup.

Fig. 10 - This *Pachyseris speciosa* has a flat shape growth. The colony is slanted, while one edge is burried, the opposite edge develops.

Fig. 11 - This Favidae, normally growing as a massive edony, takes here a wide conical shape in order to slow down sinking.

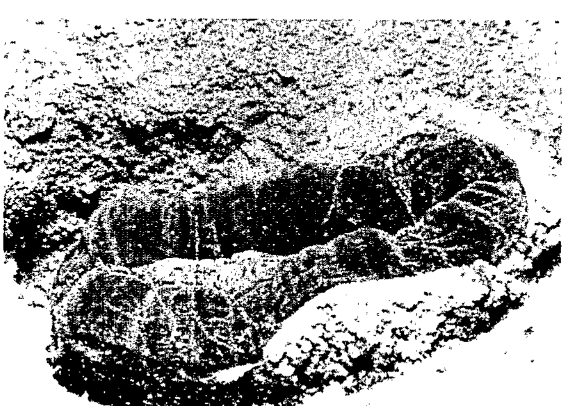

Fig. 12 - *Catalaphyllia jardinei* prevents sinking by resting up on its turgescent polyps.

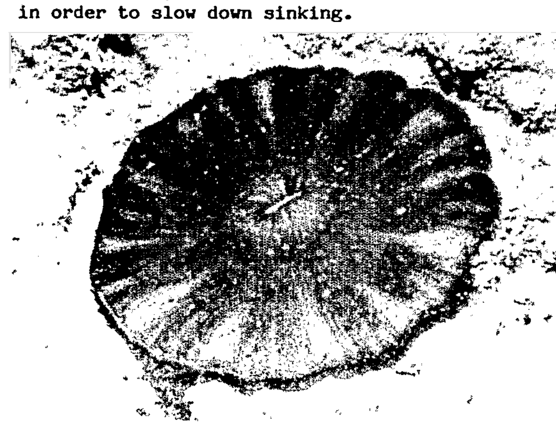

Fig. 13 - *Fungia sp.* : the only representative of this genus is extra flat. It possesses also a polyp which expands well over the edge thus allowing slight displacements and the removal of sedimentary particles.

(g) Trachyphyllia geoffroyi appears to have polyps that are much better developed here than elsewhere. During the night, these polyps become particularly swollen and rest on the sediment, preventing their conical skeleton from becoming silted. When the indentation thus made is partially freed after polyp retraction it probably fills up a little as the edges cave in (figure 12). This strategy must be adopted also by Catalaphyllia and Cynarina, which have no hard support.
(h) Polyphyllia talpina, is quite exceptional here. Its size and shape denote a particular degree of adaptation, with its great length (35 cm) that increases the bearing surface and its thinness (3mm) that lessens its weight. This species also has very well developed tentacles.
(i) Fungia sp., the only representative of the genus, is found here in an extremely flattened form, 3 to 4mm thick with a diametre of 12 to 14 centimetres (figure 13). Moreover, when its single polyp is spread open, it protrudes noticeably. Likewise, Diaseris distorta found on this site has a larger than usual average diametre while maintaining the same thickness.
(j) Lastly, certain species develop or survive in such an environment only because they have colonised a hard support that is raised much higher than the surrounding floor (Porites lobata, Favidae, Montipora).

CONCLUSION

Despite all the strategies they employ, many species of scleractinian corals appear not to be very long - lived. Small sizes are the rule in most colonies and many of them are partially buried.
The madrepores that seem best able to withstand the difficult conditions of this environment are : Catalaphyllia jardinei, Cynarina lacrymalis, Trachyphyllia geoffroyi, Plerogyra sinuosa, Euphyllia glabrescens, Blastomussa merleti, Goniopora lobata, Fungia sp., Diaseris distorta and Scolymia vitiensis.

Although scleractinian corals are characteristically fragile organisms that require specific conditions of light and substratum, they are also able to survive in a hostile environment by adapting themselves. In the scale of evolution corals are regarded as being little organised in their anatomical structure. To achieve the abovementioned adaptations they have (individually or in colonies) means of perceiving the environment and of reacting to it. It may well be however that here the balance thus achieved is very precarious.

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