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QUANTITATIVE STRUCTURE OF SOFT SUBSTRATE MACROBENTHOS OF FIJI'S GREAT ASTROLABE LAGOON

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ABSTRACT

During the joint Fijian-French ASTRO cruise conducted in April 1994 in the Great Astrolabe lagoon, the soft bottom macrobenthos was quantitatively investigated at 25 sampling stations, using a 0.1 m² Smith-McIntyre grab. At each station, sediment was sampled with a total 1 m² area (10 replicate grabs). A total of 207 taxa were identified. Shannon diversity index is 4.12 (se 0.53). The fauna is dominated by molluscs, polychaetes and crustaceans which represent about 80% of the total number of individuals. The total biomass is 4.7 (se 1.6) gAFDW m⁻². Macrophytic biomass accounts for 40% of the total organic matter. The distribution of biomass among the trophic groups reveal a dominance of suspension feeders (44%), deposit swallowers (27%) and carnivores (2%).

INTRODUCTION

Coral reefs are among the most productive, ecologically mature, diverse and complex ecosystems in nature. Most of our knowledge on benthic communities focuses on assemblages of coral and associated plants and animals (Sorokin 1993). Lagoons and back reef regions predominantly made up of carbonate sands and gravels are often considered as unimportant parts of the reef system. However, during the last decade, various investigations highlight the importance of soft sediments which shelter abundant and diverse assemblages (Chardy et al. 1988; Alongi 1990; Jones et al. 1990; Richer de Forges 1991).

Our knowledge of soft substrate benthos from Pacific lagoons is however incomplete. Further investigations considering a wide range of situations are required to gain significant insights into lagoon sediment ecology and contribute to the knowledge and the preservation of reef ecosystems. This study of Fiji's Great Astrolabe Reef lagoon is in keeping with this general purpose.

The Great Astrolabe reef and lagoon have been the subject of a baseline study (Morrison and Naqasima 1992) but this did not include the fauna and flora of the lagoonal sediments, concentrating on limited analysis and collecting resources on the reef (Naqasima and Brandy 1992). As part of a larger joint Fijian-French investigation designed to understand the structure and function of the Great Astrolabe Reef tropical lagoon, we report here on species composition, structure and biomass of soft-sediment macrobenthos.

MATERIALS AND METHODS

The study focused on subtidal sediments. Macrobenthic communities were sampled at 25 sites located between 17 and 43 m depth over the lagoon (Fig. 1). Sampling was carried out with the RV 'ALIS' in April 1994.

Macrofauna and macroflora were sampled using a 0.1 m² Smith McIntyre grab weighed down with an additional 60 kg lead ballast. The sampling unit was a 1 m² area, i.e. ten 0.1 m² grabs. The total collected volume of sediment was about 40 L. The boat was moored with a bow anchor and was free to swing under the influence of the wind. The probability of a bite coincidence between samples was consequently very low. The samples from the same station were mixed and passed through 20, 5 and 2 mm stacked sieves. On board, organisms were separated from the substrate, sorted by major taxonomic groups and preserved in 10% formalin in sea water neutralised with borax.

In the laboratory, taxonomic determinations were carried out as precisely as possible using the available literature. The results per station have been expressed as the number of individuals per m for each identified taxon for macrofauna. Dry weights were measured after oven-drying (60°C) until reaching a constant weight and the ash weight was obtained by further heating at 550°C for 3 hours. The ash free dry weight is the difference between these two values. The biomasses have been expressed in grams of dry weight (DW) and ash free dry weight (AFDW) per m² for macrofauna and macroflora. Taxonomic biomasses have been summed to obtain the total macrobenthic biomass per station. The Shannon-Wiener diversity index (Pielou, 1975) was calculated for the whole community.

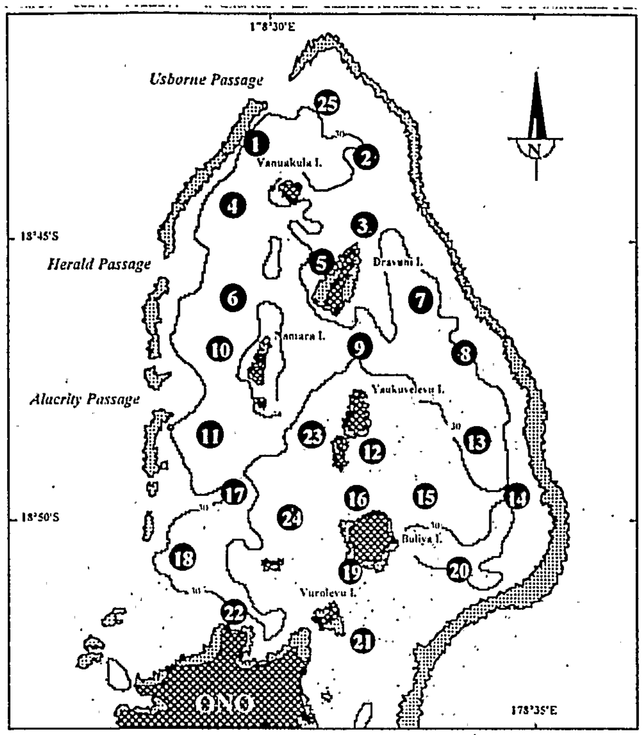

Fig. 1 : Stations sampled for infauna in the Great Astrolabe lagoon, Fiji.

Taxons were assigned to trophic group categories as defined by Chardy and Clavier (1988); i.e. benthic primary producers, suspension feeders mainly including sponges and filtering bivalves, deposit feeders including surface deposit feeders which collect their food near the water-sediment interface, and deposit swallowers which are more or less burrowers and indiscriminately absorb the substrate and associated organic matter, herbivores which feed on macrophytes, and carnivores with both predator and scavenger species. Classification of species in these groups is often uncertain and is discussed by Chardy and Clavier (1988).

RESULTS AND DISCUSSION

Raw data including a full taxonomic list, densities and biomasses by station have been published by Clavier et al (1996).

Number of taxa and abundance

In all, 1596 individuals representing 207 taxa, were identified from the samples. The number of species taken at a station (1 m²) ranged from 14 at station 3 in the northern

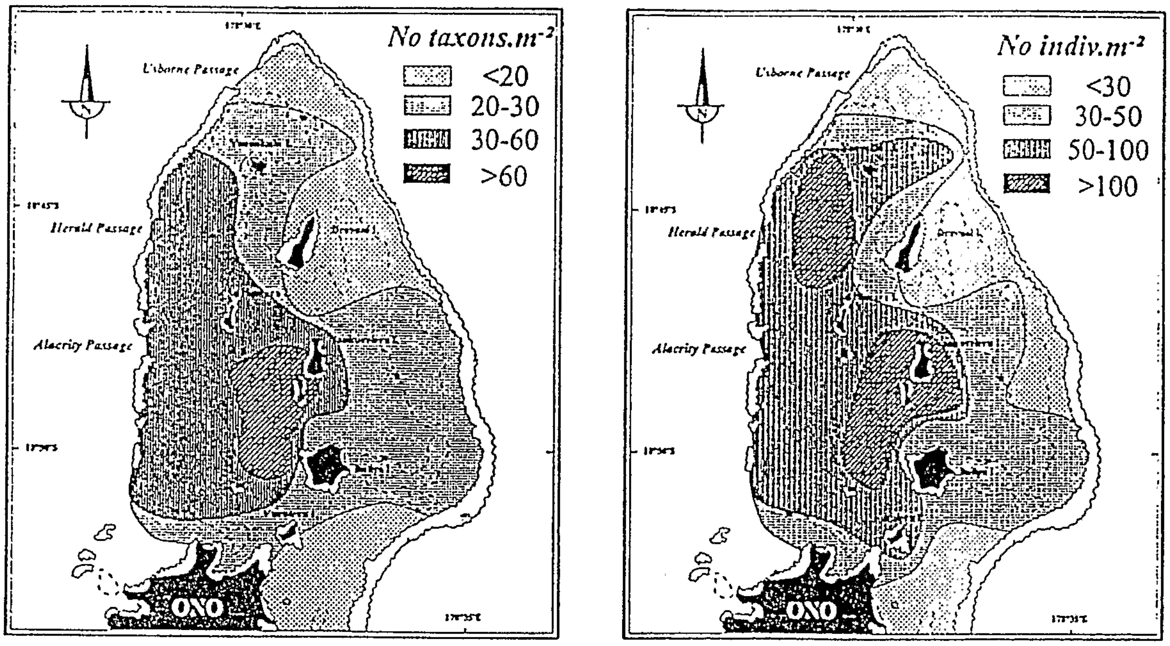

Fig.2: Distribution of species richness (No. of taxons m^{-2}) and abundance (No. of individuals m^{-2}) in the lagoon.

part to 55 at station 23, near Yaukuvelevu island. The average species richness was 27 (s.e. 2). Abundance (no. of individuals per station) ranged from 19 per 0.1 m^2 at station 25 in the north to 231 at station 12 in the centre of the lagoon, near Yaukulevu. The average abundance for the lagoon was 64 (s.e. 10). These estimations are significantly lower (t tests, $P < 0.05$) than the values recorded by Chardy et al. (1988) in the south west lagoon of New Caledonia. Distributions of abundance and number of taxons were matching (Fig. 2) with highest values in the centre and in the western part of the lagoon, and relatively low estimates along the large and continuous eastern barrier reef.

Molluscs, annelids and crustaceans numerically dominated the infauna (Fig. 3) and represented about 80% of the taxa. Dominance of these three groups seems to be a common attribute of Pacific soft bottom communities (Long and Poiner 1994; Baron et al 1993). Annelids and molluscs groups make up 9 of the 12 most abundant taxa (Table 1).

The number of taxa and individuals per station are directly related to the mesh size of the sieve used during the sampling. To get into more detail, we analysed the animal data for three size classes corresponding to 2, 5 and 20 mm mesh sizes. The number of species collected on a 5 mm mesh size (155) was roughly twice as high as on 2 mm (83 species). Only 13 species were collected on the 20 mm sieve. Number of individuals gathered on 5 and 2 mm sizes were equivalent with 53 and 46% of the total, respectively. Individuals with a size greater than 20 mm were seldom found (1%). This feature may be related to the scattering of this megafauna which is poorly sampled by the 0.1 m^2 grab. The distribution of taxonomic groups on 2 and 5 mm mesh size were similar with a clear dominance of annelids, bivalves and crustaceans. The number of crustacean taxa was however three times greater on 5 mm. A similar trend can be observed for echinoderm and gastropod numbers of taxa and individuals.

Table 1: List of the most abundant taxa presented in order of decreasing densities (N·m^{-2}).

Species	N/m2
Modiolus philippinarum	0.96
Natantia spp.	0.68
Armandia sp. cf. leptocirrus	0.49
Acranian spp.	0.32
Codakia sp.	0.30
Terebellides stroemi	0.23
Samytha sp.	0.20
Laevicardium sp.	0.20
Polydora sp.	0.17
Ophiuridae spp.	0.15
Leiochrides australis	0.13
Tellinidae spp.	0.13

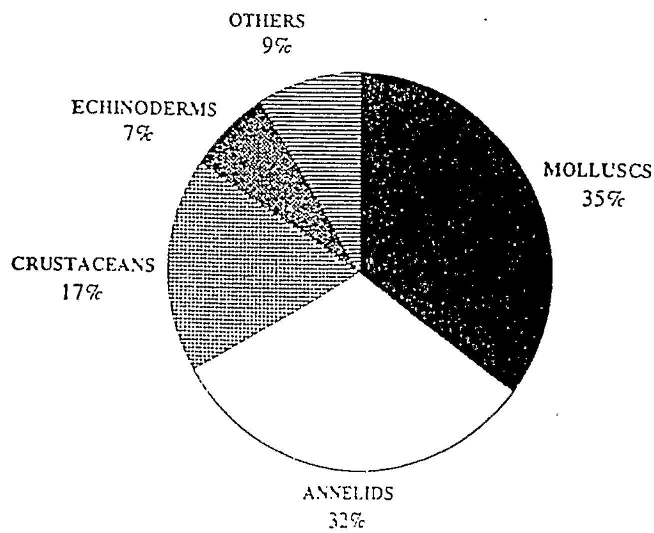

Fig. 3: Relative distribution of taxonomic groups abundances.

The mean diversity of the whole community was 4.12 bits.ind (s.e. 0.53). This value is greater than the New Caledonia SW lagoon diversity calculated by Chardy et al. (1988).

Biomass and trophic structure

The mean macrobenthic biomass was 4.70 gAFDW m^{-2} (s.e. 1.64) or 31.20 gDW m^{-2} (s.e. 14.17). The ash free dry weight of plant matter which accounts for 39% of the total organic biomass is dominated by *Halimeda* species (85% of plant biomass). The weight of organic animal matter is 2.87 gAFDW m^{-2} (s.e. 0.70) or 15.51 gDW m^{-2} (s.e. 5.89). Total biomass values ranged from 0.46 (station 25) to 31.89 gAFDW m^{-2} (station 24). Biomass distribution clearly

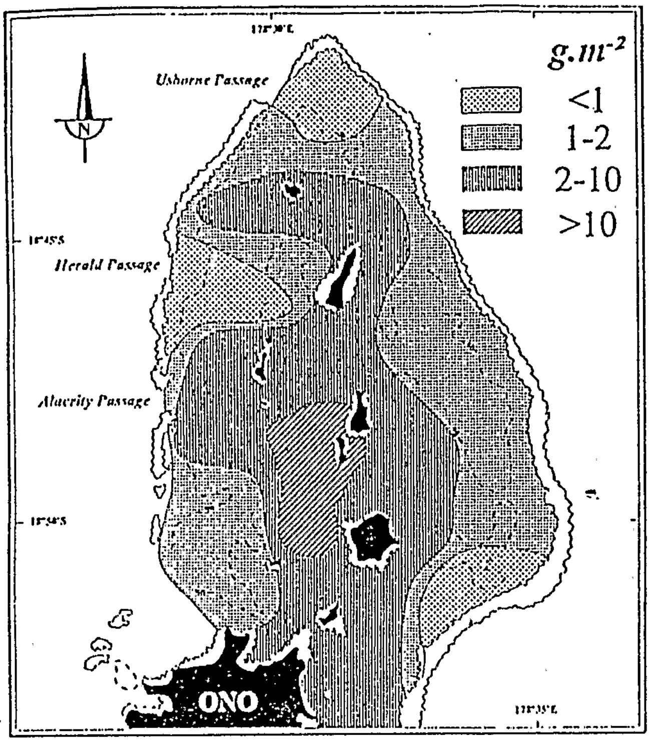

Fig. 4: Contour plot of macrobenthic biomasses.

indicated a concentric pattern with highest values in the middle of the lagoon, on the western side of Yaukulevu and Buliya islands (Fig. 4), and minimal values on the periphery, near the reef.

The total organic matter biomass is five times lower than the values recorded by Chardy and Clavier (1988) in the SW lagoon of New Caledonia (23.6 gAFDW m). The relative contribution of plant and animals is however similar. The study area (Fig. 1) consists of a relatively large lagoon (about 200 km) with several passes on the western barrier reef wide open to oceanic influence. In other respects, Ono island in the southern part and some small islands in the middle of the lagoon are a source of terrestrial material. The distribution of macrobenthos can be interpreted according to these two influences. Oligotrophic oceanic waters flowing through passes or conveyed by the surge above the reef are of little energetic value and can only sustain low biomasses. Terrestrial influence characterised by nutrients and organic matter inputs can enhance the production and support relatively higher biomasses. Oceanic and terrestrial influences are however ruled by hydrodynamism and further information about residual currents in the lagoon is required to explain the observed biomass distribution.

Macrofauna biomass is dominated by bivalves, echinoderms and crustaceans (Fig. 5). Compared to New Caledonia, molluscs are also the dominant group but cnidarians and sponges are less abundant. From the taxonomic view-point, the irregular echinoid *Metalia sternalis* (0.50 g m), the bivalves *Lioconcha ornata* (0.28 g m) and *Codakia sp.* (0.26 g m), or the cnidarian *Trachyphyllia geoffroyi* (0.21 g m) are the most abundant species by weight.

The animal biomass collected on the 5mm mesh sieve represents more than 60% of the total and is mainly composed of molluscs. The ash free dry weight of organisms collected on 2 mm is ten times lower and corresponds to annelids and crustaceans. Larger animals (> 20 mm), mostly echinoids and solitary cnidarians, make up about 30% of the total biomass. These results emphasise the importance of medium size organisms in the lagoon: animals collected on a 5 mm sieve dominate both in number of individuals and in biomass.

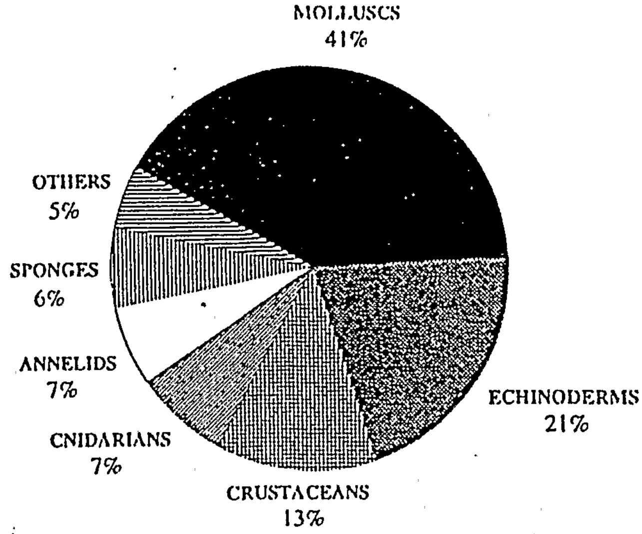

Fig. 5: Relative distribution of taxonomic group biomasses

Suspension feeders and deposit feeders dominated throughout the lagoon (44% and 35% of the total animal biomass, respectively). Bivalves represented 68% of suspension feeders biomass, followed by cnidarians (17%) and sponges (7%). Deposit swallowers accounted for about two thirds of deposit feeders with a major contribution of echinoids (80% of the deposit swallowers biomass). Surface deposit feeders biomass is more evenly distributed ; however, annelids (27% of their biomass) and crustaceans (25%) are the dominant groups. Carnivores, mainly composed of crustaceans and gastropod scavengers make up 21% of the total animal biomass. Herbivores were poorly represented (< 1%). This trophic structure, dominated by suspension and deposit feeders is very similar to the SW lagoon of New Caledonia (Chardy and Clavier 1988).

CONCLUSION

Fiji's Great Astrolabe lagoon and New Caledonia SW lagoon, set in the same geographic area, are both subject to oceanic and terrestrial influences. The configuration of Fiji's lagoon is however similar to an atoll surrounded on three sides by a barrier reef only interrupted by some passes on the western part. Terrestrial influence is only exerted by Ono island on the south, and some lesser islands in the middle of the lagoon. The SW lagoon of New Caledonia, on the other hand, is established along a large mainland whose influence is ruled by hydrodynamism (Clavier and Douillet 1996).

In spite of some similarities in trophic and size structure of macrobenthic organisms, these two lagoons obviously differ by the mean abundance and biomass which are markedly lower in Fiji. The latter mean values result, however, from very different contributions from the sampled stations. In fact, the highest biomass observed in the middle of the lagoon (28 and 31 gAFDG m in stations 23 and 24, respectively) are in the order of magnitude of New Caledonia SW lagoon. This feature suggest the importance of terrestrial input to enhance life in lagoon sediments.

Further information on hydrodynamics and sediment particle size are however required for a interpretation of the observed macrobenthic structures of the Great Astrolabe lagoon.

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