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STRUCTURE AND SEASONAL VARIATIONS IN A SANDY BEACH MACROFAUNA ON THE SOUTH-WEST COAST OF NEW CALEDONIA (SW PACIFIC OCEAN)

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Abstract

Density and biomass of the macrobenthos, as well as various environmental parameters, were investigated monthly over one year on a sandy beach at Karikate on the southwest coast of New Caledonia (SW Pacific Ocean). Fifteen taxa were identified. The average species richness was 7.3 species·sampling unit^{-1}. Average density was 100.6 individuals·m^{-2} and average biomass 1.2 gAFDW·m^{-2}. Annelids and molluscs dominated the community in terms of number of species. The bivalves *Atactodea striata* (64% of total density) and *Donax faba* (16%) exhibited the highest densities. Similarly, the average biomass was almost entirely accounted for by these two species (77% for *A. striata* and 22% for *D. faba*). No seasonality was observed in the environmental parameters, apart from temperature, nor in the species richness and biomass of the macrobenthic community, while its density fluctuated irregularly over the year in relation to the number of *A. striata* juveniles.

Introduction

At the present time in New Caledonia, as in a number of tropical countries (Alongi 1990), tourism is growing and sandy beaches are in demand as sites for tourism-oriented projects. As most of the beaches harbour sizeable biomasses of *Atactodea striata* (Gmelin, 1791) (Mesodesmatidae), a bivalve collected at low tide by Melanesian populations as much for recreation as for its food value (Baron and Clavier 1992), such touristic development needs to be planned carefully. The proper conservation of a threatened site is facilitated by the knowledge of the natural fluctuations occuring in its faunal community. There have been many studies dealing with temporal fluctuations in tropical sandy beach macrobenthic communities (Alongi 1990), but most of them were conducted in monsoon-affected regions. In New Caledonia, no quantitative data is available on the macrobenthos of sandy beach, and its temporal variations remain unknown. We therefore undertook to study the stucture of and possible seasonal fluctuations in the macrobenthos on a sandy beach on the south-west coast of New Caledonia.

Materials and Methods

Sampling was conducted monthly over one year, from December 1989 to November 1990, on a sandy beach at Karikate (22°07'S–166°12'E) about 40 km north of Noumea (New Caledonia). This beach was choosen because she had a substantial natural population of the bivalve *Atactodea striata*. The beach was about 10 m wide and had a slope of 1 in 20, which is the typical type a

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sandy beach on the south west coast of New Caledonia (Baron and Clavier 1992). At each sampling and at low tide, the interstitial water temperature (at a depth of 2 cm) was measured with a portable thermoprobe. Salinity was measured with a refractometer. The sediment (a single sample of 500 g) was sampled to a depth of 10 cm, 8 m from the berm. Particle size fractions were determined according to the procedure of Folk and Ward (1957). Organic matter content was estimated for dry sediment by weighing before and after oven heating at 550°C for 3 hours. Three samples from the top 1 cm of substratum were collected 6–8 m from the berm with a 5.7 cm² corer, stored in the dark and frozen on our return to the laboratory. Chlorophyll *a* content (expressed as mg Chla·m⁻²) was measured by spectrophotometry, after acetone extraction. Temporal fluctuations in Chlorophyll *a* contents were examined using one-way ANOVA, and we used Welsch test to separate possible sets of homogeneous months (Sokal and Rohlf 1981).

To study the macrobenthic community, we sampled one single transect 0.5 m wide perpendicular to the shore and covering the zone between the neap tide low water and high water maks, i.e. an area of 2.5 m². This strategy was choosen to avoid possible sampling errors due to tidal migrations of some species on the beach. The sand was dug out to a depth of 10 cm and washed through a 1 mm sieve. Animals > 3 mm were sorted by eye. The 1 to 3 mm size fraction was homogenized and a 6 litre sample was sorted under a dissecting microscope after staining with Rose Bengal. Densities and biomasses were estimated using the ratio sorted volume/total volume. Individuals belonging to each taxon were counted and their ash-free dry weight (AFDW) estimated to the nearest 0.001 g after drying at 60°C for 48 hours and oven heating at 550°C for 3 hours. Species richness has been expressed·sampling unit⁻¹ and density and biomass·m⁻². Temporal fluctuations in species richness and biomass were estimated by Chi² tests (Sokal and Rohlf 1981). Density variations were estimated empirically, since, for comparison of high values such as densities, the Chi² or G-test (Sokal and Rohlf 1981) are sensitive and systematically yield significant results.

Results

Maximum temperatures (29 to 30°C) were recorded from November to March and minimum temperatures (19 to 20°C) in July and August. Salinity ranged from 34 to 36‰, except in March when it dropped to 30‰. The substrate consisted of terrigeneous medium sand, characterized by absence of mud and cobbles. Sediment structure was stable over the year, except in March and June (Fig. 1). In March, the percentage of particle sizes

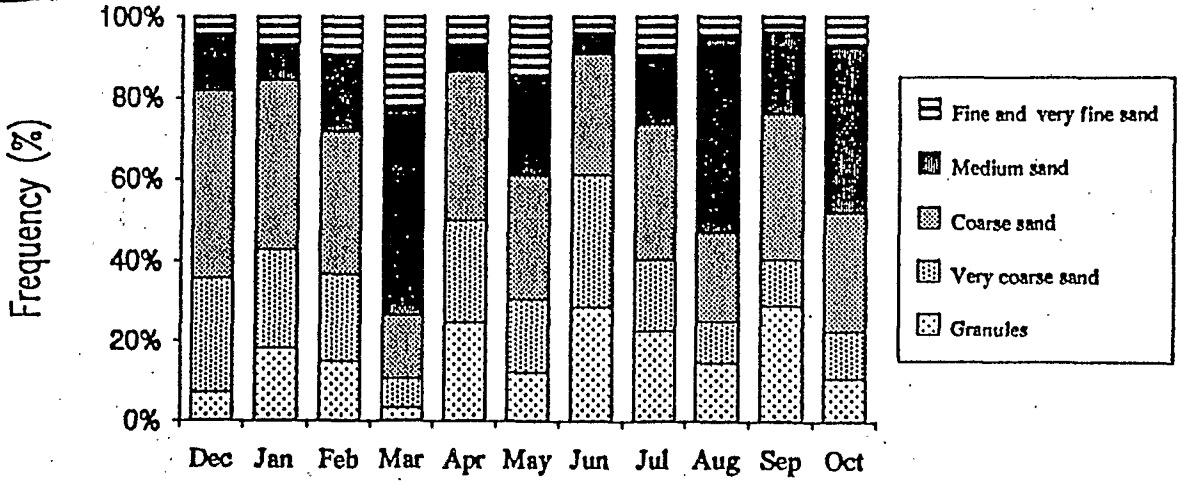

Fig. 1. Composition (%) of beach substratum in terms of major granulometric fractions.

between 0.063 and 0.5 mm rose sharply, while June had the highest percentage of coarse sand with grain sizes between 1 and 20 mm. No temporal fluctuation was observed in organic matter content, which remained between 2.6 and 5.7%. Chlorophyll *a* content (Fig. 2) showed an overall significant difference between months ($F = 2.47$, $P < 0.05$, $df = 35$). Welsch test showed a higher content only in April than in October and we were not able to demonstrate any seasonal change.

Fifteen infaunal taxa were identified (Table 1). Average species richness was 7.3 species sampling unit^{-1}. Average density was 100.6 individuals·m^{-2} (SE = 7.2) and average biomass 1.2 gAFDW·m^{-2} (SE = 0.1). Annelids and molluscs dominated the community in terms of number of species, with respectively 3.4 (SE = 0.5) and 2.7 (SE = 0.1) species··2.5 m^{-2}. The bivalves *Atactodea striata* (64.1 individuals·m^{-2}, SE = 6.3, i.e. 64% of the total) and *Donax faba* (16.6 individuals·m^{-2}, SE = 2.3, i.e. 16% of the total) were dominant. These two species almost entirely accounted for the average biomass (0.9 gAFDW·m^{-2}, SE = 0.1, i.e. 77% of the total for *A. striata* and 0.3 gAFDW·m^{-2}, SE = 0.05, i.e. 22% of the total for *D. faba*). Species richness

Table 1. List of taxa collected at Karikate beach during the study.

Platyhelminthes
Platyhelminthe

Archiannelida
Archiannelid

Polychaeta
Armandia melanura
Eunicid
Glycera sp.
Nereid
Progoniada sp.
Scoloplos sp.
Spionid
Syllid

Oligochaeta
Oligochaete

Gasteropods
Naticid

Bivalves
Atactodea striata
Donax faba

Crustaceans
Isopod

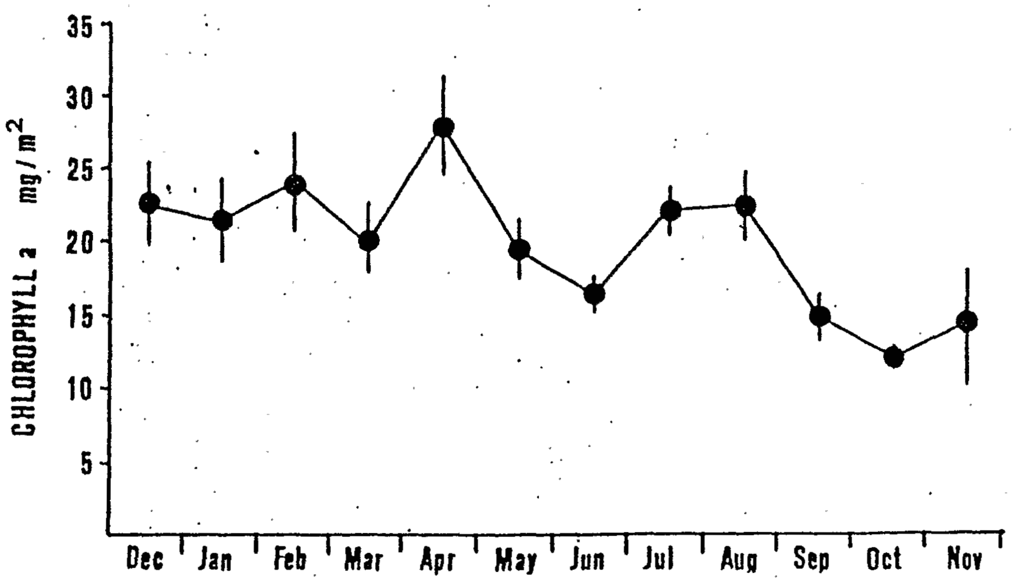

Fig. 2. Chlorophyll *a* content in the sand at Karikate beach (vertical bars show standard errors).

(Fig. 3) did not vary significantly over the year ($Chi^2 = 6.91$, $P > 0.05$, df = 11). Faunal density varied in an irregular way (Fig. 3) : minimum values were recorded in March (65.6 individuals·m^{-2}), June (78.0 individuals·m^{-2}) and November (67.6 individuals·m^{-2}), while the maximum value (161.6 individuals·m^{-2}) occurred in April. Figure 4 shows seasonal density fluctuations for the major species found on the beach. Changes in *A. striata* density, particularly in that of juveniles smaller than 5 mm, accounted for the overall density trends observed, juvenile density being lowest in March (13.2 juveniles·m^{-2}), June (18.8 juveniles·m^{-2}) and November (15.6

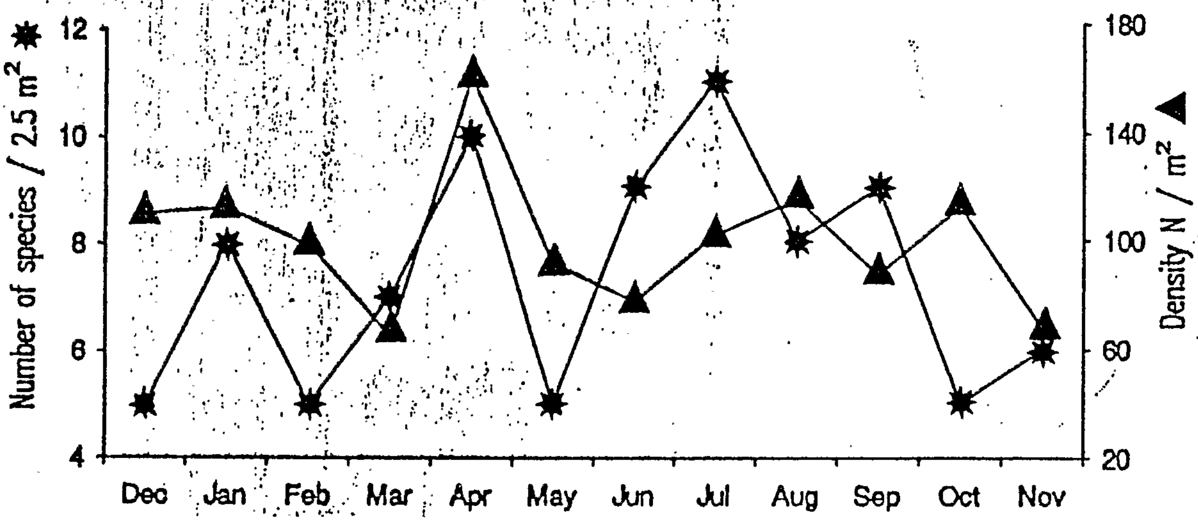

Fig. 3. Variations in the number of species (per sampling unit) and number of individuals (per m²) of the beach macrobenthic community over the year.

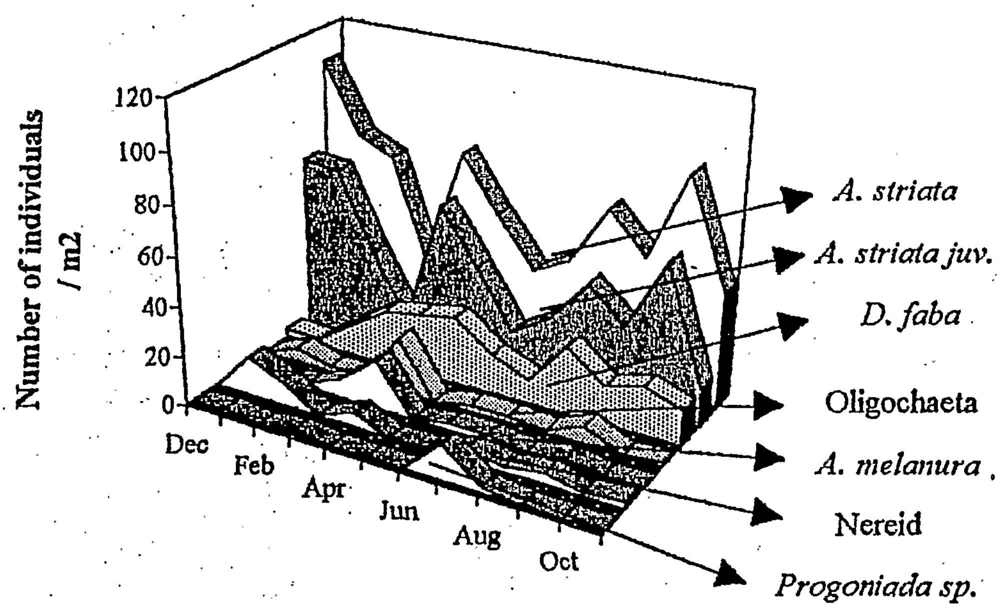

Fig. 4. Density fluctuations in major species of the intertidal macrobenthic community at Karikate beach.

juveniles·m^{-2}). *D. faba* density varied in an irregular way with no seasonal trend. Maximum abundance of the annelids *Armandia melanura*, *Progoniada* sp. and an unidentified oligochaete was recorded from April to July, at the beginning of the cool season. Density of a Nereid peaked in January and February. The biomass of the macrobenthic community displayed no seasonality ($Chi^2 = 1.94$, $P > 0.05$, df = 11), with maximum values (1.7 gAFDW·m^{-2}) recorded in July and September and minimum values (0.7 gAFDW·m^{-2}) in January and June. Biomasses of *A. striata* and *D. faba* similarly did not show seasonality ($Chi^2 = 3.86$ and $Chi^2 = 2.17$, $P > 0.05$ respectively).

Discussion

Both number of species and density on Karikate beach are low compared with those recorded on other tropical beaches (Ansell *et al.* 1972, Dexter 1974, Grelet *et al.* 1987) or in temperate areas (McLachlan *et al.* 1981; Dexter 1984). Dexter (1974, 1979), like us, observed low macrofauna densities on some beaches of Central America, for a larger number of species. Our study was however confined to the mid-littoral zone of the beach and the species that colonize the other zones (hippid decapods and naticid gasteropods) were not collected. The mid-littoral portion of tropical sandy-beaches is generally characterized by one or several isopods and amphipods (Trevallion *et al.* 1970) which are often dominants. Their absence at Karikate could be due to the slight wave action on this beach, crustaceans being generally more abundant on relatively exposed sites (Dexter 1984). *Atactodea striata* and *Donax faba* are found together commonly on Indo-Pacific sandy beaches (Pichon 1962; Beu 1972; Purchon and Purchon 1981; Ansell 1983). In New Caledonia, these two species are the only bivalves found on the beaches of the south-west coast, and *A. striata* clearly dominates beaches fauna in density and biomass (Baron and Clavier 1992). Gibbs (1978) reported *Atactodea glabrata* to be dominant on the coral island beaches of the Great Barrier Reef. We found no other reports of mesodesmatid dominance on Indo-Pacific beaches, in particular as regards *A. striata*, which accounts for only 8% of the individuals on Red Sea beaches (Grelet *et al.* 1987) and 35% of the biomass on Indian ocean beaches (Narayanan and Sivadas 1986).

The macrofauna of Karikate beach is characterized by stable species richness and biomass throughout the year. The micro-phytobenthic chlorophyll *a* content did not show any seasonal variation. In the New Caledonia south-west lagoon, Rougerie (1986) also observed an absence of seasonal changes in phytoplankton. The organic matter in the sediment did not show any temporal fluctuation either. The stability of organic resources in the substratum would contribute to maintaining faunal populations at a constant level. Faunal density varied aperiodically, however, with the density of *A. striata* juveniles. We observed *A. striata* juveniles all through the year, although the species does, on the same site, have a peak of reproductive activity during the hot season and a resting phase from May to July (Baron 1992). The continuous presence of juveniles therefore implies the existence of fluctuations in the reproductive cycle of *A. striata* populations in neighbouring areas. The sedimentary structure of Karikate beach is moreover stable throughout the year, except in March and June. In March, the proportion of fine particles increases as a result of the sediments deposited by runoff after heavy rains, as is supported by the salinity decrease recorded in the same period. In New Caledonia, south-east tradewinds blowing from 10 00 to 17 00 are dominant winds. In June, the increase in the coarse fraction is probably caused by the winds sweeping off the fine sediment, most of the low tides occuring during the daytime in that month. The lowest *A. striata* juvenile densities were associated with changes in the texture of the substratum. We concluded that these changes were responsible for the decline in population numbers, as it has been observed in monsoon-affected regions, where changes in the grain-size distribution of the substrata cause a decline in macrofauna density (Ansell *et al.* 1972, Achuthankutty *et al.* 1978, Ansari *et al.* 1986). This sensivity of *A. striata* juveniles must be taken into account, when planning for human activities that are liable to modify the grain-size distribution of beaches.

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