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Spatial and temporal variability in the composition and structure of meiobenthic assemblages (especially nematodes) in tropical beaches (Guadeloupe, FWI)

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Abstract: Short term fluctuations in physical parameters are particularly important in determining faunal diversity of intertidal beaches, and the main objective of this paper is to describe the situation on the Caribbean island of Guadeloupe with respect to the meiobenthos of this habitat. A meiofaunal inventory was established for 23 beaches in 1979 and six representative beaches were surveyed five more times up to 1984. The proportions of higher meiofauna taxa present were highly variable in both space and time, and are shown to correlate with sediment grain-size and $CaCO_3$ content. The nematode generic composition was highly variable at the more wave-exposed locations, but less so at the more sheltered locations. There was a significant effect of grain-size on the generic composition of the samples, but not on univariate measures of species diversity. Dominance patterns varied over time at a given location, but the trends of variation are not consistent among stations. Interpretation of future changes in community composition in terms of anthropogenic activities must therefore be approached with caution. For example, changes which might be regarded as indicative of organic pollution, such as switches from copepod dominance to nematode dominance, are shown to occur naturally over short periods of time (< 1 year) on the same beach.

Résumé : *Variabilité spatio-temporelle de la composition et de la structure du méiobenthos (en particulier des nématodes) des estrans tropicaux (Guadeloupe, Antilles, France)*
Les fluctuations à court terme des paramètres physiques jouant un rôle fondamental dans la diversité faunistique des estrans, notre objectif était d'étudier le méiobenthos de divers sédiments intertidaux du littoral de la Guadeloupe. En 1979, le premier inventaire de la méiofaune de cette île a été effectué, et pour six plages particulièrement représentatives des différents types d'habitat, cinq autres séries de prélèvements ont été effectuées jusqu'en 1984. Le pourcentage des principaux taxa représentés varie fortement selon le lieu et aussi le temps; il montre une nette corrélation avec la granulométrie et le taux de CO_3Ca du sédiment. La composition, au niveau générique, des peuplements de nématodes est nettement plus variable dans les sites de mode battu que dans ceux de mode calme. La granulométrie influe de façon significative sur la composition générique des assemblages de nématodes mais pas sur les mesures de diversité spécifique. En un site donné le profil des dominances varie en fonction du temps, mais la tendance de ces variations n'est pas la même d'une station à l'autre. C'est pourquoi toute interprétation d'éventuels changements dans la composition du méiobenthos intertidal doit être envisagée avec de grandes précautions; par exemple des changements qui pourraient être interprétés comme signe d'une pollution organique, tel que le passage d'une dominance de copépodes à celle de nématodes, apparaissent semble-t-il naturellement après une courte période (< un an) dans le même milieu interstitiel marin.

Keywords : meiofauna, nematoda, composition, diversity, Caribbean beaches.

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Introduction

Coastal regions in the tropics, particularly sand-beach and coral reef areas, are coming under increasing threats from man's activities through both tourism and agriculture, resulting in increased nutrient levels and physical disturbances. In order to assess the effects of this activity on various components of the biota in these regions, it is necessary first to establish baselines in terms of the structure and degree of natural variability of the assemblages present. Short term fluctuations in physical parameters are particularly important in determining faunal diversity of intertidal beaches (Ott, 1972), and the main objective of this paper is to describe the situation on the Caribbean island of Guadeloupe with respect to the meiobenthos of this habitat.

After a preliminary collecting survey of the meiofauna of the coralline, mixed and volcanic sand beaches (Renaud-Mornant & Gourbault, 1982, 1984) a four year study was undertaken, focusing on a few representative sites. This gave rise to a large series (c. 25) of taxonomic papers on several meiobenthic taxa (nematodes, tardigrades, copepods, oligochaetes). In addition, sublittoral meiobenthic samples were analysed off the same sites (Boucher & Gourbault, 1990). More recently, a study comparing the effect of sampling methods on the determination of nematode biodiversity was undertaken on the coralline sand beach at Gosier (Gourbault & Warwick, 1994).

Meiofauna from western tropical Atlantic beaches have seldom been inventoried, apart from our preceding studies and the qualitative study of nematodes from two sites on a beach close to Alligator Harbor, Florida (King, 1962). Sublittoral habitats have been rather better studied. Also in the Atlantic South West, phytal meiofauna from an artificial jetty were observed in South Carolina (Coull *et al.*, 1983). In Florida, a subtropical seagrass nematode community was described on the western shore of Key Biscayne (Hopper & Meyers, 1967 a and b) and the weak response to disturbance of nematode assemblages from subtidal fine sands was examined in St. George Sound (Sherman *et al.*, 1983). Ecological aspects of East Flower Garden brine seep meiofauna (Powell *et al.*, 1983) and nematodes (Jensen, 1986) have also been studied. Investigations have also been undertaken in the sublittoral sands of the Gulf of Mexico, Campeche Sound (de Jésus-Navarrete, 1993) and in Cuba (Andérès, 1985; Lopez-Canovas, 1989).

Study sites and methods

Stations : All the 23 sampling sites (Fig. 1) have been previously described (Renaud-Mornant & Gourbault, 1982) and were sampled in April 1979; six stations, representative of different beach types and faunistic compositions (2, 6, 8, 9, 14 and 22) were sampled five more times (Dec 1982, Apr 1983, Dec 1983, Apr 1984, Nov 1984) and are characterized below:

- Station 2, Anse Laborde, is a large exposed beach, flat in the dry part of the sand but with a marked slope in the moister part (depth of samples to water table at 50-90 cm). In the sediment, the temperature varies from 25 to 29 °C, salinity 34-37.5 PSU, ph 7.8-8.1 and oxygen 81-91%. Coralline sand ($CaC0_3$ 91-93%) with a median grain-size equal 325-380 μm, exceptionally 500 μm and So (Trask coefficient) 1-1.5

- Station 6, Plage de la Gourde, is narrow with a steep slope (water table at 50-70 cm) and high energy. Temperature 26-28 °C, salinity 30-38 PSU, ph 7.9-8, oxygen 86-94%. Sand coarse (md 410-570 μm) and coralline ($CaC0_3$ 92-95%).

- Station 8, Bois Jolan, very narrow and flat (water table at 15-30 cm) belt of sand between a large coconut tree plantation and a sheltered calm lagoon. Temperature 26-33 °C, salinity 29-37 PSU, ph 7.2-7.7, oxygen 34-42. Fine coralline sediment mixed with soil waste, md 170-290 μm, So 1.1-1.4, $CaC0_3$ 91-94%.

- Station 9, Gosier, narrow beach with a gentle slope (water at 35-55 cm) moderate energy. Temperature 25-28 °C, salinity 24-37 PSU, ph 7.6-7.8, oxygen 80-90. Coralline and medium sand, md 168-300 μm, So 1-1.6 and $CaC0_3$ 92-95%.

- Station 14, Grande Anse Trois Rivières, wide (50 m) beach with a gentle slope (water table at 30-60 cm), moderate energy. Temperature 25-27.5 °C, salinity 36-37 PSU, ph 7.6-8, oxygen 80-95%. Black sand, fine (md 132-210 μm, So 1.3) and volcanic ($CaC0_3$ 5-9%).

- Station 22, Grande Anse Deshaies, narrow and long (2 km) beach with a steep slope (water table at 70-90 cm), high energy. Temperature 25-28 °C, salinity 35-38 PSU, ph 7.6-8, oxygen 88%. Sand yellowish mixed with shells of molluscs and forams, md 215-308 μm, So 1.2-1.5 and $CaC0_3$ 84-92%.

Sampling procedure: The collecting was made by the Karaman/Chappuis (KC) method: a hole is dug in the sand above the high water mark into the phreatic zone. Water seeping into this hole is agitated to suspend the meiobenthos and detritus, then collected and a standard 15 litres is filtered through a 40 μm mesh sieve. This agitation serves to detach some meiofauna adhering to the sand grains, so the quantity of sediment collected is relatively small. The duration of sampling depends on the water flow velocity, which in turn depends on the porosity of the sand. This sampling method collects meiofauna from a relatively large area of the beach when compared with small core samples of sediment, and thus to some degree ameliorates the problem of spatial variability, the need for replication, and the confounding of spatial and temporal variability. When beaches were sampled on subsequent occasions, great care was taken to precisely relocate the sampling point. The method is clearly not strictly quantitative, so that the data are analysed as the proportion of each taxon as a fraction of the total abundance. The samples were preserved in buffered 7%

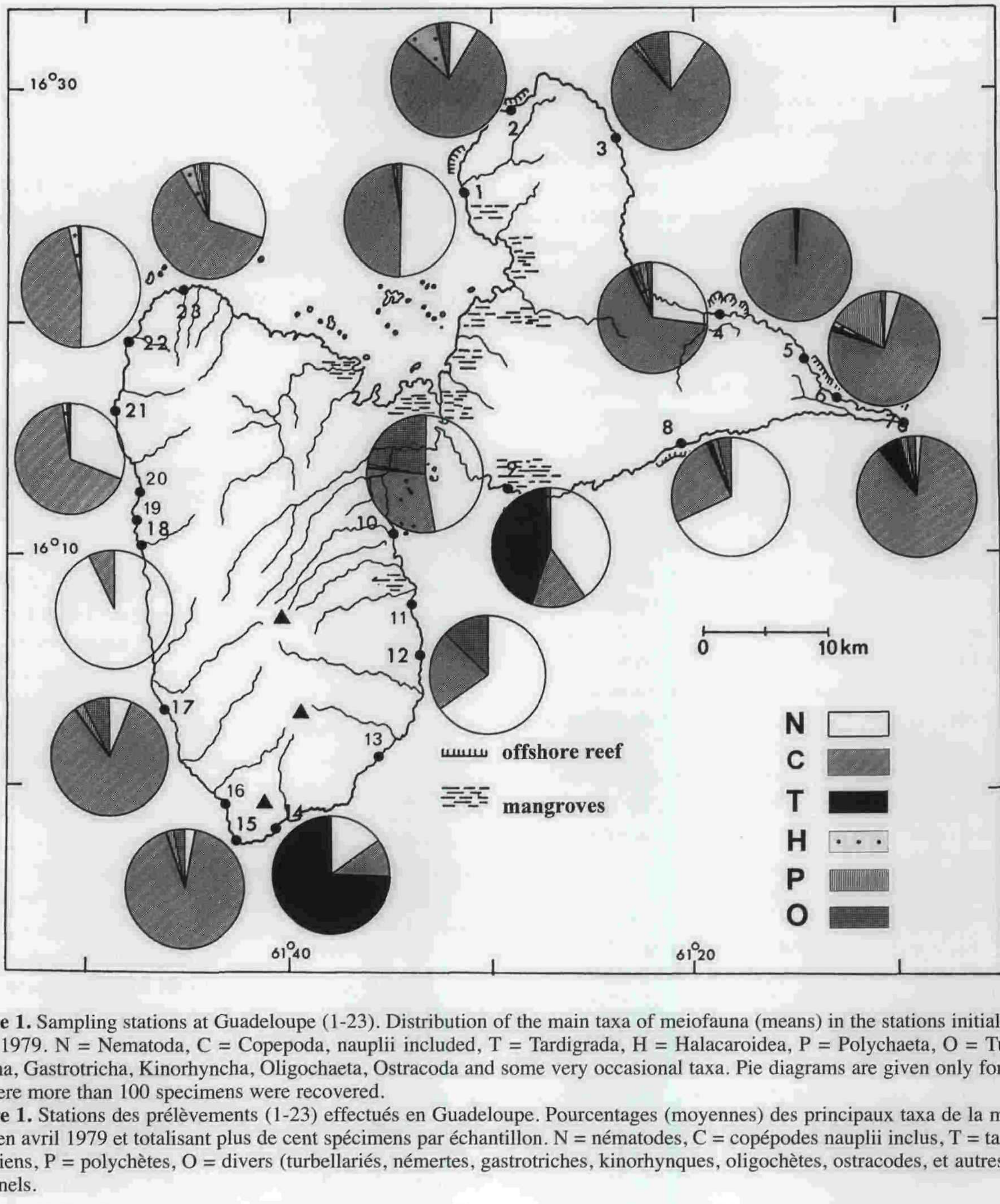


Figure 1. Sampling stations at Guadeloupe (1-23). Distribution of the main taxa of meiofauna (means) in the stations initially studied in April 1979. N = Nematoda, C = Copepoda, nauplii included, T = Tardigrada, H = Halacaroidea, P = Polychaeta, O = Turbellaria, Nemertina, Gastrotricha, Kinorhyncha, Oligochaeta, Ostracoda and some very occasional taxa. Pie diagrams are given only for the locations where more than 100 specimens were recovered.

Figure 1. Stations des prélèvements (1-23) effectués en Guadeloupe. Pourcentages (moyennes) des principaux taxa de la méiofaune, récoltée en avril 1979 et totalisant plus de cent spécimens par échantillon. N = nématodes, C = copépodes nauplii inclus, T = tardigrades, H = acariens, P = polychètes, O = divers (turbellariés, némertes, gastrotriches, kinorhynques, oligochètes, ostracodes, et autres taxa très occasionnels.

seawater/formalin. Meiobenthos was extracted by elutriation. At least the first 100 nematodes encountered from each sample were mounted on slides in glycerine or formalin-glycerine. Nematodes and tardigrades (cf Dr. J. Renaud-Mornant) were identified to specific level. The other meiobenthos was identified to major taxon level and specimens were counted under the stereomicroscope in a multichambered dish ("cuve de Dolffus"). Sediment grain size and calcium carbonate content have been determined for all stations, but not on all sampling occasions.

Data analysis: Community composition of nematode species and major taxa were analysed by univariate, graphical/distributional, and multivariate methods. Species richness (S), Evenness (J'), and Shannon diversity (H') were calculated using $\log_e$. Diversity profiles were visualized by the use of *k*-dominance curves (Lambshead *et al.*, 1983). Similarity of nematode species and higher taxa composition between samples was determined by non-metric multidimensional scaling (MDS; Kruskal & Wish, 1978) ordination using the square root (nematode species) or fourth root (meiobenthic taxa) transformed data and employing the Bray-Curtis similarity index. The nematode species or higher taxa responsible for the Bray-Curtis dissimilarity between groups of samples were determined using the computer programme SIMPER (Clarke, 1993). The ANOSIM test (Clarke, 1993) was used to assess the significance of differences between sample groups. The variability in community composition over time was assessed in terms of the Index of Multivariate Dispersion (Warwick & Clarke, 1993). All statistical analyses were implemented using the software package PRIMER (Clarke & Warwick, 1994).

Results

Major Taxa. - In the initial 1979 survey there was a considerable degree of spatial variation in the proportions of the dominant meiofaunal taxa (Fig. 1). Copepods were dominant at ten sites, nematodes at six and tardigrades at two sites (14 and 9). Subsequent surveys at some of these sites also showed that the taxonomic composition was also highly variable temporally (Fig. 2). This figure shows that there are no clear trends of change in taxonomic composition over time: variability is stochastic and a detailed account of the changes is best gained by inspection of the figure rather than a lengthy textual description. The locations with the coarsest sediment (2 and 6) are generally dominated by harpacticoid copepods, although not always so, and the stations with the finer sediments (8, 9 and 14) are generally dominated by nematodes, although tardigrades are also important, particularly towards the beginning of the study period.

K-dominance curves for seven sites (the monitored six plus station 8 with heterogeneous sand, sampled on three occasions only), averaged over all sampling occasions, showed similar patterns (Fig. 3a), but again this averaged picture is rather misleading, since there was a considerable degree of variability between the individual curves for any one site, particularly at station 2 (the most exposed beach).

The MDS ordination of the standardised fourth root transformed taxon abundance data, for all samples for which grain size and $CaCO_3$ data are available (Fig. 3b), shows that samples from the same location taken at different times group quite closely together. Samples with a tendency for nematode domination are towards the top right of the configuration (indicated by N), those with a tendency for copepod domination to the left (C) and those dominated by tardigrades to the bottom left (T). The copepod dominated samples tend to have the coarsest sediments, and the tardigrade dominated samples are in the finer volcanic sediments (low $CaCO_3$) (Fig 3c and d).

The relationship between the dominance of major taxa and median grain size is confirmed by regression analysis of taxon dominance against (Log) median particle diameter (Table 1). There is a significant positive relationship (more in coarser sediments) for copepods ($p<0.001$) and a significant negative relationship (more in finer sediments) for nematodes ($p<0.01$) and tardigrades ($P<0.05$), but no significant relationships for any other taxa.

For tardigrades, the total abundance varies from 1 to 940 (at station 14, see Fig. 2); the number of species is correlated to grain size (Fig. 4) taking into consideration samples comprising more than 5 individuals. Most of the samples with one species (*Stygarctus gourbaultae* Renaud-Mornant) consist of fine sand, md< 250 μm and display high number of specimens. The highest diversity was at station 6 with 5 species for 20 individuals (5/20) in November 1984 and 5/21 in April 1979, and in station 2 (4/5 in April 1979 and 3/11 in April 1984).

Nematodes. - Altogether 122 species of freeliving nematodes belonging to 112 genera were found. The number of species in any one sample ranged from 7 to 29.

The MDS of standardized square root transformed data (Fig. 5a and b) is based on abundance of *genera* rather than species, since although species within a genus were separated for each station, the matching of species identities between samples is uncertain. The grouping of samples at a given location over time is quite tight for some locations (e.g. 9 and 6), but there is considerable temporal variability in species composition at other locations (e.g. 2 and 22).

Variability, quantified by the Index of Multivariate Dispersion, is given in Table 2, which indicates a ranking from the least to most variable stations 9<6<14<4<22<2. This roughly corresponds with the ranking of sites relative to the degree of low to high exposure to wave action. Samples with the coarser sediments tend to cluster together on the MDS (Fig. 5a, b), and a one-way ANOSIM test shows a highly significant difference between the generic composition of samples with a median particle diameter of <350 mm (fine-medium sand) and those with a particle diameter of >350 mm (coarse sand) (sample statistic 0.228, significance level 0.0% with 5000 permutations). The genera which mainly contribute to the dissimilarity between these two groups of samples (from a SIMPER analysis) are given in Table 3.

A variety of univariate measures for the nematode species data are given in Table 4. There is a considerable degree of spatial and temporal variability in all these measures, but no significant correlation between any of the diversity indices and sediment grain size; i.e. although the species composition is affected by grain size, the diversity is not.

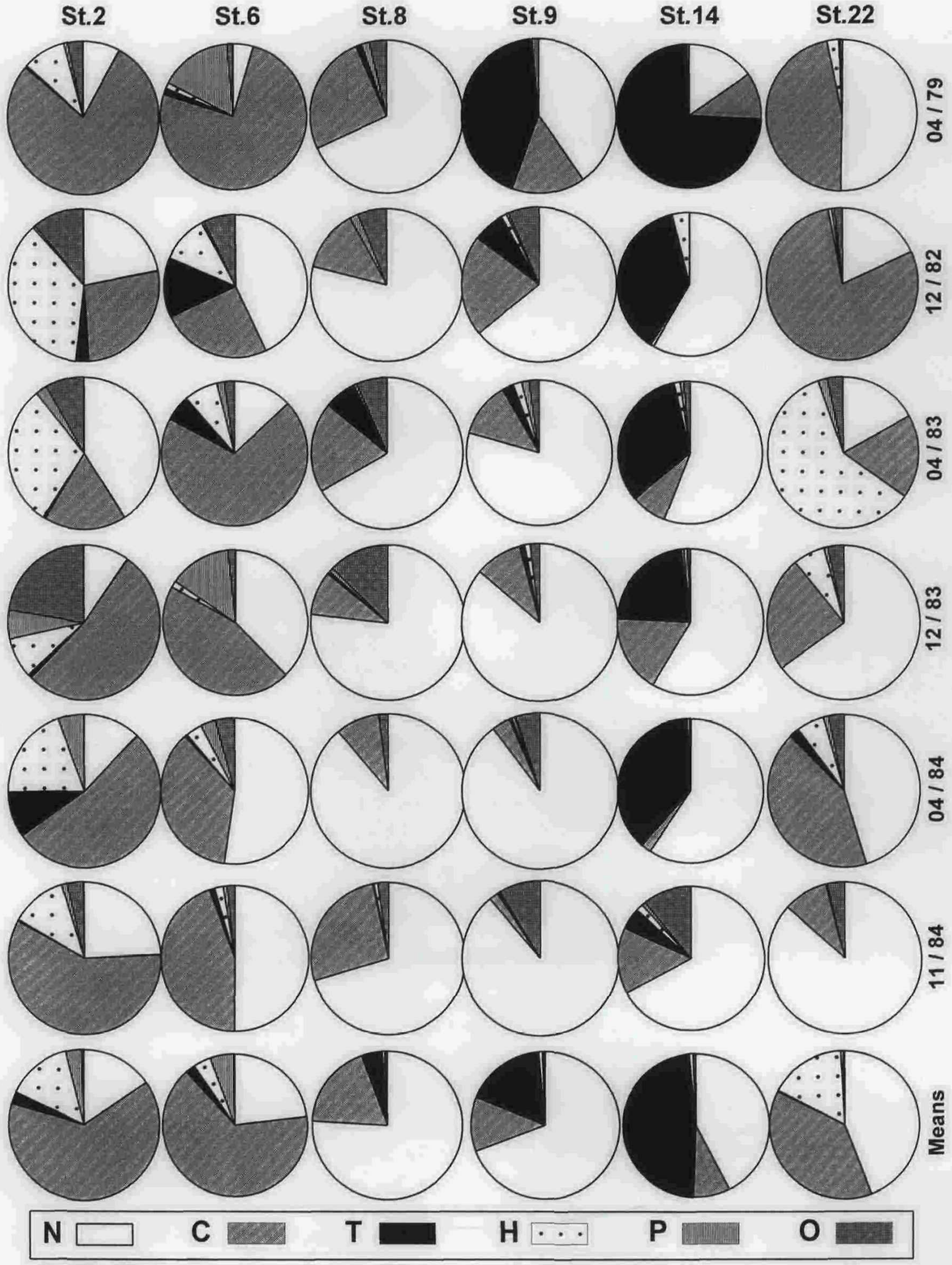


Figure 2. Distribution (means) of the main taxa (lettered as in Fig. 1) in the monitored stations from April 1979 to November 1984 and the mean values for all sampling times.

Figure 2. Pourcentages (moyennes) des principaux taxa (même légende que Fig. 1) des stations suivies d'avril 1979 à novembre 1984 et moyenne générale par station.

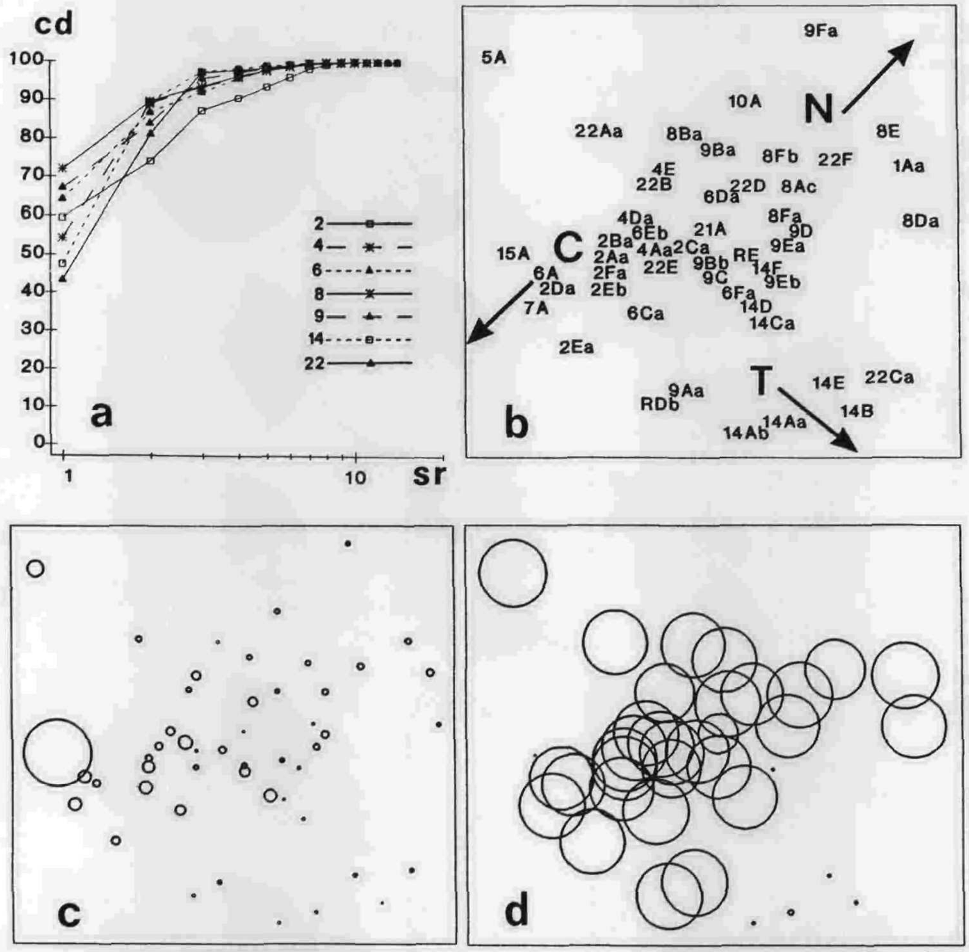


Figure 3. Meiofauna groups: (a) *k*-dominance curves for monitored sites 2, 4, 6, 8, 9, 14 and 22 (cd = cumulative % dominance; sr = species rank); b) non-metric MDS ordination of samples for which environmental data are available; arrows indicate predominance of nematodes (N), copepods (C) and tardigrades (T); the stations are numbered, the capital letters refer to the sampling date (see Table 4), and the small letters (a, b or c) refer to the replicate; (c) as (b), but with sample numbers replaced by circles scaled in size to represent median particle diameter; (d) as (b), but with sample numbers replaced by circles scaled in size to represent % of Ca CO^3.

Figure 3. Méiofaune : (a) diagrammes de "k-dominance" pour les stations expérimentales 2, 4, 6, 8, 9, 14,et 22 (cd = pourcentage des abondances cumulées ; sr = rang des différentes espèces) ; b) ordination non-métrique MDS des échantillons pour lesquels les données environnementales sont connues; les flèches rendent compte de la prédominance des nématodes (N), copépodes (C) et tardigrades (T) ; chaque point comporte le numéro de la station et la date du prélèvement exprimée par une majuscule (cf tableau 4), les minuscules a, b, ou c signalent les replicats ; (c) semblable à (b), la désignation des échantillons étant remplacée par des cercles dont le diamètre correspond à celui de la médiane des particules sédimentaires ; (d) semblable à (b), le diamètre des cercles correspondant à la valeur du pourcentage de CO^3Ca.

Table 1. Regression analysis for percentage dominance of major taxa against log particle diameter.

Tableau 1. Relation entre la dominance (pourcentage) des principaux taxa et le diamètre des particules sédimentaires (en log).

Taxa	R^2 (%)	Slope sign	F value	Significance
Copepoda	34,42	+	25,19	***
Nematoda	13,29	-	7,35	**
Tardigrada	11,67	-	6,34	*
Polychaeta	6,29	+ / -	3,22	NS
Halacaroidea	0,31	+ / -	0,15	NS

NS = Non-significant, * = p<0.05, ** = p<0.01, *** = p<0.001

The *k*-dominance curves for the temporally monitored stations (Fig. 6) show considerable variation in most cases. There is no correspondence in the trends of increasing or decreasing species dominance profiles among these locations.

Similar variations are found in the percentage of nematode trophic groups. The means calculated for some stations (those with >100 nematode specimens reported on Table 4) are recorded in figure 7. A few species are responsible of the pattern observed. For station **1** (1 sample, md = 340 μm): *Microlaimus* sp. and *Endeolophos* sp.; st. **2** (6 samples, md means 373 μm): Epsilonematidae

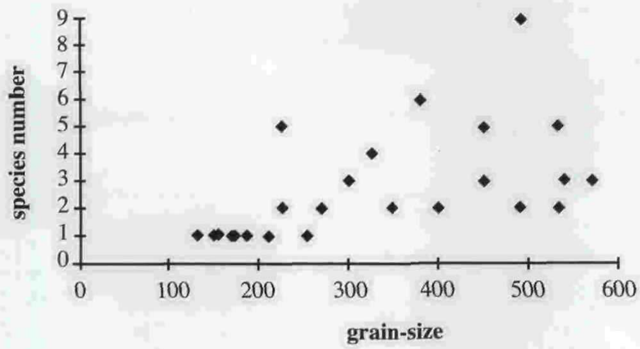


Figure 4. Distribution of the number of species of Tardigrades as a function of grain-size in the beaches.

Figure 4. Relation entre le nombre d'espèces de tardigrades et la granulométrie de l'estran.

(*Metaglochinema globicephalum* Gourbault & Decraemer, *Metepsilonema callosum* Lorenzen), *Tricoma* sp., *Actinonema pachydermatum* Cobb, *Trileptium* sp.; st. **4** (5, md 351 µm): *Dracograllus antillensis* Decraemer & Gourbault, *Metepsilonema bermudae* Lorenzen, *Lauratonema spiculifer* Gerlach, *Paracyatholaimus* sp., *Latronema orcinum* (Gerlach); st. **6** (7, md 498 µm): *Dracognomus simplex* (Gerlach), *Dracograllus antillensis*, *Metaglochinema globicephalum*, *Metepsilonema hardyi* Decraemer & Gourbault; st. **8** (3, md 245 µm): *Prorhynchonema warwicki* Gourbault, Microlaimidae, *Pomponema* sp.; st. **9** (7, md 292 µm): *Haliplectus bickneri*

Table 2. Index of Relative Multivariate Dispersion over time in six monitored beaches in Guadeloupe, arranged in increasing order of dispersion.

Tableau 2. Coefficients de dispersion multivariée des six périodes et six estrans étudiés, classés par ordre croissant de dispersion.

Station n°	Dispersion
9	0,51
6	0,80
14	1,06
4	1,20
22	1,27
2	1,60

Chitwood; *Metepsilonema clasingae* Decraemer & Gourbault, *Rhynchonema sieverti* Gourbault, *Endeolophos minutus* (Gerlach), *Latronema orcinum*; st. **10** (1, 263 µm): *Trichotheristus* sp.; st. **14** (6, 171 µm): *Latronema orcinum*, *Calomicrolaimus* sp., *Haliplectus bickneri*; st. 15 (1, 2500 µm): *Dracognomus simplex*, *Theristus* sp.; st. **18** (1, 165 µm): *Rhynchonema ornatum* Lorenzen, *Microlaimus* sp.; st. **22** (5, 270 µm): *Haconnus millelacunatus* Andrassy; *Rhynchonema dispar* Gourbault, Microlaimidae, *Latronema orcinum*.

Selective deposit feeders with a small non cuticularized buccal cavity dominate at more than 40% in the coarsest coralline sandy beaches, 2, 4 and 6; non-selective deposit feeders occur in volcanic sediments mostly with large populations of *Theristus s.l.*

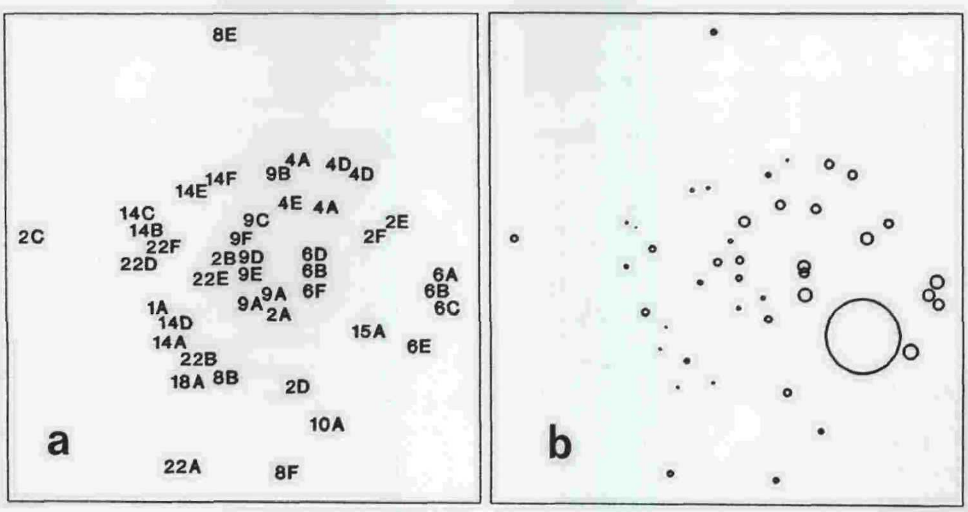


Figure 5. (a) nematode assemblages: non-metric MDS ordination of samples for which environmental data are available, based on square root transformed abundances of genera; (b) as (a), but with sample numbers replaced by circles scaled in size to represent median particle diameter.

Figure 5. (a) ordination non-métrique MDS des échantillons pour lesquels les données environnementales sont connues, basée sur l'analyse (racine carrée des abondances) des genres de nématodes ; chaque point comporte le numéro de la station et la date du prélèvement exprimée par une majuscule (cf tableau 4) ; (b) semblable à (a), la désignation des échantillons étant remplacée par des cercles dont le diamètre correspond à celui de la médiane des particules sédimentaires.

Table 3. Nematode genera responsible for the Bray-Curtis dissimilarity between group 1 (coarsest sediments, md>350 μm) and group 2 (finer sand with md< 350 μm), ranked in order of importance of their contribution to the average dissimilarity (77.88).

Tableau 3. Genres de nématodes les plus impliqués dans les coefficients de distance (Bray-Curtis) entre les groupes 1 (sables les + grossiers, md>350 μm) et 2 (md< 350 μm), classés par ordre d'importance de leur contribution à la distance moyenne (77,88).

Genera	Group 1 av.abund.	Group 2 av.abund.	av. term.	Cum. %
Dracognomus	18,5	0,0	5,3	6,8
Latronema	5,7	17,3	4,5	12,6
Microlaimus	2,7	17,5	4,4	18,2
Metepsilonema	13,9	4,0	4,3	23,7
Haliplectus	7,9	6,5	3,2	27,8
Dracograllus	6,5	0,0	2,6	31,2
Theristus	5,8	1,9	2,4	34,3
Trileptium	4,2	1,3	2,1	37,0
Endeolophos	1,6	3,2	1,9	39,5
Calomicrolaimus	0,4	4,9	1,9	41,9
Perepsilonema	2,4	1,0	1,7	44,2
Bathylaimus	2,0	1,6	1,6	46,3
Rhabditis	1,0	2,5	1,6	48,4
Paracyatholaimus	2,0	1,9	1,6	50,4
Desmoscolex	1,7	1,1	1,6	52,5
Rhynchonema	0,2	2,3	1,6	54,4
Tricoma	1,2	1,5	1,4	56,2
Haconnus	0,3	2,1	1,3	57,9
Procamacolaimus	1,4	0,9	1,3	59,6
Dorylaimus	1,2	1,3	1,3	61,3
Metaglochinema	1,4	3,5	1,2	62,8
Molgolaimus	0,1	3,4	1,1	64,2
Oncholaimus	0,9	0,4	1,1	65,5
Halalaimus	0,4	1,2	1,0	66,8
Litinium	0,9	0,3	0,9	68,0
Actinonema	1,1	0,9	0,9	69,2
Viscosia	0,3	0,8	0,9	70,3
Leptepsilonema	1,2	0,3	0,9	71,5
Bathyepsilonema	1,0	0,1	0,9	72,6
Syringolaimus	1,1	0,2	0,8	73,6
Innocuonema	0,8	0,2	0,8	74,7
Platycoma	0,3	0,5	0,7	75,6
Chromaspirinia	0,1	0,5	0,7	76,4
Sigmophoranema	0,4	0,5	0,6	77,2
Eubostrichus	0,2	0,7	0,6	77,9
Eurystomina	0,1	0,6	0,6	78,7
Chromadorita	0,4	0,5	0,6	79,4

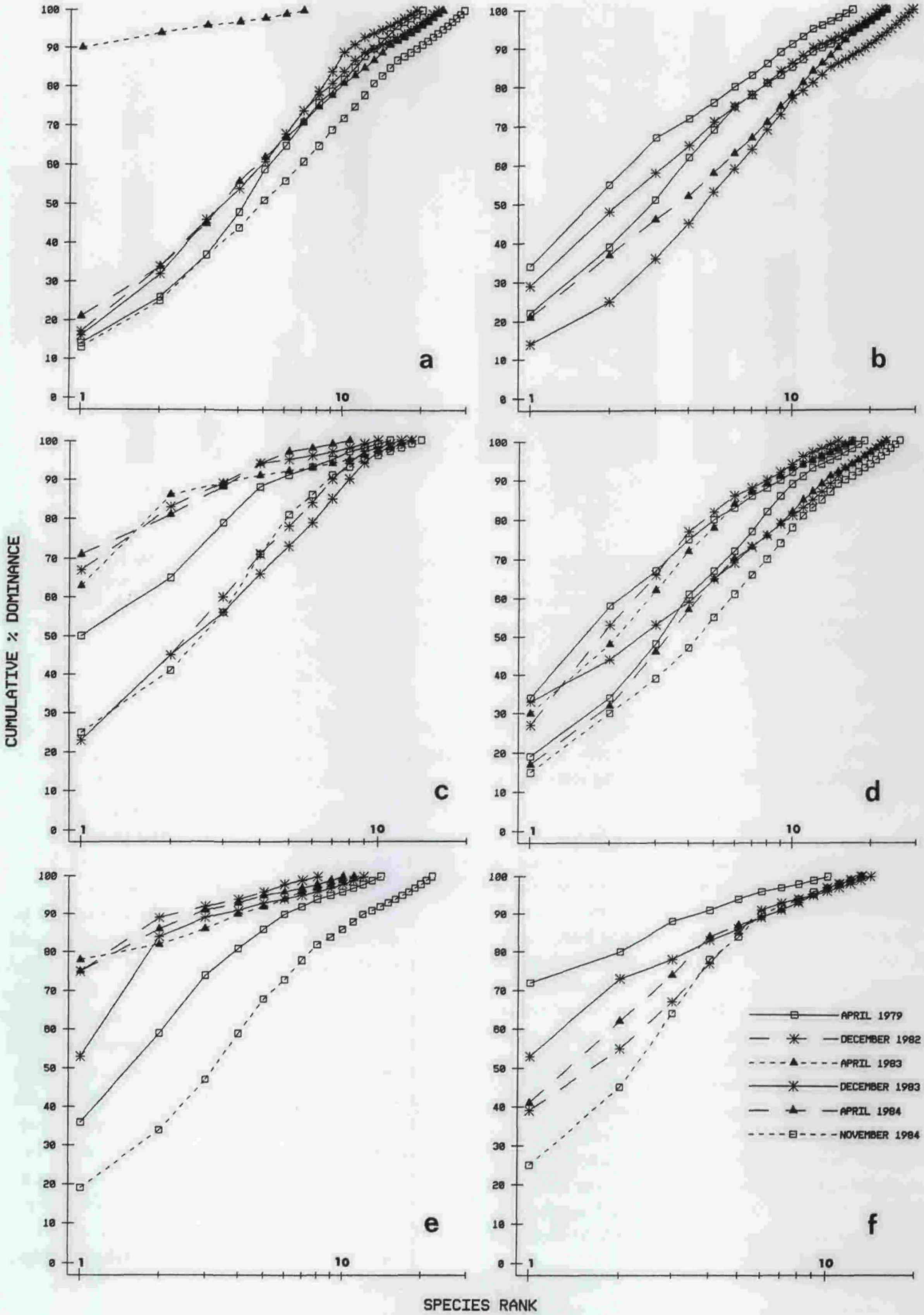
Table 4. Species number (N), species richness (S), Shannon index (H') and evenness (J') calculated for 100 nematodes from each sample.

Tableau 4. Nombre d'espèces (N), richesse spécifique (S), diversité spécifique indice de Shannon (H') et équitabilité (J) calculés pour 100 nématodes dans chaque échantillon.

Stations Samples	Date	N	S	H' (log e)	J'
1 A	April 1979	15	3,04	1,70	62,8
2 A	April 1979	20	4,13	2,66	88,9
2 B	December 1982	19	3,91	2,53	85,9
2 C	April 1983	7	1,30	0,48	25,0
2 D	December 1983	23	4,78	2,63	84,0
2 E	April 1984	24	4,99	2,67	84,0
2 F	November 1984	29	6,08	2,96	87,8
4 Aa	April 1979	17	3,47	2,14	75,4
4 Ab	April 1979	23	4,78	2,52	80,3
4 Da	December 1983	22	4,56	2,40	77,6
4 Db	December 1983	29	6,08	2,91	86,4
4 E	April 1984	23	4,78	2,69	85,9
6 A	April 1979	11	2,17	1,60	66,8
6 Ba	December 1982	10	1,95	1,16	50,2
6 Bb	December 1982	12	2,39	2,09	84,3
6 C	April 1983	13	2,61	1,23	47,8
6 D	December 1983	13	2,61	2,19	85,4
6 E	April 1984	8	1,52	1,07	51,5
6 F	November 1984	14	2,82	2,13	80,5
8 B	December 1982	19	3,91	1,98	67,4
8 E	April 1984	14	2,82	1,37	52,0
8 F	November 1984	15	3,04	1,92	70,7
9 Aa	April 1979	19	3,91	2,47	83,9
9 Ab	April 1979	17	3,47	2,08	73,3
9 B	December 1982	15	3,04	2,07	76,3
9 C	April 1983	17	3,47	2,18	76,8
9 D	December 1983	23	4,78	2,50	79,8
9 E	April 1984	23	4,78	2,63	83,9
9 F	November 1984	26	5,43	2,82	86,5
10 A	April 1979	16	3,26	1,98	71,3
14 A	April 1979	14	2,82	1,89	71,5
14 B	December 1982	8	1,52	0,92	44,4
14 C	April 1983	11	2,17	1,00	41,7
14 D	December 1983	12	2,39	1,33	53,4
14 E	April 1984	10	1,95	0,99	43,2
14 F	November 1984	22	4,56	2,54	82,1
15 A	April 1979	18	3,69	1,89	65,2
18 A	April 1979	13	2,61	1,22	47,6
22 A	April 1979	10	1,95	1,11	48,4
22 B	December 1982	14	2,82	1,92	72,6
22 D	December 1983	13	2,61	1,62	63,1
22 E	April 1984	13	2,61	1,81	70,7
22 F	November 1984	13	2,61	2,02	78,6

Figure 6. Nematodes assemblages; *k*-dominance curves for selected monitored sites: (a) st.2, (b) st. 4, (c) st.6, (d) st. 9; (e) st.14, (f) st.22.

Figure 6. Distribution d'abondance des nématodes des sites sélectionnés pour le suivi : (a) st.2, (b) st. 4, (c) st.6, (d) st. 9 ; (e) st.14, (f) st.22.


CUMULATIVE % DOMINANCE
SPECIES RANK
a
b
c
d
e
f
APRIL 1979
DECEMBER 1982
APRIL 1983
DECEMBER 1983
APRIL 1984
NOVEMBER 1984

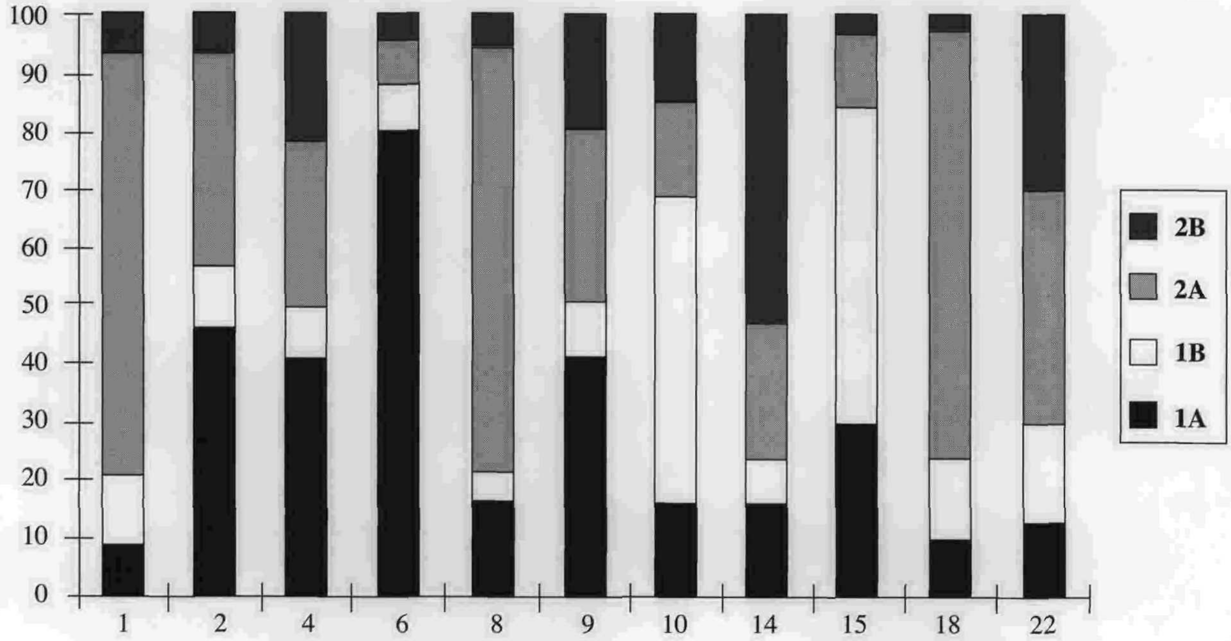


Figure 7. Distribution of the 4 major nematode trophic groups (1A = selective deposit - bacteria - feeders, 1B = non-selective deposit feeders, 2A = epistrate - diatoms - feeders, 2B = predators/omnivores) for stations which had >100 nematodes (means), see Table 4.

Figure 7. Pourcentage des groupes trophiques de nématodes (1A = déposivores sélectifs et bactériophages ; 1B = déposivores non-sélectifs ; 2A = suçeurs d'épistrates et perceurs de diatomées ; 2B = prédateurs/omnivores) dans les échantillons où leur nombre est supérieur à 100 (moyennes), voir tableau 4.

In the sheltered stations 1, 8 and 18, epistrate feeders clearly dominate, whereas carnivore/omnivores are more numerous in the exposed beaches with lower organic content.

Discussion

The sand-beaches of Guadeloupe clearly constitute a favourable habitat for a diverse assemblage of meiofaunal taxa, tardigrade and nematode species. Unfortunately very few comparable data exist for other tropical beaches: for example, none of the papers mentioned in the Introduction give diversity indices. Consequently, we are not able to make broader comparisons. However, in terms of the objectives of this study, to establish a baseline against which future changes can be monitored, the results are not particularly encouraging in view of the high degree of spatial and temporal variability in community composition and diversity. For example, switches from copepod dominance to nematode dominance which might be regarded as indicative of organic pollution, are shown to occur naturally over short periods of time (< 1 year) on the same beach. Great care would therefore need to be exercised in the interpretation of such changes.

The sampling strategy adopted here to assess temporal changes is obviously less than ideal, since there is no replication and the KC samples are not strictly quantitative. However, KC samples can be regarded as a good compromise, since the method does collect meiofauna from a relatively large area of the beach when compared with small core samples of sediment, and provides an average picture of species composition over that area.

Changes in community structure and composition in the narrow microtidal beaches here are considered to result from stochastic events in both the terrestrial (freshwater runoff) and marine (storms, hurricanes: David, 29 August 1979; Hugo, 16-17 September 1989) environment, and it would clearly be difficult to assess anthropogenic effects against such an unstable and unpredictable baseline. This is particularly true for physical disturbances that might result in changes in sediment composition and mobility. However, increased eutrophication resulting from sewage or agricultural runoff is likely to result in changes in species composition that fall outside the currently observed range of variability, so that these will probably be detectable.

Monitoring in the vicinity of intensive tourist development areas might establish whether significant changes have already occurred in the decade since the surveys described here were undertaken.

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