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Crustacean Decapods from Cardenas Bay and the macrolagoon of the Sabana-Camagüey Archipelago (Northern coast of Cuba)

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Abstract. A total of 126 species of decapods were collected in the soft bottoms of the macrolagoon of the Sabana-Camagüey Archipelago and Cardenas Bay (North coast of Cuba). The faunistic data pooled by sectors (Cardenas Bay, Santa Clara Bay, Fragoso Key to San Juán de los Remedios, Buenavista Bay-Coco Key and Perros Bay-Sabinal) and the environmental characteristics (salinity, organic material, particle size of the sediment, depth and presence of algae and seagrasses) are given. Dominant species were: *Neopanope packcardii*, *Tozeuma carolinense*, *Sicyonia typica*, *Alpheus normanni*, *Petrolisthes armatus* and *Synalpheus brooksi*, though distributions and abundances vary within the area. The highest values of abundances and richness were found in sectors open to the ocean, in which there are intense water exchanges, values of salinity close to those of open sea and well developed vegetal communities; in this way, the richness showed a significant correlation with the total seagrass and algal biomass. These factors are postulated to explain the similarity found between some sectors (as shown in the aggregation and MDS ordination analysis). Conversely, poor abundance and richness was found in the eastern sector, Perros Bay to Sabinal, relatively isolated from the ocean, with high salinity and water temperature and scarce development of vegetal communities. These unfavourable conditions have been exacerbated by the construction of "pedraplenes" (berm or landfill roads built across the macrolagoon), which makes necessary the development of a management program.

Résumé. *Crustacés décapodes de la Baie de Cardenas et de la macro-lagune de l'archipel de Sabana-Camagüey (côte nord de Cuba)*. Un total de 126 espèces de crustacés décapodes a été récolté sur les fonds meubles de la macro-lagune de l'archipel Sabana-Camagüey et de la Baie de Cardenas (côte nord de Cuba). Les données faunistiques cumulées par secteur (Baie de Cardenas, Baie de Santa Clara, Caye Fragoso à San Juán de los Remedios, Baie de Buenavista-Caye Coco et Baie de Perros-Sabinal) et les caractéristiques de l'environnement (salinité, matière organique, granulométrie, profondeur, et présence d'algues ou d'herbiers) sont données. Les espèces dominantes sont: *Neopanope packcardii, Tozeuma carolinense*, *Sicyonia typica, Alpheus normanni, Petrolisthes armatus* et *Synalpheus brooksi*, mais les distributions et les abondances des espèces varient dans la zone étudiée. Dans la macro-lagune, les valeurs les plus élevées d'abondance et de richesse spécifique correspondent aux secteurs ouverts à l'océan, dans lesquels il y a des échanges d'eau importants, une salinité proche de celle de la mer ouverte et une couverture végétale bien développée ; de sorte que la richesse est corrélée de façon significative avec la biomasse végétale totale. Ces facteurs sont invoqués pour expliquer la similitude reconnue entre certains

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secteurs (comme le montrent les données de similarité et les analyses multivariées MDS). Au contraire, des abondances et richesses spécifiques faibles sont observées dans le secteur est, de la Baie de Perros à Sabinal, relativement isolé de l'océan, aux salinités et aux températures élevées et à la couverture végétale éparse. Ces conditions défavorables ont été exacerbées par la construction de digues traversant la lagune, de sorte qu'un programme de gestion devrait être mis en place.

Keywords: Crustacean decapods, Cuba, Biodiversity, Biogeography.

Introduction

The Sabana-Camaguey Archipelago is constituted by more than 2500 island-keys close to the shore along 465 km of the Central-North Coast of Cuba. This archipelago delimits an inner and interconnected water mass system of few meters deep that forms a macrolagoon. The high ecological importance of this archipelago includes a broad variety of habitats and marine ecosystems, such as beaches, mangroves, coral reef, among others.

Also, this area is an important zone of socio-economic development, with a substantial fishery and tourism activity. In the western margin is found Cardenas City, with several industries and fisheries and the tourist complex of Varadero, and in the eastern part are found other tourist resorts complexes, such as Coco Key and Guillermo Key.

This human activity and economic development depend upon maintaining good health of the ecosystem, but if this development is inappropriate it will be negative for the ecosystem, for the biodiversity and consequently for the economy. An example of inadequate environmental management has been the construction of "pedraplenes", landfill roads built across the macrolagoon, which connect the keys with the mainland and impede, reduce or modify the water flows, modifying the abiotic conditions and, consequently, the biotopes and the structure of communities. These constructions appear to have an evident effect on the macrolagoon and adjacent lands: for example, around the Coco Key "pedraplen", there are zones where mangroves have died.

Considering the high ecological value of this area, the Institute of Oceanología of Cuba made a comprehensive survey for general overview of the communities, measurement of biodiversity of the megazoobenthos (specimens with size > 4 mm; Alcolado et al., 1998) and characterization of the abiotic characteristics in the Sabana-Camagüey Archipelago and Cardenas Bay.

Results of this research are the studies on chemical oceanography (Lluis-Riera 1981, 1983, 1984; Lluis-Riera et al., 1989), physical oceanography (Rodríguez-Portal & Rodríguez-Ramirez, 1983; Fernández-Vila et al., 1990), geology (Zenkovich & Ionin, 1969; Ionin et al., 1972a; Ionin et al., 1972b; Gil-Valdéz, 1988), plankton (Kabanova & López-Baluja, 1973; Fabré & Campos, 1980; Orozco et al., 1980; Borrero et al., 1981), bivalve mollusc (Herrera & Espinosa, 1988), macrobenthos (Jiménez & Ibarzabal, 1982; Alcolado et al., 1998) and ecology (Alcolado et al., 1990a; 1990b and Alcolado et al., 1999). Some information on the decapods is given by Alcolado et al. (1998).

The aim of this paper is to provide a descriptive and global information on the Decapoda community living in a very large area, the macrolagoon of the Sabana-Camagüey Archipelago (soft bottoms) including Cardenas Bay (in the western margin), with emphasis on the biodiversity and general distribution of species.

Material ad methods

The material was collected during two expeditions conducted by the Institute of Oceanología of Cuba. The samples of the Sabana-Camagüey Archipelago, from Santa Clara to Sabinal (Fig. 1) were taken using a toothed dredge with a 70 x 25 cm opening, and a net mesh of 4 mm, from March 28th to May 8th of 1989; and the samples from Cardenas Bay (Fig. 1) were taken during February 1985, using a dredge with a 1 m wide opening, and a net mesh of 4 mm. For the analysis a network of sampling stations was designed (Fig. 1). Trawling speed was one knot during approximately 1 minute. This sampling method was designed to get a general view of all megabenthos on soft bottoms (Alcolado et al., 1998).

The specimens collected were identified, quantified and deposited in the "Instituto de Oceanología". The quantitative values by samples in each sector were referred to a similar area of about 22 m^2; these values must be taken into account as a first appointment because we have used a general sampling methodology (for all megabenthos) and in the studied zone many habitats and microhabitats exist, many of them not always accessible with this methodology; furthermore because of the high mobility of several decapod species. However these estimates give a general view and could be very useful for next specific studies.

To determine the relationships along the studied area five sectors were established, taking into account the existence of bays, the human constructions (such as berm or landfill roads ("pedraplenes") built across the macrolagoon) and the interactions or exchanges with the open ocean, which define different conditions and, consequently, differentiate sectors.

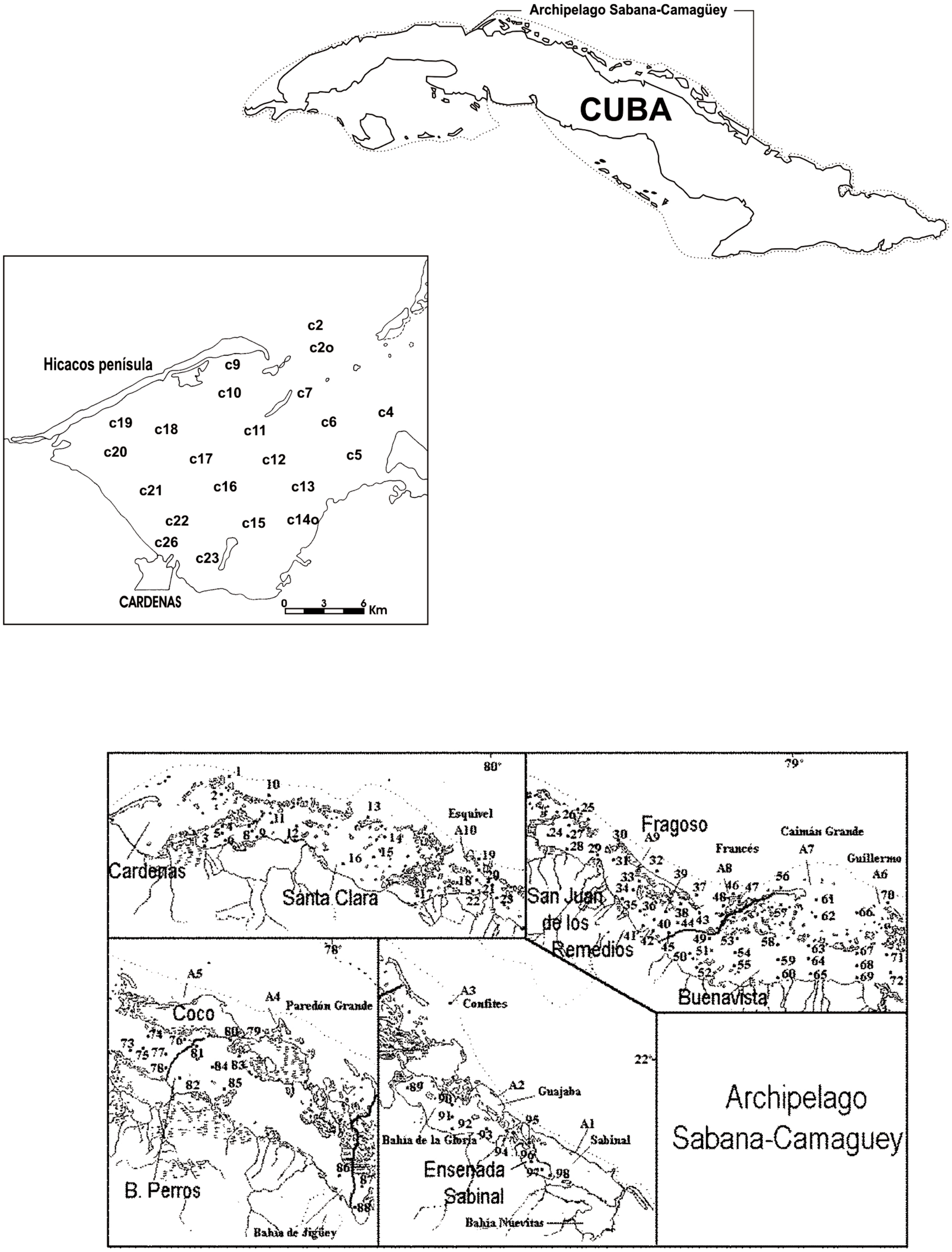

Figure 1. Study area and sampling stations.
Figure 1. Région étudiée et localités d'échantillonnage

These sectors were (Fig. 1): Cárdenas Bay (samples c1 to c26), Santa Clara Bay (SC, samples: 1 to 23), Fragoso Key - San Juán de los Remedios (F-SJ, samples 24 to 48), Buenavista Bay - Coco Key (BB-CC, samples 49 to 78) and Perros Bay - Sabinal (PB-Sa, samples 79 to 98).

The environmental characteristics of each sampling point were analysed (salinity, organic material, particle size of the sediment, depth and presence of algae or seagrasses). The organic material (MOS) from the superficial sediment (1-2 cm, obtained with a small dredge) was obtained by calcinations (after sieving through a mesh size of 1 mm). The granulometric study was made in the Department of Geology of the Instituto de Oceanología. The salinities were determined by conductivity.

Comparative analyses of decapod community between sectors were made and the samples of each sector were grouped. Theses assemblages do not allow us to detect variability between sampling points but provide us a general view by sectors, reducing the possible errors or variations consequences of local and temporal changes (e.g. sampling in different hours or days) and reducing the limitations before mentioned in the considerations on quantitative values. For this analysis the PRIMER software (Plymouth Routines In Multivariate Ecological Research) (Clarke & Warwick, 1994) was employed, using the quantitative and qualitative data with a square root transformation. The Bray-Curtis similarity index was calculated and an aggregation (program CLUSTER) and ordination analysis (program MDS) were made, and for comparing sectors the AMOSIN analysis was used. In addition, the abundance curves (species rank - relative abundance) (Magurran, 1989) have been represented.

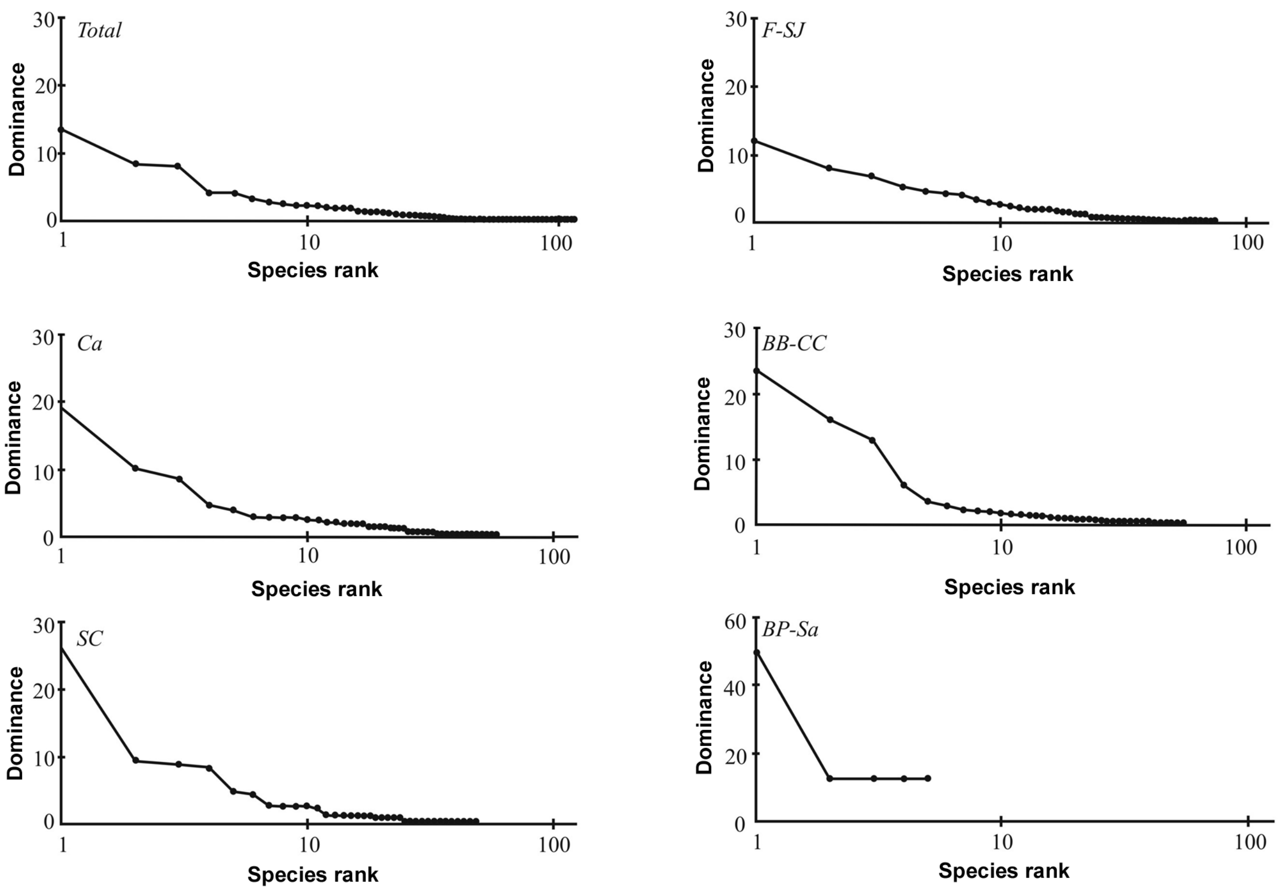

Figure 2. Abundances curves by sector (Ca: Cardenas Bay, SC: Santa Clara, F-SJ: Fragoso-San Juán de los Remedios, BB-CC: Buenavista Bay-Coco Key, PB-Sa: Perros Bay-Sabinal) and in general (Total).

Figure 2. Courbes d'abondances par secteur (Ca : Baie de Cardenas, SC : Santa Clara, F-SJ : Fragoso-San Juán de los Remedios, BB-CC : Baie de Buenavista-Caye Coco, PB-Sa : Baie de Perros-Sabinal) et en général (Total).

Table 1. Characteristics of the sampling stations (St.). D(m): depth in meters. Sal.: salinity. O.M.: Organic material. M: Mud. T: Superficial temperature of water. BF: Seagrass biomass. BA: Macroalgae biomass. BH Biomass of the macroalgae *Halimeda spp*. (Biomasses in $g.m^{-2}$). Samples 1-23: Santa Clara sector (SC), 24-48: Fragoso-San Juán de los Remedios sector (F-SJ), 49-78: Buenavista Bay-Coco Key sector (BB-CC) and 79-98: Perros Bay-Sabinal sector (PB-Sa). The biomass data by Beatriz Martínez-Daranas in *Archivos Científicos Instituto de Oceanología de Cuba* (unpublished data). Nd: no data.

Tableau 1. Caractéristiques des stations d'échantillonnage (St.). D(m) : profondeur en mètres. Sal. : Salinité. O.M. : Matière organique. M : Vase. T : Température de surface de l'eau. BF : Biomasse de phanérogames. BA : Biomasse de macroalgues. BH : Biomasse des macroalgues *Halimeda spp*. (Biomasses en $g.m^{-2}$). Echantillons 1-23 : secteur de Santa Clara (SC), 24-48 : secteur Fragoso-San Juán de los Remedios (F-SJ), 49-78 : secteur Baie de Buenavista-Caye Coco (BB-CC) et 79-98 : secteur Baie de Perros-Sabinal (PB-Sa). Données de biomasses de Beatriz Martínez-Daranas dans *Archivos Científicos Instituto de Oceanología de Cuba* (non publiées). Nd : données non disponibles.

St.	D(m)	Sal.	O.M. (%)	M (%)	T °C	BF	BA	BH
1	2.8	37.3	4.7	0	nd	41	155	97
2	2	38.3	20.6	45.86	nd	112	0	0
3	2.8	41.2	15.2	34.48	25.8	0	0	0
4	2	38.4	17.4	17.02	22.9	6	0	0
5	3	40.9	17,0	35.44	23.5	0	0	0
6	2	40.7	8.8	16.19	24.9	2	2	0
7	2.5	40.5	9,0	30.01	20	18	1	0
8	3	41.3	10.3	20.68	19.8	6	3	0
9	3	41.5	10.1	17.96	19.3	5	1	0
10	3.7	36.9	4.7	33.12	21	73	301	284
11	3	40.2	13.5	30.31	18	8	0	0
12	3	40.3	18.9	77.84	18	6	1	0
13	3	36.6	4.9	32.35	27.3	46	149	134
14	2.3	37.5	4.7	4.64	27	3	26	16
15	2.5	41.8	12.7	47.96	26	20	0	0
16	2.9	43.2	10.4	35.85	26	3	92	0
17	1	40.1	25,0	1.96	21	16	81	0
18	2.7	36.8	14.5	29.81	20	33	470	467
19	4.5	36.4	6.3	8.29	24.7	28	75	59
20	3.9	36.6	17.2	69.01	23	52	0	0
21	4	36.5	17,0	24.42	22	0	0	0
22	4	36.5	11.1	68.94	21	0	0	0
23	4.9	36.1	26.4	31.44	22.5	0	0	0
24	3.5	37	6.4	42.92	23	0	0	0
25	6.7	36.7	6.8	59	26	88	52	41
26	4.5	37	21.1	68.51	24	0	0	0
27	3.5	36.5	13.4	45.7	24	0	0	0
28	3	37.5	3.4	7.38	25	0	0	0
29	4	38.1	nd	16.55	25	17	96	48
30	4	37.2	5.1	35.48	27	56	124	118
31	2	38.4	14.3	46.7	28	16	24	0
32	4.2	37.2	6.2	32.99	26	113	31	26
33	1.5	41.8	16.7	2.26	26.5	1	5	4
34	2	37.9	14,0	39.48	26	4	86	25
35	2.9	38.1	5.9	34.94	27	2	195	5
36	2.5	39	2.8	12.44	27	0	7	0
37	3.5	36.8	3.4	6.48	26	106	3	2
38	2	39.2	10.4	21.34	27	30	34	4
39	3.5	37.3	13.6	50.56	26.5	19	45	26
40	3	37.8	12.1	58.02	26	0	16	16
41	3.5	37.2	8.9	5.25	26	26	3	3
42	2 .0	38.7	7.3	53.22	25.3	8	0	0
43	2.8	39.3	5.3	69.25	26.9	46	100	53
44	3	38.9	13.1	24.3	26	22	119	118
45	2.5	39.2	5.9	3.86	26	8	207	205
46	14	36.5	4,0	53.22	25	0	0	0
47	4.8	36.6	8.5	27.14	25	103	1	0
48	3.5	38.7	4.6	48.8	26	57	24	20
49	2.5	38.6	30.9	63.84	26	37	7	5
50	3	39.7	15.2	21.75	26.2	9	177	170
51	2.5	36.5	19.6	52.07	25	0	0	0
52	2	37.4	24.4	69.08	26	52	0	0
53	3	38.9	7.3	65.56	26	45	1	0
54	4	39.1	34.3	50.83	26	0	0	0
55	4.5	39.2	12.7	53.56	26.2	0	0	0
56	5.8	36.7	2.9	1.03	25.5	0	0	0
57	1.6	38.7	10.4	73.31	24.3	43	14	3
58	4	38.7	10.5	91.78	24.5	1	0	0
59	4.05	38.7	30.3	62.85	24	0	0	0
60	2.6	39.3	4.9	32.5	nd	16	119	117
61	6	36.6	2.9	8.43	24.9	11	44	17
62	2.5	36.9	2.9	3.59	24	31	75	2
63	2.8	37.3	8.9	66.29	24.5	24	132	103
64	3.8	38.9	33.5	57.04	24.5	0	0	0
65	2.3	39	9.5	32.69	24.5	6	12	0
66	3.5	36.8	3.4	5.29	24.5	67	31	0
67	2.9	37.8	17.5	73.84	nd	50	43	11
68	3	39.1	13.9	36.69	23	15	4	4
69	3	38.1	9.1	12.64	22.5	11	42	42
70	3.5	36.9	3.6	2.37	24	17	50	36
71	3.5	39.7	9.7	31.4	24.5	6	0	0
72	2.2	42.1	8.5	43.77	25	10	66	0
73	2.2	60	16.7	69.93	24.5	15	0	0
74	1.7	63.02	12.35	44.03	27	0	35	0
75	1.5	61	37,0	68.04	25	91	0	0
76	1.2	64.22	18.83	30.36	26	4	3	0
77	1.8	60	23.85	55.42	24.5	24	0	0
78	2.6	60	68.15	53.84	24.5	21	1	0
79	2.5	62.13	5.8	47.57	25	93	0	0
80	1	64.68	7.72	66.14	27	5	14	0
81	0.6	52.15	9.82	66.17	27	3	19	0
82	2	60.13	20.38	53.72	27	1	0	0
83	1.5	62.55	9.29	57.61	26	0	0	0
84	1.8	65.57	1.94	86.23	25	0	0	0
85	1	65.98	11.44	68.92	26	0	0	0
86	2.3	46	nd	42.33	nd	0	0	0
87	1.8	46.5	nd	37.9	nd	0	0	0
88	1	38	nd	62.37	nd	0	0	0
89	1.5	39.3	22.7	66.83	28.9	0	0	0
90	2.5	37.7	14.4	39.98	28.7	9	1	0
91	1	36.9	10.6	31.39	28	0	0	0
92	1.3	38.2	13.7	32.45	28	0	0	0
93	1.5	39.3	24.94	37.95	28	0	0	0
94	1	38	7.48	52.12	28	22	4	0
95	2.4	39.5	26.2	74.68	28	81	7	0
96	2.5	45.2	23.4	38.41	28.5	22	4	0
97	4.5	45.4	14.5	30.34	28	25	10	0
98	3.2	nd	nd	39.23	31	0	0	0

Results

The sampling stations with their environmental features are given in Tables 1 and 2. A total of 126 species of decapods was collected, most of them represented by few specimens (Table 3, Fig. 2). Of these, 21 were identified only at genus level because the specimens were juveniles, broken or in bad conditions. No species was caught in all the sectors; however, we know that some species, such as *Callinectes sapidus* Rathbun, 1896, live in the whole Archipelago (probably with low density in some areas), but they may have escaped our dredge sampling; for this reason the abundances of the species of this genus are probably undervalued. In addition, we have caught the species *Tetraplax quadridentata* (Rathbun, 1898) in the area, but not in this study.

The six most abundant species were: *Neopanope packcardii* (Kingsley, 1879), *Tozeuma carolinense* Kingsley, 1878, *Sicyonia typica* (Boeck, 1864), *Alpheus normanni* Kingsley, 1878, *Petrolisthes armatus* (Gibbes, 1850) and *Synalpheus brooksi* Coutière, 1909. Only *Tozeuma carolinense*, *Sicyonia typica* and *Alpheus normanni*, together with other 11 species with lower number of specimens, were present in the 80% of the total studied area. Also, these six species showed a different abundance by sectors. *Petrolisthes armatus* was dominant in Cardenas Bay, *Neopanope packcardii* in all the central sectors, but mainly in Buebavista Bay-Coco Key, *Synalpheus brooksi* in Fragoso Key-San Juan de los Remedios, *Tozeuma carolinense* and *Alpheus normanni* from Fragoso Key to Coco Key and *Sicyonia typica* from Buenavista Bay to Coco Key.

By sector, the highest abundance and richness were found in Fragoso key-San Juan de los Remedios (Table 3) and an extreme poorness was found in the oriental sector, from Perros Bay to Ensenada Sabinal. The richness in the sectors of the macrolagoon showed a significant correlation with the total vegetal biomass of macroalgae + seagrass (Kendall, T = 1, $p < 0.05$). In this way, the values found (species number-vegetal biomass) in the different sectors were, Santa Clara Bay: 60-1835, Fragoso Key-San Juán de los Remedios: 77-1894, Buenavista Bay-Coco Key: 56-1462 and Perros Bay-Sabinal: 6-320 (tables 1, 2 and 3). Between adjacent sectors, the number of shared species was similar (less Cardenas with Santa Clara, which is lower), decreasing with the geographical distance (Table 4).

The dominance curves by sector and the total (Fig. 2) showed a high number of species with few specimens (more than the 70 % with less than 10 specimens) and few species with medium-higher dominances. Also, an evident poorness appeared in Perros Bay-Ensenada Sabinal (BP-Sa), in which there were very few species and low abundances (Table 3).

The quantitative and qualitative aggregation and ordination analyses (Figs. 3 and 4) by sector showed the same results: clear and significant differences in the eastern sector and, also, but to a lesser extent in Cardenas Bay. Even the qualitative analysis of all samples (not grouped) showed a higher significant separation of the eastern sector (AMOSIN: Global R: 0.243, significance level of sample statistic: 0.001. Pairwise tests by group (R, p): Ca/SC (0.238, 0.001); Ca/F-SJR (0.337, 0.001); Ca/BB-CC (0.443, 0.001); Ca/BP-Sa (0.508, 0.001); SC/F-SJR (0.034, 0.1); SC/BB-CC (0.165, 0.003); SC/BP-Sa (0.344, 0.001); SC/BB-CC(0.085, 0.008); F-SJR/BP-Sa (0.404, 0.001); BB-CC/BP-Sa (0.593, 0.001), and no significant difference between Santa Clara and Fragoso-San Juan de los Remedios sectors.

Finally, richness increased in the salinity range 35.0 to 38.5, it decreased in the range 38.5 to 45.0, and between 45.5 to 61.0. There was maintenance of richness with five or four species and only one species could be found at salinity higher than 61.0 (Fig. 5). By sector (tables 1, 2 and 3), the number of species/average salinity showed a negative correlation (Cardenas: 49/38.88; Santa Clara Bay 60/38.9;

Table 2. Characteristics of sampling stations in Cardenas Bay. Md: median, (Th): *Thalassia*, (A): macroalgae, (f): rare, (nd): no data.

Tableau 2. Caractéristiques des localités d'échantillonnage dans la Baie de Cardenas. Md : médiane , (Th) : *Thalassia*, (A) : macroalgues, (f) : rare, (nd) : données non disponibles.

Station	Salinity	Particle size Md (mm)	Depth (m)
2	37.5	0.05 – 0.10	6
2A	37.3	0.25- 0.50	7
3	nd	nd	nd
4	39.74	0.010 – 0.05 (f Th)	4
5	40.16	0.007 – 0.010	3
6	40.21	0.007 – 0.010 (f A)	5
7	39.42	0.010 – 0.05	3.2
8A	nd	< 0.007	5.5
9	37.61	0.010 – 0.05	3.5
10	37.86	0.010 – 0.05 (Th)	3.5
11	38.93	0.007 – 0.010	5
12	40.37	0.007 – 0.010 (f A)	5
13	40.5	0.10 – 0.25	4
14A	nd	< 0.007	3
15	39.09	0.05 – 0.10	3.5
16	39.2	0.010 – 0.05	6
17	38.66	0.010 – 0.05 (f A)	5.5
18	38.57	0.007 – 0.010	6.5
19	38.42	0.010 – 0.05	5.5
20	38.8	0.010 – 0.05 (with Porifera)	4.5
21	nd	nd	nd
22	38.95	0.007 – 0.010	5.5
23	38.3	0.010 – 0.05	3
26	38.6	0.010 – 0.05 (f P)	3
26A	38.33	0.010 – 0.05 (f A)	4
26B	38.73	0.010 – 0.05	5
26C	nd	0.010 – 0.05 (f A)	3

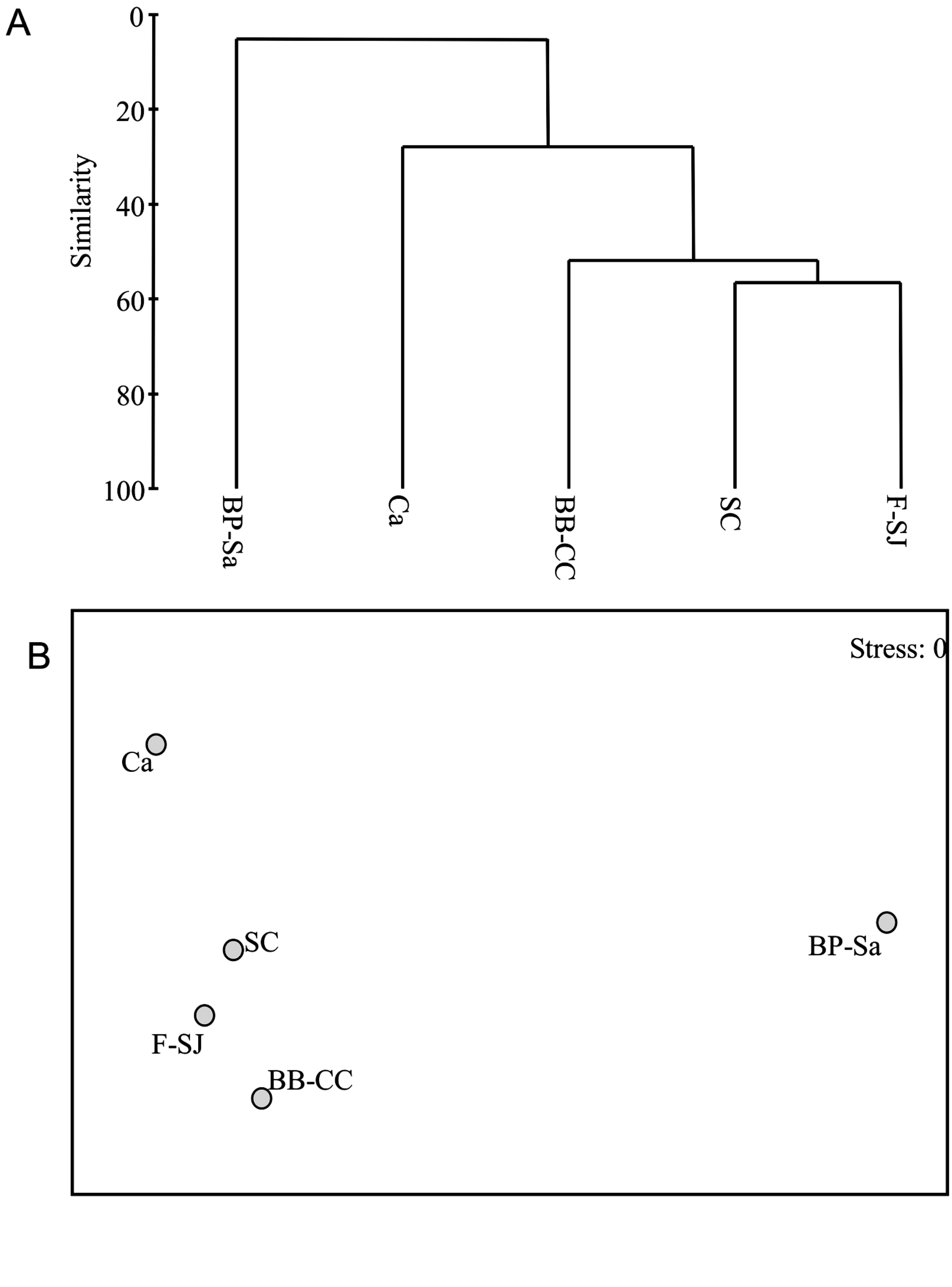

Figure 3. Aggregation (A) and MDS ordination analyses (B) of quantitative data, by sector (Ca: Cardenas Bay, SC: Santa Clara, F-SJ: Fragoso-San Juán de los Remedios, BB-CC: Buenavista Bay-Coco Key, PB-Sa: Perros Bay-Sabinal).

Figure 3. Agrégation (A) et ordination multidimensionnelle MDS (B) des valeurs quantitatives, par secteur (Ca: Baie de Cardenas, SC: Santa Clara, F-SJ: Fragoso-San Juán de los Remedios, BB-CC: Baie de Buenavista-Caye Coco, PB-Sa: Baie de Perros-Sabinal).

Table 3. Number of specimens (n) collected in an area of around 22 m^2, in Cardenas Bay (Ca) and in the macrolagoon of the Archipelago Sabana-Camagüey: in Santa Clara sector (SC), Fragoso-San Juán de los Remedios sector (F-SJ), Buenavista Bay-Coco Key sector (BB-CC) and Perros Bay-Sabinal sector (PB-Sa). Pt%: presence of the species in the whole area. Nt: total number of specimens.

Tableau 3. Nombre d'individus (n) récoltés sur une surface d'environ 22 m^2, dans la Baie de Cardenas (Ca) et dans la macro-lagune de l'Archipel Sabana-Camagüey : secteur Santa Clara (SC), secteur Fragoso-San Juán de los Remedios (F-SJ), secteur Baie de Buenavista-Caye Coco (BB-CC) et secteur Baie de Perros-Sabinal (PB-Sa). Pt% : présence dans la région étudiée, Nt : nombre total d'individus.

	Ca	Sc	F-SJ	BB-CC	PB-Sa		
Species	n	n	n	n	n	Pt%	Nt
Acantholobulus bermudensis? (Benedict & Rathbun, 1891)	1	0	0	0	0	20	1
Alpheus amblyonyx Chace, 1972	0	0	1	0	0	20	1
Alpheus armillatus H. Milne Edwars,1837	0	1	2	0	0	40	3
Alpheus floridanus Kingsley, 1878	20	2	6	0	0	60	28
Alpheus heterochaelis? Say, 1818	6	0	0	0	0	20	6
Alpheus normanni Kingsley, 1878	10	7	23	53	0	80	93
Alpheus sp	0	2	8	0	1	60	11
Anchistioides antiguensis (Schmitt, 1924)	0	1	0	0	0	20	1
Automate rectifrons Chace,1972	1	0	0	0	0	20	1
Brachycarpus biunguiculatus (Lucas, 1849)	0	1	2	0	0	40	3
Calappa gallus (Herbst, 1803)	1	0	0	0	0	20	1
Calcinus tibicen (Herbst, 1791)	0	0	1	0	0	20	1
Callinectes ornatus Ordway, 1863	2	13	4	9	0	80	28
Callinectes sapidus Rathbun, 1896	0	1	2	3	4	80	10
Callinectes sp	0	0	0	2	0	20	2
Clibanarius sp	0	1	0	0	0	20	1
Clibanarius tricolor (Gibbes, 1850)	0	0	8	2	0	40	10
Clypeasterophilus rugatus Bouvier, 1917	0	0	0	3	0	20	3
Cryptosoma balguerii (Desbonne, 1867)	1	0	0	0	0	20	1
Cronius tumidulus (Stimpson, 1871)	1	0	3	4	0	60	8
Cyrtoplax spinidentata (Benedict, 1802)	10	8	2	2	0	80	22
Ebalia cariosa Stimpson, 1860	2	0	0	0	0	20	2
Eucratopsis crassimanus (Dana, 1851)	21	0	1	5	0	60	27
Eurypanopeus turgidus (Rathbun, 1930)	2	2	6	0	0	20	2
Farfantepenaeus aztecus? (Ives, 1891)	0	0	1	0	0	20	1
Farfantepenaeus brasiliensis (Latreille, 1817)	0	0	1	0	0	20	1
Farfantepenaeus notialis (Pérez-Farfante, 1967)	0	7	14	15	0	60	36
Euryplax nitida Stimpson, 1859	1	0	0	0	0	20	1
Hepatus pudibundus (Herbst, 1785)	1	1	0	0	0	40	2
Heterocrypta granulata (Gibbes, 1850)	1	3	0	0	0	40	4
Hexapanopeus caribbaeus (Stimpson, 1871)	0	0	2	0	0	20	2
Hippolyte zostericola (Smith, 1873)	0	0	1	0	0	20	1
Iridopagurus sp	2	0	4	3	0	60	9
Latreutes fucorum (Fabricius, 1798)	0	0	1	1	0	40	2
Leander paulensis Ortmann, 1897	0	1	0	2	0	40	3
Leander tenuicornis (Say, 1818)	1	1	3	0	0	60	5
Leptochela serratorbita Bate, 1818	1	0	0	0	0	20	1
Libinia erinacea A. Milne Edwards, 1879	0	1	0	0	0	20	1
Libinia dubia H. Milne Edwards, 1834	0	0	0	1	0	20	1
Libinia rhomboidea Streets, 1870	0	0	0	2	0	20	2
Libinia sp	0	0	0	1	0	20	1
Macrocoeloma eutheca (Stimpson, 1871)	0	1	0	0	0	20	1
Macrocoeloma sp	0	0	1	0	0	20	1
Macrocoeloma trispinosum (Latreille, 1825)	1	4	3	7	0	80	15
Menippe mercenaria (Say, 1818)	1	0	1	0	0	40	2
Metapenaeopsis goodei (Smith, 1885)	0	1	3	1	0	60	5
Metapenaeopsis martinella Pérez-Farfante, 1971	1	1	3	0	0	60	5

Metapenaeopsis sp	0	0	1	2	0	40	3
Metoporhaphis calcarata (Say, 1818)	0	0	1	4	0	40	5
Microphrys antillensis Rathbun, 1920	0	0	1	0	0	20	1
Microphrys bicornutus (Latreille, 1825)	3	2	5	4	0	80	14
Mithraculus forceps (A. Milne Edwards, 1875)	0	5	3	0	0	40	8
Mithraculus sculptus (Lamarck, 1818)	0	1	0	0	0	20	1
Mithrax hispidus (Herbst, 1790)	0	0	5	0	0	20	5
Mithrax spinosissimus (Lamarck, 1818)	2	0	0	1	1	60	4
Mithrax sp	0	1	2	1	1	80	5
Nanoplax xanthiformis (A. Milne Edwards, 1880)	1	0	0	0	0	20	1
Neopanope packardii (Kingsley, 1879)	0	53	22	121	0	60	196
Paguristes perplexus Mclaughlin & Provenzano, 1974	0	5	8	5	0	60	18
Paguristes tortugae complex Schmitt, 1903	11	0	0	0	0	20	11
Paguristes sp	0	6	18	5	0	60	29
Paguristes sp1	0	0	1	0	0	20	1
Pagurus brevidactylus (Stimpson, 1859)	1	0	3	0	0	40	4
Pagurus carolinensis McLaughlin, 1975	1	0	0	0	0	20	1
Pagurus maclaughlinae Garcia-Gómez, 1982	6	1	2	3	0	80	12
Pagurus sp	0	11	17	4	1	80	33
Pagurus sp1	0	0	1	0	0	20	1
Pagurus stimpsoni (A. Milne Edwards & Bouvier, 1893)	0	6	3	12	0	60	21
Panopeus herbstii Milne Edwards, 1834	3	0	0	0	0	20	3
Panopeus harttii Smith, 1869	0	4	3	0	0	40	7
Panopeus lacustris Desbonne, 1867	0	1	0	0	0	20	1
Panopeus occidentalis de Saussure, 1857	19	3	11	0	0	60	33
Panopeus sp	0	0	0	0	0	60	10
Panoplax depressa Stimpson, 1871	0	1	1	0	0	40	2
Panulirus argus (Latreille, 1804)	0	2	0	0	0	20	2
Paractaea rufopunctata nodosa (Stimpson, 1860)	0	0	0	2	0	20	2
Penaeidae (*Penaeus?)* sp	0	1	4	0	0	40	5
Periclimenes (*Harpilius*) *americanus* (Kingsley, 1878)	0	2	28	18	0	60	48
Periclimenes (*Periclimenes*) *longicaudatus* (Stimpson, 1860)	0	0	5	4	0	40	9
Periclimenes (*Periclimenes) pedersoni* Chace, 1958	0	1	0	0	0	20	1
Periclimenes sp	0	0	2	0	0	20	2
Persephona mediterranea (Herbst, 1794)	1	0	0	0	0	20	1
Petrolisthes armatus (Gibbes, 1850)	59	2	0	0	0	40	61
Petrolisthes galathinus (Bosc, 1802)	0	1	12	0	0	40	13
Pilumnus caribaeus Desbone & Schramm, 1867	1	0	0	0	0	20	1
Pilumnus dasypodus Kingsley, 1879	0	1	0	0	0	20	1
Pilumnus gemmatus Stimpson, 1860	0	0	0	2	0	20	2
Pilumnus pannosus Rathbun, 1896	3	4	3	2	0	80	12
Pilumnus sp	0	0	1	1	0	40	2
Pinnixa floridana Rathbun, 1918	1	0	0	0	0	20	1
Pitho aculeata (Gibbes, 1850)	0	0	0	1	0	20	1
Pitho anisodon (Von Martens, 1872)	0	8	2	31	0	60	41
Pitho lherminieri (Schramm in Desbonne and Schramm, 1867)	0	7	8	2	0	60	17
Pitho mirabilis (Herbst, 1794)	0	1	0	0	0	20	1
Pitho quadridentata (Miers, 1879)	1	3	4	11	0	80	19
Pitho sp	0	0	4	6	0	40	10
Plathylambrus serrata (H. Milne Edwards,1834)	1	0	0	0	0	20	1
Polyonyx gibbesi Haig, 1956	6	0	0	0	0	20	6
Portunus anceps (de Saussure, 1858)	0	0	1	0	0	20	1
Portunus depressifrons (Stimpson, 1859)	3	0	1	0	0	40	4
Portunus ordwayi (Stimpson, 1860)	3	3	3	0	0	60	9
Portunus sebae (H. Milne Edwards, 1834)	0	0	1	0	0	20	1
Portunus sp	0	0	1	0	0	20	1
Processa bermudensis (Rankin, 1900)	0	1	1	4	0	60	6
Processa sp	0	0	0	3	0	20	3
Sicyonia laevigata Stimpson, 1871	0	0	1	1	0	40	2

Sicyonia parri (Burkenroad, 1934)	0	0	1	0	0	20	1
Sicyonia stimpsoni Bouvier, 1905	0	0	0	1	0	20	1
Sicyonia typica (Boeck, 1864)	3	28	19	66	0	80	116
Synalpheus brevicarpus (Herrick, 1891)	0	24	9	1	0	60	34
Synalpheus brooksi Coutière, 1909	0	8	50	2	0	60	60
Synalpheus longicarpus (Herrick, 1891)	0	0	7	0	0	20	7
Synalpheus minus (Say, 1818)	3	1	0	0	0	40	4
Synalpheus pectiniger Coutière, 1907	0	2	0	8	0	40	10
Synalpheus sp	2	0	0	4	0	40	6
Thersandrus compressus (Desbonne, 1867)	5	0	0	2	0	40	7
Thor dobkini Chace, 1972	0	0	1	10	0	40	11
Thor floridanus Kingsley, 1878	0	4	10	7	0	60	21
Thor manningi Chace, 1972	0	1	0	1	0	40	2
Thor sp	0	0	4	8	0	40	12
Tozeuma carolinense Kingsley, 1878	1	5	33	82	0	80	121
Trachypenaeopsis mobilispinis (Rathbun, 1915)	1	0	1	0	0	40	2
Rimapenaeus constrictus (Stimpson, 1874)	6	8	1	7	0	80	22
Rimapenaeus similis (Smith, 1885)	0	5	1	0	0	40	6
Upogebia affinis (Say, 1818)	1	0	0	0	0	20	1
Xanthodius denticulatus (White, 1847)	0	1	0	0	0	20	1
Total number of species	49	60	77	56	5		**126**
Total number of individuals	236	284	436	565	8		**1529**
Number of station	27	23	25	30	20		
Samples with decapods (%)	81.5	100	82.4	84.1	25		

Table 4. Number of shared species and of exclusive species between the defined sectors (Ca: Cardenas Bay, SC: Santa Clara, F-SJ: Fragoso-San Juán de los Remedios, BB-CC: Buenavista Bay-Coco Key, PB-Sa: Perros Bay-Sabinal).

Tableau 4. Nombre d'espèces en commun entre les secteurs précédemment définis et d'espèces exclusives (Ca : Baie de Cardenas, SC : Santa Clara, F-SJ : Fragoso-San Juán de los Remedios, BB-CC : Baie de Buenavista-Caye Coco, PB-Sa : Baie de Perros-Sabinal).

Shared species	Ca	SC	F-SJR	BB-CC	PB-Sa
Ca		21	24	17	1
SC			42	30	4
F-SJR				40	4
BB-CC					40
BP-SA					
	Ca	SC	F-SJR	BB-CC	PB-Sa
Exclusive species	18	11	15	7	0

Fragoso Key-San Juan de los Remedios: 77/37.9; Buenavista Bay-Coco Key: 56/43 and Perros Bay-Sabinal: 6/46.2; Pearson's correlation coefficient, r = - 0.86, P = 0.063).

Discussion

In comparison to data obtained from the Batabanó Gulf, South of Cuba, in which a total of 216 species was caught in three keys (Martínez Iglesias & García Raso, 1999), the biodiversity of the decapods from the Sabana-Camaguey Archipelago (including Cardenas Bay) could be considered as medium-low. However, this lower number of specie was, at least in part, also due to the fact that we have only studied the megabenthos from soft bottoms (no other substrata or biotopes).

The number of exclusive and shared species (Tables 3 & 4), which can be used as descriptors of the sectors (and/or biotopes), showed the occurrence of an environmental gradient between these, with a progressive decrease of shared species with the distance. A similarity in the specific composition implies, in general, a similarity of habitats (Gore et al., 1978). This would support the highest similarity between Santa Clara and Fragoso-San Juan de los Remedios (Figs. 3 & 4), contiguous sectors, in which the higher values of abundances and richness were found. Both sectors are open to the ocean and an intense water exchange exists (Lluis Riera et al., 1989), which allows a more stable salinity, with values close to those of open sea (rarely higher than 40) and there is not excessive accumulation of mud and MOP (Alcolado et al., 1998). Also, in both, a greater density of seagrasses and macroalgae exist (Table

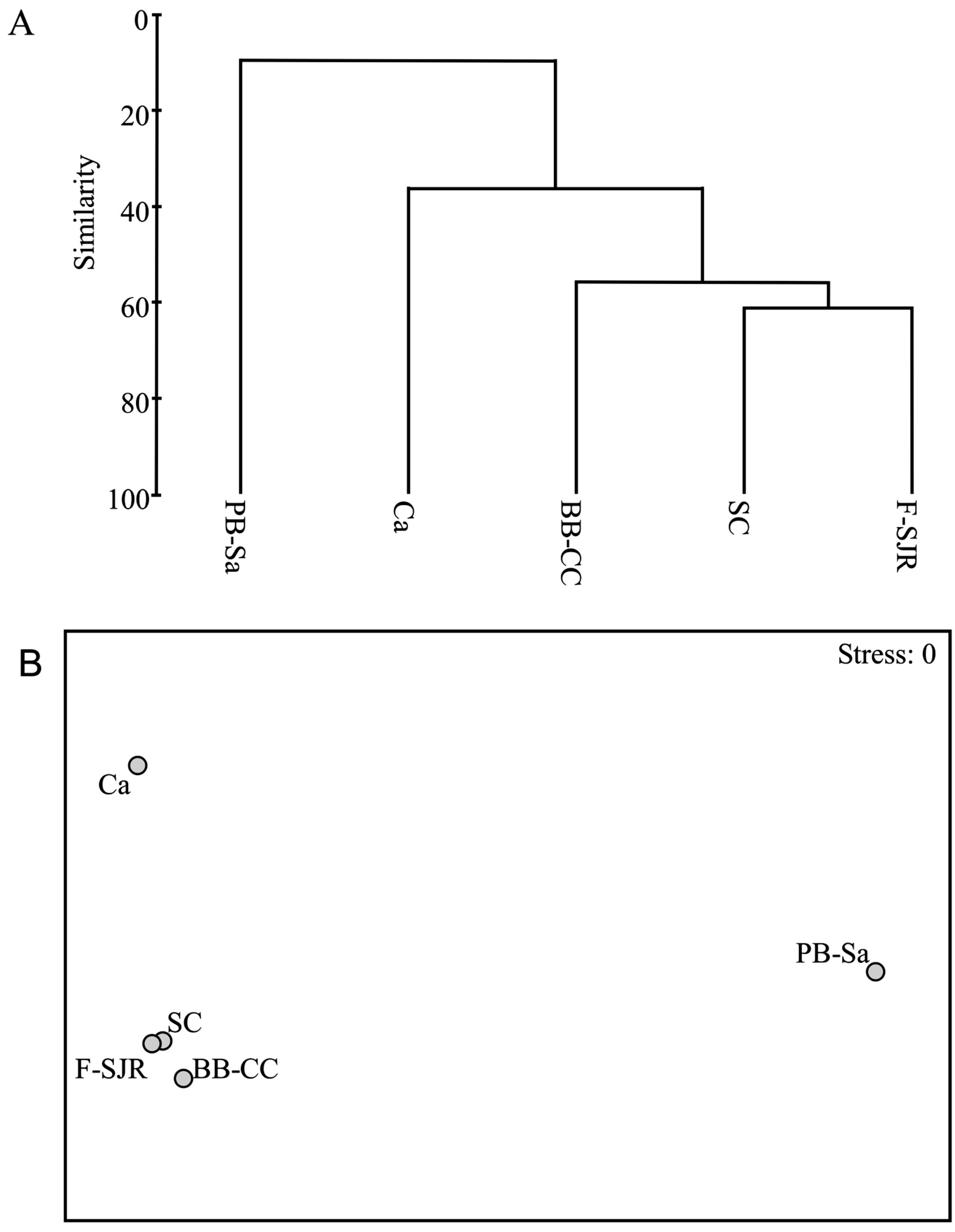

Figure 4. Aggregation (A) and MDS ordination analyses (B) of qualitative data (presence/absence) by sector (Ca: Cardenas Bay, SC: Santa Clara, F-SJ: Fragoso-San Juán de los Remedios, BB-CC: Buenavista Bay-Coco Key, PB-Sa: Perros Bay-Sabinal).

Figure 4. Agrégation (A) et ordination multidimensionnelle MDS (B) des données qualitatives (présence/absence) par secteur (Ca : Baie de Cardenas, SC : Santa Clara, F-SJ : Fragoso-San Juán de los Remedios, BB-CC : Baie de Buenavista-Caye Coco, PB-Sa : Baie de Perros-Sabinal)

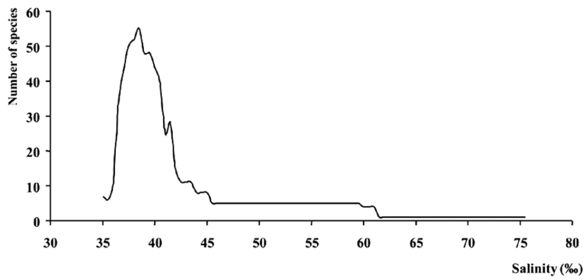

Figure 5. General curve of salinity-richness in the studied area.
Figure 5. Relation salinité-richesse spécifique dans la zone étudiée.

1). This is a very important factor because it induces an increase in the structural heterogeneity, giving a three-dimensional scale to the area and providing more ecological niches available to different species, which increases the structural complexity of the communities (Gray, 1977; Isaksson & Pihl, 1992). In fact, a well developed vegetal community (in addition to the type-particle size of the sediments) is one of the more important determinants of the species composition and abundances in benthic communities (Thorhaug & Roessler, 1977; Gore et al., 1981; Baden & Pihl, 1984; Pihl, 1986; Isaksson & Pihl, 1992; Manjón-Cabeza & García Raso, 1998). This consideration agrees with the result found inside of the macrolagoon in which there was a significant correlation between richness and the total vegetal biomass. The abundance of species such as *Tozeuma carolinense* was influenced by this factor.

In these open sectors, and particularly in the western part of Santa Clara, retention of bioparticles occurred (seston and benthic larval settlement, coming from eastern) which increased the zoobenthos density (Alcolado et al., 1998). Also, in these areas, sponges were abundant, which contributed to increase the structural complexity of the decapod community. This could justify the abundance of *Synalpheus brooksi*, in Fragoso Key-San Juan de los Remedios because this species was associated with sponges (Erdman & Blake, 1987).

By contrast, the studied eastern margin (Perros Bay to Ensenada Sabinal) is a sector almost closed, with very scarce water exchange, highest salinity, high concentrations of clay, turbidity and water temperature, and almost no vegetal formations (Alcolado et al., 1998; Tables 1 and 2). All these features suggested an environmental stress, which produced lower richness. In this way, the salinity may have a clear influence in the richness of decapods (Abele, 1982) and in the general community diversity (Therriault & Kolasa, 1999). In our study, the high salinity was an obvious limiting factor. From our data and captures, only the species *Callinectes sapidus* was clearly euryhaline, living in salinity range from 0 (Abele & Kim, 1989) to 75 (present study). Another important factor was the restricted water circulation, which along other factors, such as the higher temperatures and salinities (absolute values and ranges), could limit larval access and the colonization for several species as seen in Florida (Holmquist et al., 1989a&b). These unfavourable conditions were exacerbated in this sector by the landfill roads built across this shallow marine water bodies, which reduced the water flow and generated hypersaline conditions, anoxia, and changes in the biotic communities, such as the mortality of seagrasses. Also during many years, the evaporation of this area has been higher than fresh water input and the hydrology was very fluctuating (see Alcolado et al 1998). On this sector, our data showed a precarious and preoccupant situation and that makes necessary the development of an intensive management program.

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