

# Temporal and spatial distribution of Cladocera in the coast of Rio de Janeiro City, Brazil

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## Abstract

The aim of this study was to analyse the seasonal and spatial variation pattern of marine cladocerans at part of Rio de Janeiro coast. Monthly samplings were made from September 1988 to September 1989 at 8 stations: 4 located close to the coast and 4 farther away. Five species of cladocerans were observed: *Penilia avirostris*, *Pseudevadne tergestina*, *Evadne spinifera*, *Pleopis polyphemoides* and *Podon intermedius*. In general, these organisms presented high densities in the spring-summer period. Densities dropped in winter and a number of species disappeared. The species *P. avirostris* and *P. polyphemoides* displayed their greatest densities in the stations closer to the coast, in contrast with *P. tergestina* and *E. spinifera*. These results confirm the neritic and estuarine nature for the two first species, and indicate an oceanic affinity for *E. spinifera* and *P. tergestina*. The hypothesis of temperature influence on the temporal and spatial distribution of cladocerans is contested.

**Key words:** Zooplankton, Crustacea, Cladocera, Distribution, Brazil.

## Introduction

So-called marine "cladocerans" are small crustaceans generally observed in coastal and estuarine waters, and may represent an important fraction of the mesozooplanktonic community during some periods of the year (Gieskes, 1971; Della Croce and Venugopal, 1972; Tang *et al.*, 1995). Thus, these organisms play an important trophodynamic role, serving as food for fish, for carnivorous zooplankton species and their larvae (Cheng and Chao, 1982).

One of the most interesting aspects observed in marine cladocerans refers to their reproductive strategy, which alternates parthenogenetic and gamogenic phases. For most part of the year only females occur, which reproduce by parthenogenesis, generating just females. Normally, under optimum conditions the population have rapid growth, stemming from their parthenogenetic generation and sometimes even exceeding the densities of other zooplankton (Onbé, 1978a; Tang *et al.*, 1995). The females retain their eggs in a brood pouch and the embryos continue to develop until they become miniature of the adult animal, then they are released in the water with the maternal exuvia (Ramirez, 1981). When environmental conditions become unfavourable the females, which had previously been reproducing by parthenogenesis, form eggs that originate individuals of different sexes promoting the appearance of males in population. Following copulation and fecundation, generally the female produces a single large egg with a resistant external membrane, the so-called resting egg (Onbé, 1978b). In this period, cladocerans populations suffer a decline in density, even to the point of disappearing from plankton, whereas the resting eggs remain in the sea bottom. The animal developed from a resting egg is always a female that restarts the parthenogenetic cycle.

In spite of their abundance in warm and temperate water, marine cladocerans have received a little attention when compared to the great number of papers related to other planktonic crustaceans, such as copepods. The available data on marine cladocerans come from observations made mainly in temperate

waters [e.g. South Atlantic (Ramirez and De Vreese, 1974; Ramirez and Perez Seijas, 1985), the North Atlantic and North Sea (Gieskes, 1971), the East coast of Sweden (Eriksson, 1974), the Mediterranean (Specchi, 1970; Thiriot, 1972; Moraitou-Apostolou and Kiotsis, 1973), the Indian Ocean (Della Croce and Venugopal, 1972), and the East Pacific (Longhurst and Seibert, 1972)]. Marine cladocerans have already been reported by several authors in Brazilian waters (Barth, 1972; Bonecker *et al.*, 1991; Resgalla and Montú, 1993). Marazzo (1998) started observations on marine cladocerans in Guanabara Bay (Rio de Janeiro - Brazil), with the objective of detecting spatial and temporal patterns in distribution, occurrence and reproduction.

The present paper aims to contribute with additional information on the temporal and spatial distribution patterns of marine cladocerans in tropical waters, thereby providing subsidies to future research with these animals. This research attempts to determine the occurrence and seasonality of marine cladocerans and the density and percentage of parthenogenetic females, gamogenic females and males, off the coast of Rio de Janeiro city, Brazil.

## Materials and Methods

The samples analysed result from an integrated research program between the Water and Sanitation State Company (CEDAE) and the Zooplankton Laboratory of the Marine Biology Department - UFRJ. Rio de Janeiro city is in Southeastern Brazil ( $22^{\circ}57'30''$  -  $23^{\circ}04'42''$  S and  $43^{\circ}11'12''$  -  $43^{\circ}14'00''$  W) and displays a humid tropical climate, with a rainy season in summer - from December to March (IBGE, 1977).

The sampling was made from September 1988 to September 1989 (except December), at eight stations located in the region close to the submarine sewage discharge pipeline in Ipanema, with an average depth of 27 m. Four stations are located close to the shoreline (3A, 3B, 3C and 3D), whereas the others are farther away (1A, 1B, 1D and 2E) (Figure 1). The numeric codes of the sampling stations follows the codes defined by CEDAE in its research program.

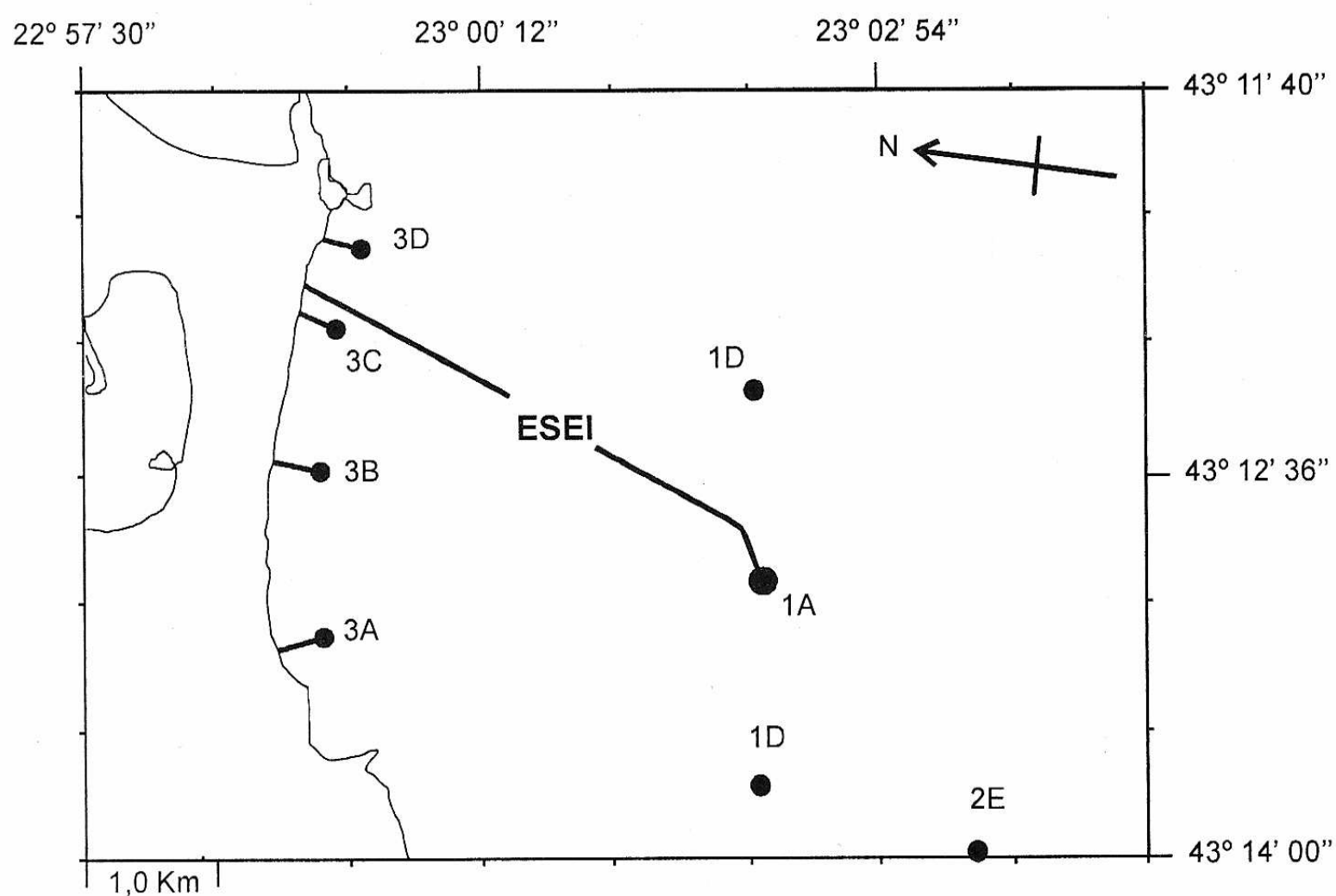


Figure 1: Location of sampling stations in the proximities of the submarine sewage discharge pipeline in Ipanema (ESEI).

The samples were obtained by horizontal hauls in the surface, with a conical-cylindrical net (200 $\mu$ m mesh-sized). The material collected was preserved in formaldehyde 4%, neutralized with sodium tetraborate (Steedman, 1981). Temperature and salinity data were simultaneously obtained. At the laboratory, the organisms were identified and quantified on the whole of the sample or on subsamples, in the case of high abundance of organisms.

The mean values, standard deviation and standard error of abiotic and biotic variables were calculated considering the set of the eight stations. In this paper we could use the mean values because the proximity of the stations, what determines the homogeneity of physical and biological factors. The spatial distribution patterns of cladocerans were defined as from a cluster analysis of samples collected at the eight stations during the periods of high abundance, avoiding the inclusion of null values that make harder the formation of groups. The Manhattan distance and the complete linkage (amalgamation rule) were used (Legendre and Legendre, 1998).

Results

Surface water temperature variation reflects the climatic conditions in the study region, with maximum values (29°C) in summer and minimum in winter (21.5°C). However, an anomalous value was observed in January 1989 (Figure 2). Mean salinity values varied between 33 and 36 (Figure 3). Station 1A had the lowest mean salinity values (< 32). Spatially, we observed great homogeneity of temperature and salinity among the eight sampling stations.

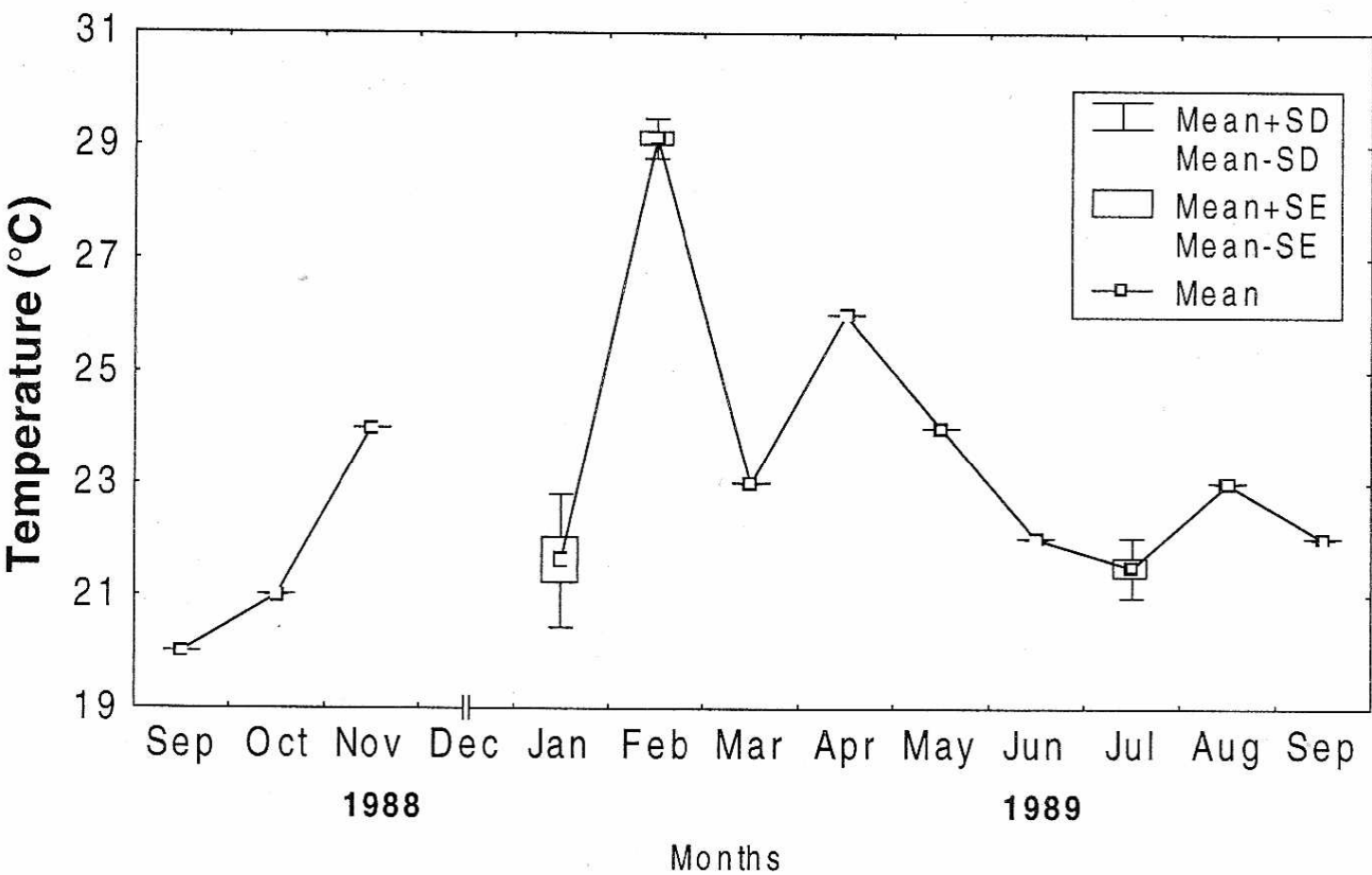


Figure 2: Mean surface water temperature values (°C) in the proximities of the submarine sewage discharge pipeline in Ipanema (SD = standard deviation; SE = standard error). No sampling was made in December 1988.

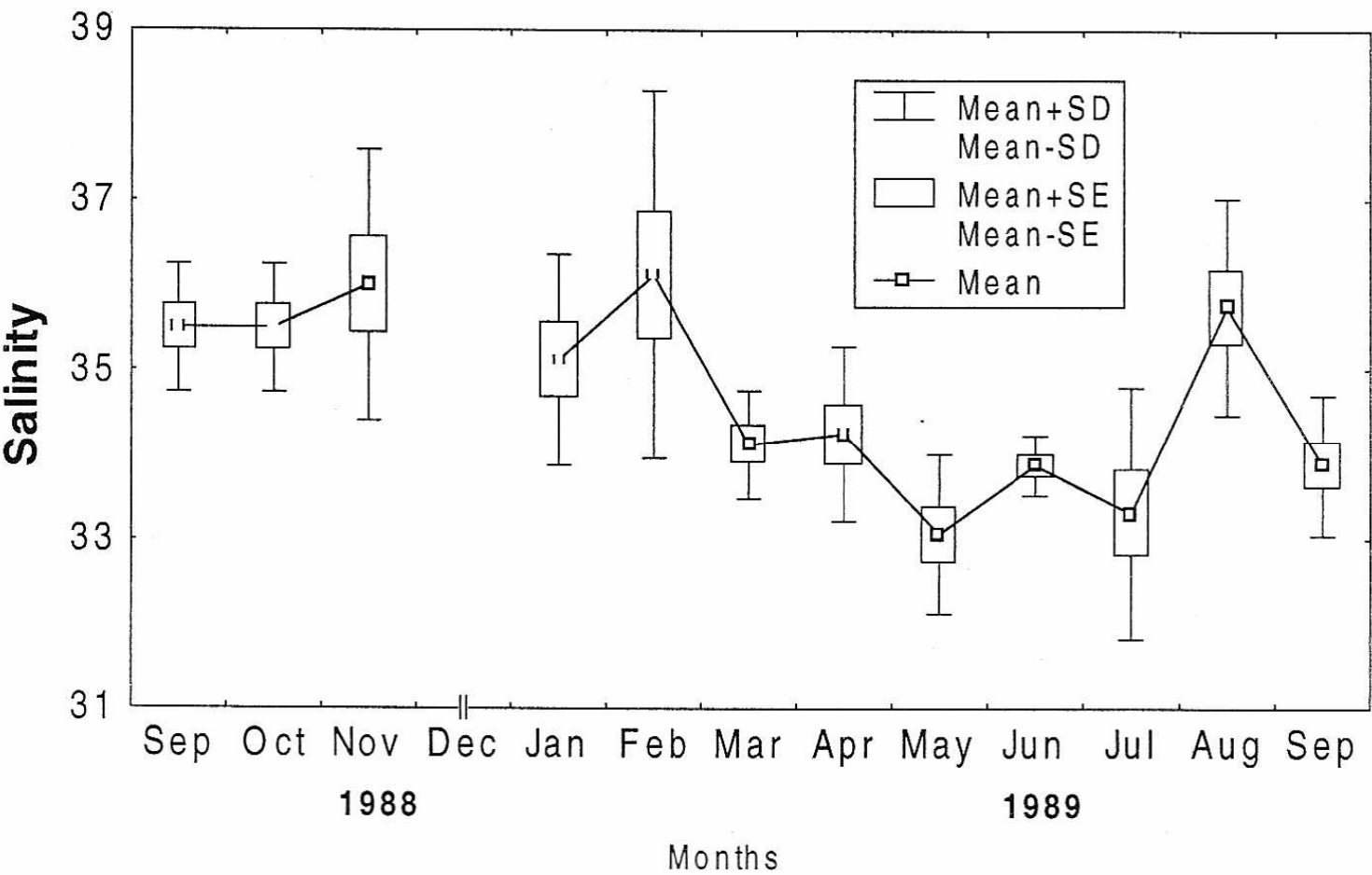


Figure 3: Mean surface water salinity values in the proximities of the submarine sewage discharge pipeline in Ipanema (SD = standard deviation; SE = standard error). No sampling was made in December 1988.



Five species of cladocerans were observed in this study: *Penilia avirostris*, *Pseudevadne tergestina*, *Evadne spinifera*, *Pleopis polyphemoides* and *Podon intermedius*.

*Penilia avirostris* had two well-marked peaks in the proximities of the submarine pipeline: in October 1988 (Max. = 1388 ind . m<sup>-3</sup>; mean = 286 ind . m<sup>-3</sup>) and April 1989 (Max. = 761 ind . m<sup>-3</sup>; mean = 419 ind . m<sup>-3</sup>). From May to September this species tended towards complete disappearance from the study area (< 13 ind . m<sup>-3</sup>). Gamogenic individuals were observed mainly in September 1988, comprising around 25% of the population, but also in a lower proportion in other months (between 1 - 10% of the population) (Figure 4). Females bearing two resting eggs were recorded in August, when the presence of only one egg in the brood pouch was usual.

Except for a single peak in January 1989 (Max. = 6469 ind . m<sup>-3</sup>, mean = 1536 ind . m<sup>-3</sup>), *Pseudevadne tergestina* densities were considerably low during the period of the study (< 53 ind . m<sup>-3</sup>). Gamogenic individuals occurred only in September (31%) and October (15%) 1988 (Figure 5).

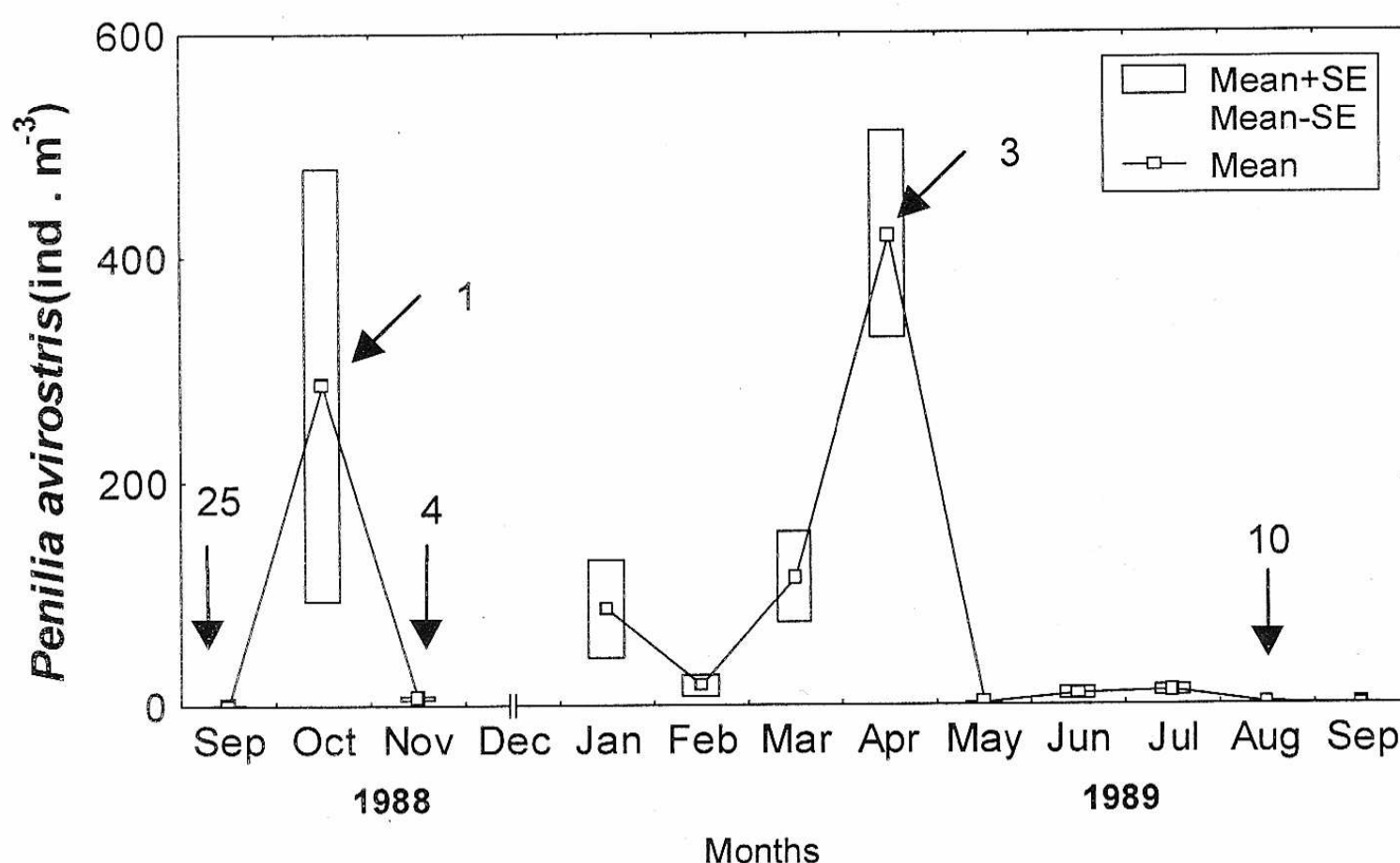


Figure 4: Abundance of *Penilia avirostris* in the proximities of the submarine sewage discharge pipeline in Ipanema (eight station mean) (SD = standard deviation; SE = standard error). The numbers indicate the percentage of gamogenic individuals. No sampling was made in December 1988.

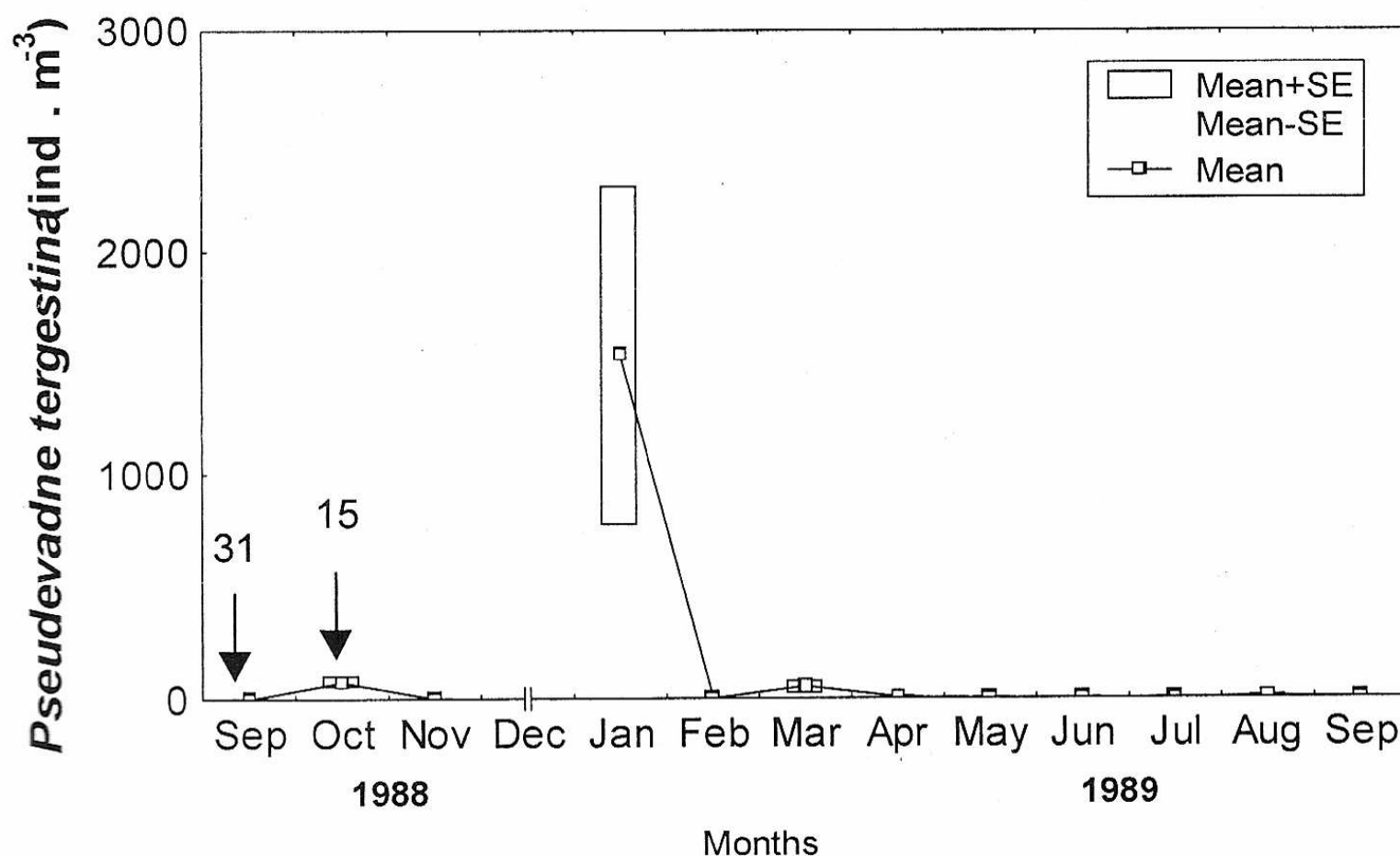
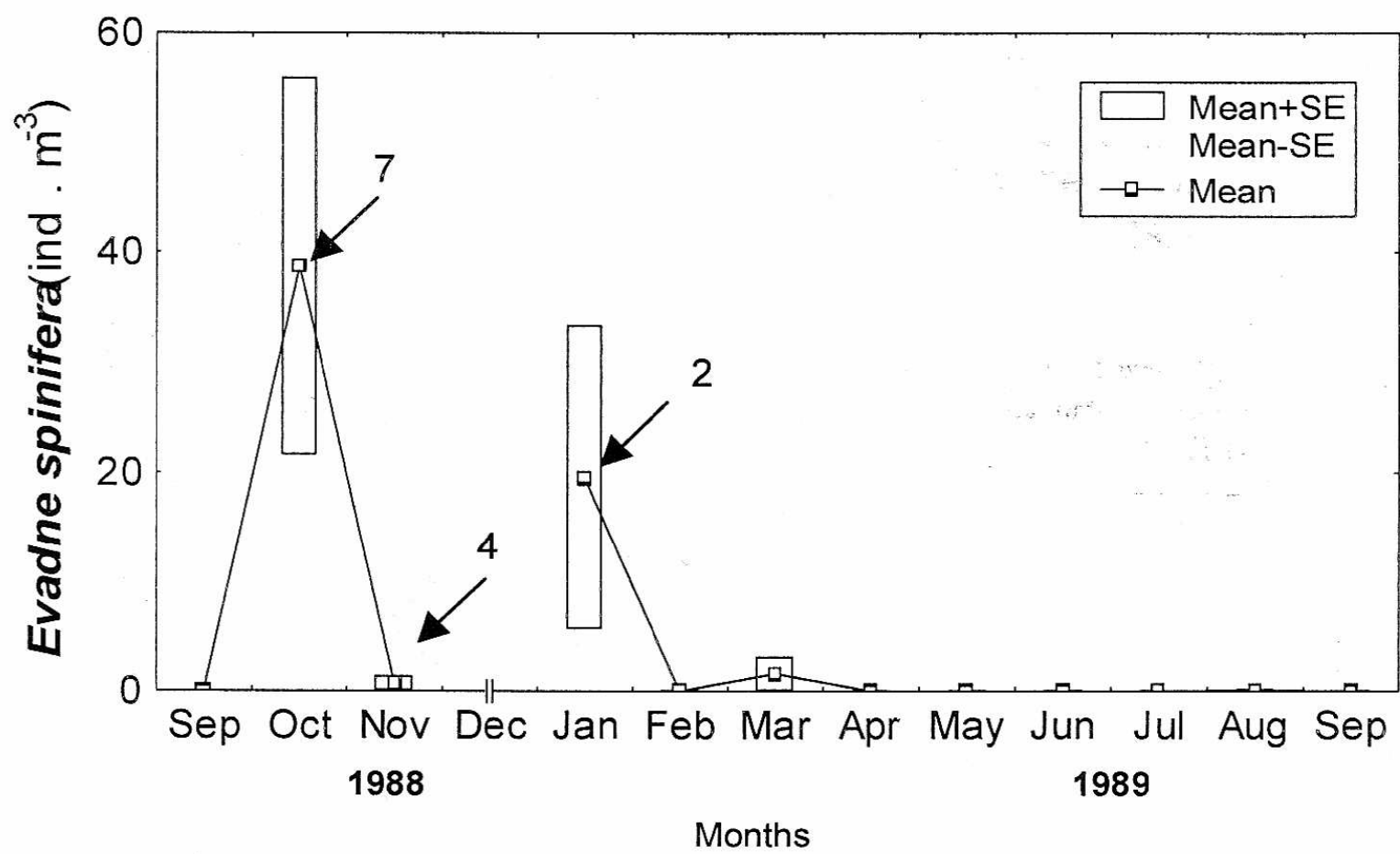


Figure 5: Abundance of *Pseudevadne tergestina* in the proximities of the submarine sewage discharge pipeline in Ipanema (eight station mean) (SD = standard deviation; SE = standard error). The numbers indicate the percentage of gamogenic individuals. No sampling was made in December 1988.

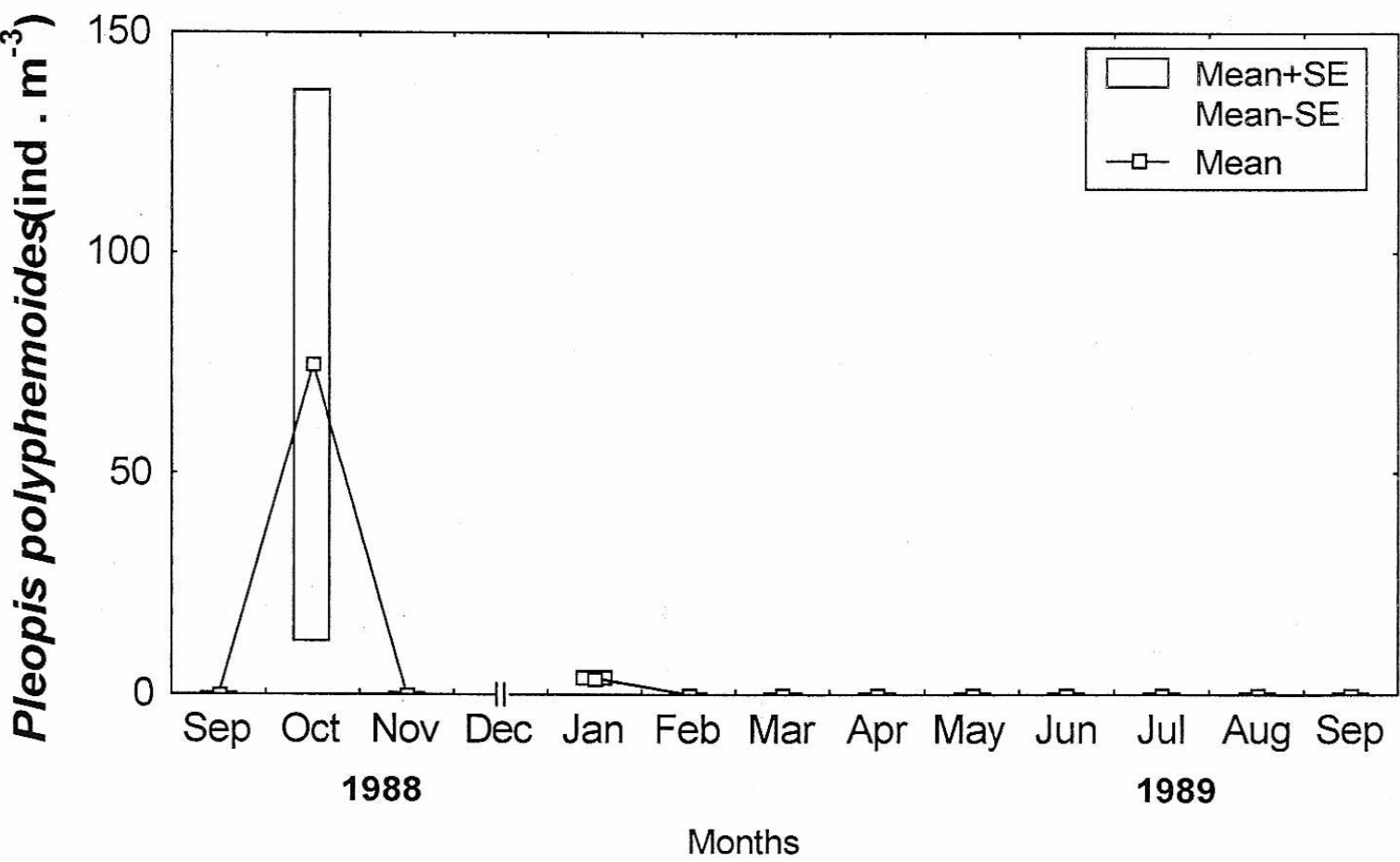
*Evadne spinifera* had its maximum densities in October 1988 (Max. = 101 ind . m<sup>-3</sup>, mean = 39 ind . m<sup>-3</sup>) and in January 1989 (Max. = 115 ind . m<sup>-3</sup>; mean = 19 ind . m<sup>-3</sup>). From March to September 1989, this species disappeared almost completely from the area (< 2 ind . m<sup>-3</sup>). Gamogenic individuals occurred in October (7%) and November (4%) 1988, and January (2%) 1989 (Figure 6).

*Pleopis polyphemoides* had a single peak in October 1988 (Max. = 444 ind . m<sup>-3</sup>; mean = 74 ind . m<sup>-3</sup>), all individuals being in a parthenogenetic phase (Figure 7), and *Podon intermedius* appeared only in January 1989 (< 2 ind . m<sup>-3</sup>; 9% gamogenic) (Figure 8).

In January 1989, cluster analysis showed two groups of stations: group I, with stations close to the shore, and group II, with stations farther away from the shore (Table I; Figure 9 a). The determination of these two discrete areas is due to a heterogeneous distribution of *P. polyphemoides*, more abundant at the stations close to the shoreline, and especially to the greater density of *P. tergestina* and *E. spinifera* at the farther stations. In January a quite homogeneous distribution of *P. avirostris* throughout the area was observed.



**Figure 6:** Abundance of *Evadne spinifera* in the proximities of the submarine sewage discharge pipeline in Ipanema (eight station mean) (SD = standard deviation; SE = standard error). The numbers indicate the percentage of gamogenic individuals. No sampling was made in December 1988.



**Figure 7:** Abundance of *Pleopis polyphemoides* in the proximities of the submarine sewage discharge pipeline in Ipanema (eight station mean) (SD = standard deviation; SE = standard error). No gamogenic individuals were detected for this species. No sampling was made in December 1988.

This pattern was also observed in October 1988 (Table I; Figure 9 b), although with a slight difference: station 3A joined group II, because the low abundance of *P. avirostris*, *P. polyphemoides* and *E. spinifera* in that station. In April 1989 (Table I, Figure 9 c), the distribution of cladocerans was more homogeneous, only station 2E stands out for its low density.

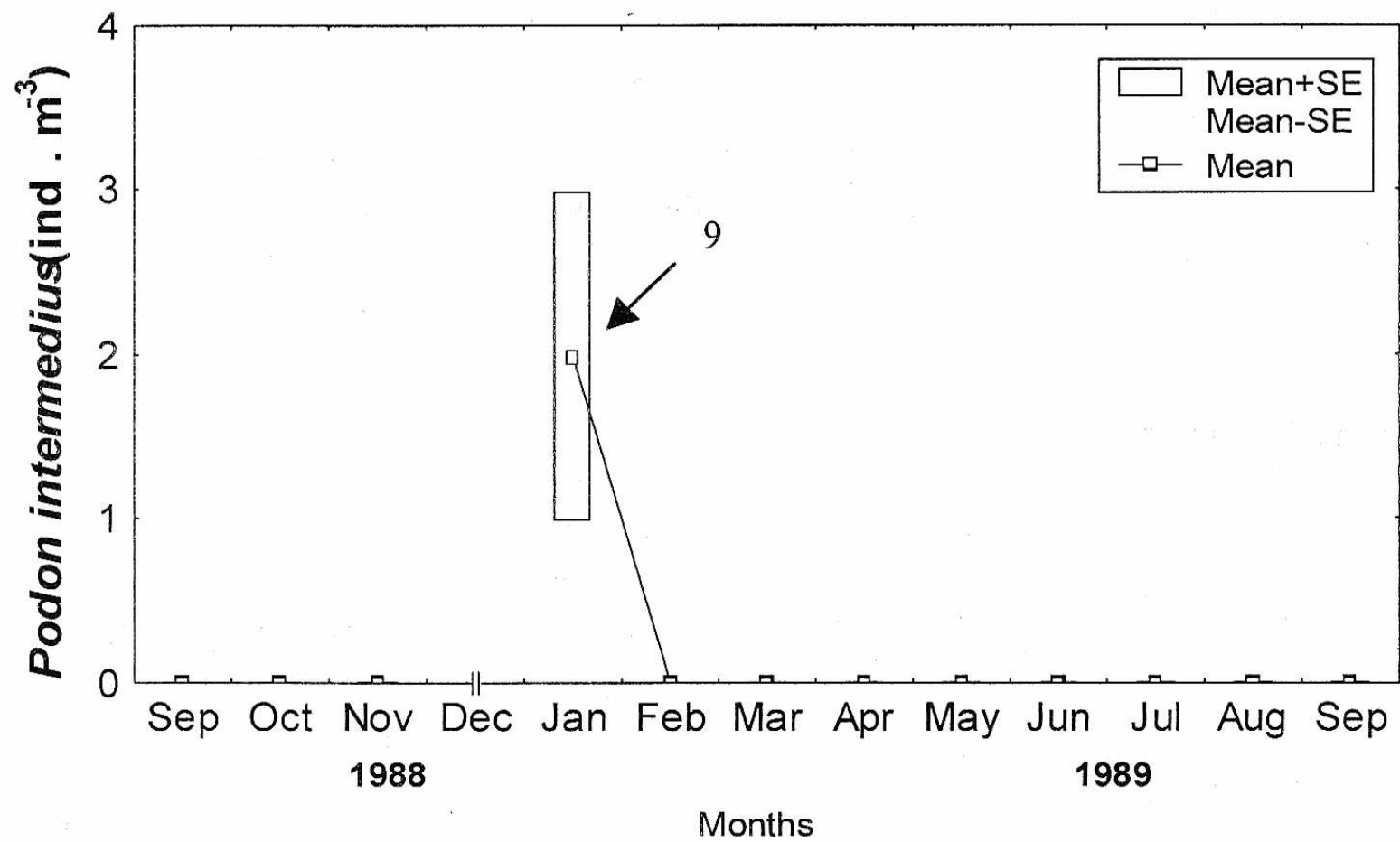


Figure 8: Abundance of *Podon intermedius* in the proximities of the submarine sewage discharge pipeline in Ipanema (eight station mean) (SD = standard deviation; SE = standard error). The numbers indicate the percentage of gamogenic individuals. No sampling was made in December 1988.

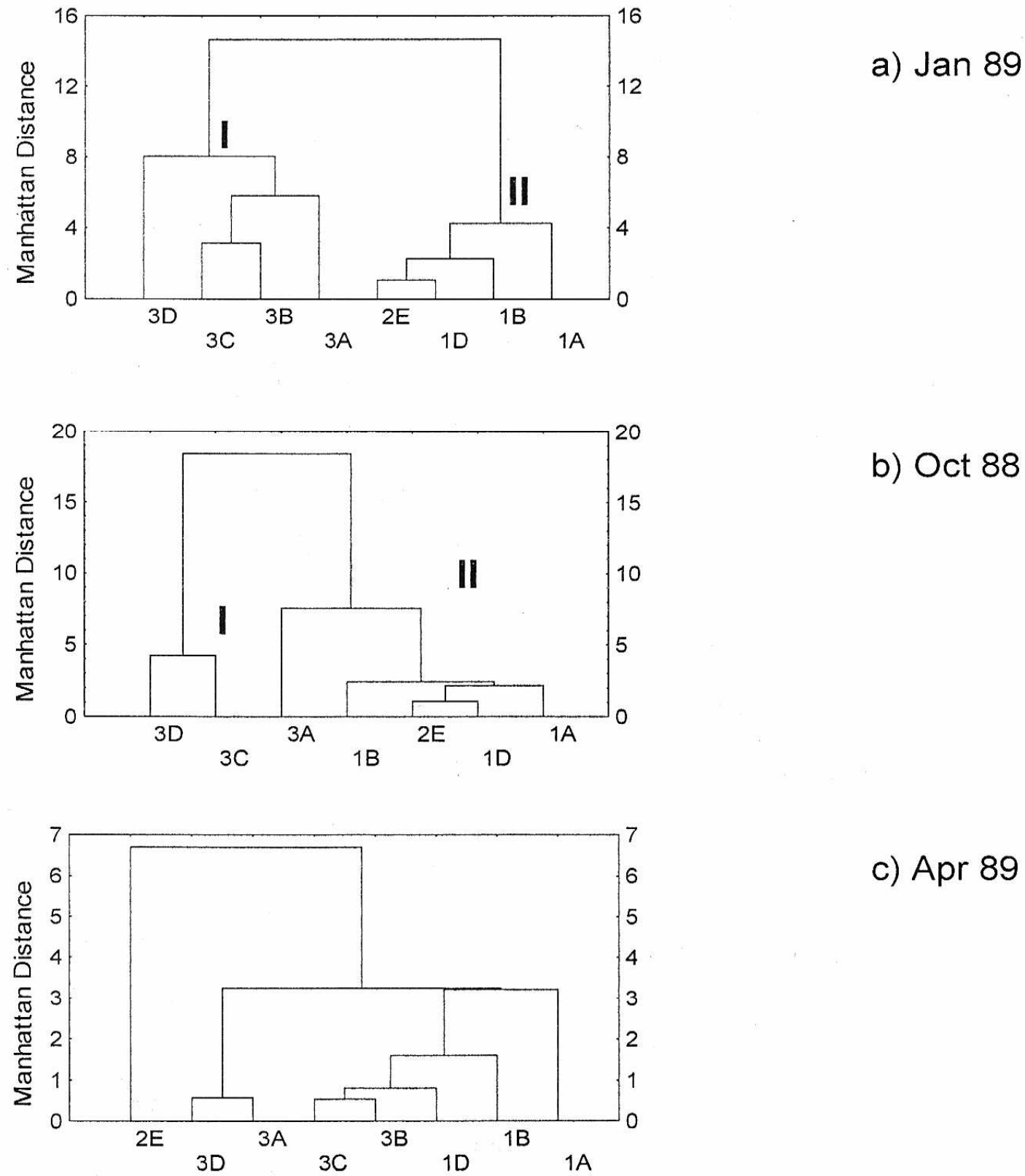


Figure 9: Cluster analysis using cladocerans abundances to group sampling stations in the submarine sewage discharge pipeline area in Ipanema during the months of greater abundance of cladocerans. The Manhattan distance and the complete linkage method were used. Group I: stations close to the shore; Group II: stations farther away from the shore.

**Table I:** Spatial distribution of cladocerans in the months of higher abundance (ind . m<sup>3</sup>).  
(\*) Missing data.

Month	Station	Species				
		<i>Penilia avirostris</i>	<i>Pseudevadne tergestina</i>	<i>Evadne spinifera</i>	<i>Pleopis polyphemoides</i>	<i>Podon intermedius</i>
Oct 88	1A	32	169	100	0	0
	1B	41	96	22	0	0
	1D	40	51	46	0	0
	2E	35	43	101	0	0
	3A	12	162	0	1	0
	3B	*	*	*	*	*
	3C	1388	2	0	444	0
	3D	455	6	1	76	0
Jan 89	1A	22	1515	115	1	0
	1B	12	6469	14	0	0
	1D	17	1515	9	0	0
	2E	20	2194	13	0	0
	3A	380	19	0	4	6
	3B	149	80	2	10	3
	3C	87	389	1	11	6
	3D	4	102	1	3	0
Apr 89	1A	95	4	0	0	0
	1B	485	23	0	0	0
	1D	722	6	0	0	0
	2E	13	0	0	0	0
	3A	762	0	0	0	0
	3B	437	8	0	0	0
	3C	403	5	0	0	0
	3D	434	0	0	0	0

Discussion

*Penilia avirostris*, *Pseudevadne tergestina*, *Evadne spinifera*, *Pleopis polyphemoides* and *Podon intermedius* are epiplanktonic, seasonally abundant in estuarine and coastal waters of temperate regions and in warm and tropical seas (Gieskes, 1971; Ramirez and Perez Seijas, 1985; Mordukhai-Boltovskoi and Rivier, 1987). The marked peaks of *P. avirostris*, *P. tergestina*, *E. spinifera* and *P. polyphemoides* observed in this study, match those described by several authors who worked with marine cladocerans in different parts of the world. They recorded a sudden increase in the population and documented the importance of these organisms, in quantitative terms, for the local zooplanktonic community in certain periods of the year (e.g. Onbé, 1978a; Ramirez and Perez Seijas, 1985; Tang *et al.*, 1995).

Nauplius



*Penilia avirostris* and *Pseudevadne tergestina* frequently appear associated as observed by Della Croce and Venugopal (1972) in the Indian Ocean, by Onbé and Ikeda (1995) in Toyama Bay, and by Tang *et al.* (1995) in coastal waters in the South of China. In the present study, these two species were associated both in time and space.

Although with maximum density in spring and autumn, *P. avirostris* has an annual and almost continuous spatial occurrence in the proximities of the submarine sewage discharge pipeline in Ipanema, thus matching Della Croce's (1974) observations. This author pointed out that *P. avirostris* is particularly abundant in coastal tropical waters. Annual cycles of this species have already been reported by other authors around the world (e.g. Rocha, 1977, studied the temporal distribution of cladocerans off the coast of Santos city, Brazil).

*Pseudevadne tergestina* and *Evadne spinifera* showed high densities in summer at the stations farthest from the shore and almost disappeared in the rest of the year, as also observed in other areas (Kim *et al.*, 1993; Onbé and Ikeda, 1995; Tang *et al.*, 1995). *E. spinifera* is mentioned by Valentin (1988), Resgalla & Montú (1993) and Alecrim (2000) as a rare species, with low tolerance to temperature and salinity variations.

*Pleopis polyphemoides*, a cosmopolitan species according to Ramirez (1981) occurred in a wide range of temperature and salinity. Its populational peak, observed during the end of the spring, is in accordance with Ramirez (1981) for the Argentinean coast. However, Resgalla and Montú (1993) defined winter as a dominant period for this species in the continental shelf of Rio Grande do Sul. *P. polyphemoides* occurred mainly at the stations close to the shoreline. The preference of this species for brackish environments (Ramirez, 1981; Onbé, 1999) suggests the influence of continental effluents in the area. However, the salinity levels observed do not support this hypothesis.

*Podon intermedius*, a very rare species in our samples, occurred only in January 1989, close to the shore. Temperatures were lower ( $= 23^{\circ}\text{C}$ ) than the monthly average for the same month, which might be explained by the penetration of deep waters. *P. intermedius* is a typical species of subtropical waters and, in fact, Valentin (1988) related the occurrence of this species to the upwelling in Cabo Frio region.

Until now, no conditioning factor has been found to justify neither the populational explosions, nor the disappearance of these organisms at certain times of the year. According to Ramirez and Perez Seijas (1985) and Onbé and Ikeda (1995) in temperate environments, the marked seasonality in the occurrence of marine cladocerans in plankton depends primarily on water temperature. Cladocerans may be considered seasonal organisms because of their absence during the winter, when survival is ensured by the presence of their resting eggs in the sea floor. This hypothesis of temperature influence as the determining factor for density decline and for the disappearance of the organisms from the proximities of the submarine sewage discharge pipeline, may be affecting the populational variation. However, considering that the temperatures observed for the winter months did not differ drastically from those found in the summer (as in temperate regions) and that no clear association between the density of marine cladocerans and temperature was found in other studies carried out in tropical regions (Resgalla and Montú, 1993; Marazzo, 1998; Alecrim, 2000), it would be premature to conclude about the occurrence of cladocerans as from the results obtained in this. The distribution of cladocerans in the pipeline area can be associated to other factors such as: trophic conditions (Ramirez, 1981), presence of predators (Cheng and Chao, 1982) and distribution of resting eggs in sediment (Onbé, 1974, 1977). The sudden growth of a population of cladocerans in the water is also connected to the hatching, even partial of the resting eggs. Although it was not possible to check this hypothesis because of lack of information on the distribution of these eggs in the area under study, it is probable that this factor acts frequently on the recruiting of planktonic populations, and their temporal and spatial distribution.

Tang *et al.* (1995) reported that the scarcity of females with resting eggs suggests that environmental conditions are favourable to the species. In such case, the population may spread mainly by parthenogenesis. So, the occurrence of resting eggs may be due to the action of some factor, which induced the appearance of their gamogenic individuals through the year. The action of pollutants from the pipeline over the



spatial distribution of marine cladocerans as well over sexual reproduction may not be discarded. However, up to now, we did not find any report on how the marine pollutants act on the physiology of marine cladocerans. Thus, other studies are required for the clarification of their possible influence.

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