SEASONAL DIATOM AND COPEPOD ABUNDANCES IN THE GULF OF MONTIJO, PANAMA

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ABSTRACT

Between November 1996 and December 1997 a study was conducted in the gulf of Montijo, Panamá to evaluate the spatial and seasonal diatom-copepod abundances. Water temperature averaged 29.1ºC and salinity fluctuated from a minimum of 21.6 psu in November 1996 to a maximum of 30.3 psu in March 1997. Secchi depths increased from inshore to offshore stations with higher values in March and October. A seasonal pattern of rainfall prevailed in the gulf with cumulative precipitation peaked in June, September and November whereas lower values were registered from January to April. Copepods and nauplii were numerically the major component of the zooplankton community comprised over 90% of the catches whereas phytoplankton was diatom dominated. Both groups showed a distinct seasonal pattern. Whereas copepods were dominant during the rainy season, diatoms were in the dry season. In addition, an inverse spatial diatom-copepod relation was observed. Copepod and nauplii abundances decreased from inshore to offshore stations whereas diatom increased. Field observations were consistent with an expected inhibitory effect of diatom on copepod population.

KEYWORDS

Phytoplankton, diatoms, zooplankton, seasonal plankton, gulf of Montijo.

RESUMEN

Se efectuó un estudio con el propósito de evaluar la abundancia espacial y estacional de copépodos y diatomeas en el golfo de Montijo, Panamá. Las muestras se recolectaron entre noviembre de 1996 y diciembre de 1997. La temperatura anual promedio fue 29.1 °C mientras que la salinidad fluctuó entre un mínimo de 21.6 psu en noviembre de 1996 y un máximo de 30.3 psu en marzo de 1997. La transparencia de las aguas aumento hacia el exterior del estuario con valores máximos en marzo y octubre. Las mayores precipitaciones se presentaron en junio, septiembre y noviembre y los mínimos entre enero y abril. El fitoplancton estuvo dominado por diatomeas mientras que el zooplancton por copépodos y nauplii. Ambos grupos mostraron un comportamiento anual inverso. Los copépodos fueron abundantes en la estación lluviosa y las diatomeas en la estación seca. La distribución espacial reflejó el mismo comportamiento. Los copépodos y nauplii disminuyeron hacia la boca del estuario mientras que las diatomeas aumentaron. Estas observaciones sugieren una relación inhibitoria entre las diatomeas y la población de copépodos.

PALABRAS CLAVES

Fitoplancton, diatomeas, zooplancton, plancton estacional, golfo de Montijo.

INTRODUCTION

Copepods are the most widely distributed zooplankton organisms in the marine ecosystems. They can graze both phytoplankton and micro zooplankton and play important roles in the dynamic of plankton in estuaries and coastal systems. As long as copepods dominate the zooplankton and are the major source of food for other organisms, diatoms dominate the phytoplankton assemblages. Several studies have been conducted to investigate aspects such as the graze relation between copepods and phytoplankton (Bautista & Harris, 1992; Dagg, 1995; Froneman, 2000) or the seasonal variation of species composition (Yoshioka *et al*., 1985; García & López, 1989; Buskey, 1993; Gilbes *et al*., 1996; Tilstone *et al.*, 2000) but the spatial and temporal variation of copepods and their relationships with food sources such as diatoms have seldom been explored. Traditionally, diatoms have been considered the bulk of food that sustains the marine food chain to top consumers and important fisheries (Cushing, 1989). However, several laboratories worldwide have presented strong evidence of inhibition of copepod reproduction by diatoms (Ban *et al.*, 1997). Some studies have reported that some diatoms potentially reduce copepod egg viability up to 100% (Ianora *et al.*, 2003). This strategy allows diatoms to reduce the grazer population and constitute a new model termed the paradox of diatom-copepod interaction in the pelagic food web (Ianora *et al.*, 2003). Since herbivorous copepods are the major predator of plankton diatom, it is possible to expect correspondence between their abundances on different temporal and/or spatial scales (Runge, 1988). This paper provides a description of changes observed in the diatom-copepod abundances in the estuarine system of the gulf of Montijo.

MATERIALS AND METHODS

Area of study

The Gulf of Montijo is an 80,765 ha area located on the Pacific coast, about 30 km southwest of the city of Santiago, province of Veraguas, western Panama (**Coordinates:** 07°45'N 081°07'W) (Fig. 1.). It is an estuarine system with humid tropical climate and fringed by mangroves with a wide variety of landscapes. The annual average precipitation is 3,000 mm, ranging between 2,000 and 3,200 mm.

Sample Collection, equipment and procedure

Samples for total diatoms abundance were obtained for one year from November 1996 to December 1997 in a six stations transect between Puerto Mutis and Cébaco Island. At each station three 10 liter surface samples were taken for analysis. Samples were passed through an 80 um mesh-size phytoplankton net to obtain 100 ml concentrates which were fixed in 3% buffered formalin. Three replicates and two aliquots per replicate were counted in a Sedgwick Rafter Plankton Counting Chamber under stereoscopic binocular microscope according to EPA procedure (1973). Zooplankton abundance was determined by count under a dissecting microscope and using a squared Petri disc. Readings of temperature, salinity and light penetration were recorded using an YSI-30 Conductivity-Salinometer and a Secchi disk.

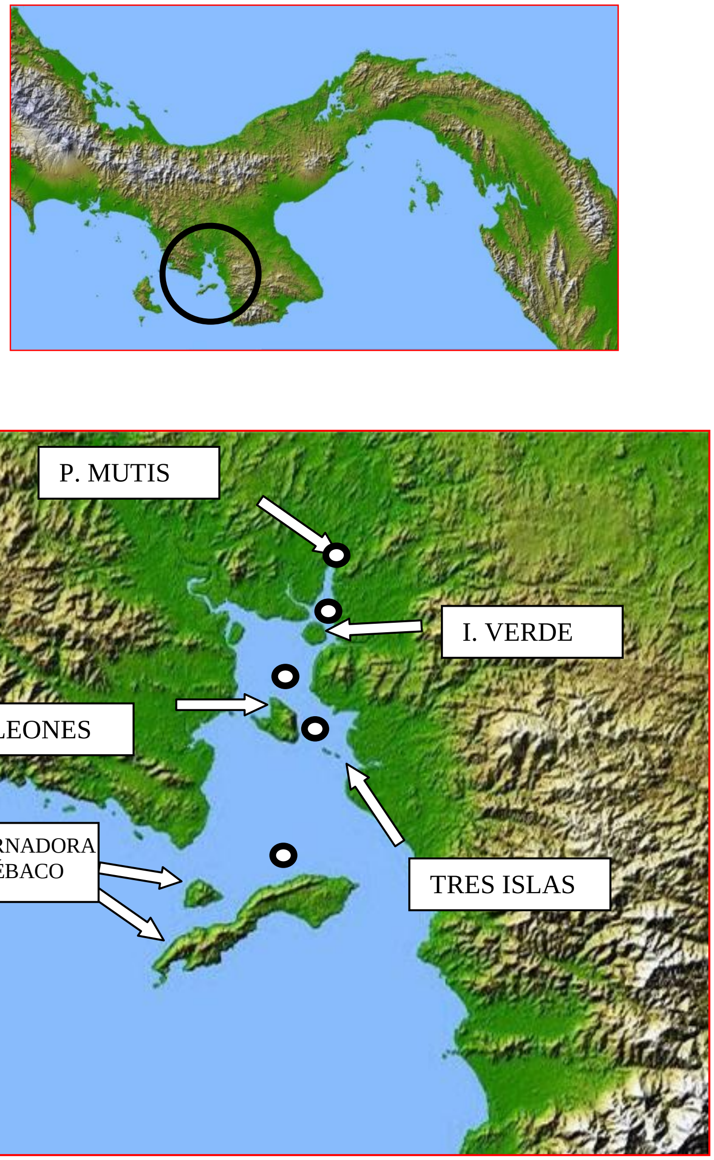


Fig.1. Map of the Republic of Panama, showing the Gulf of Montijo (Source: Earth Observatory, SERVIR.). The dots represent the sampling site.

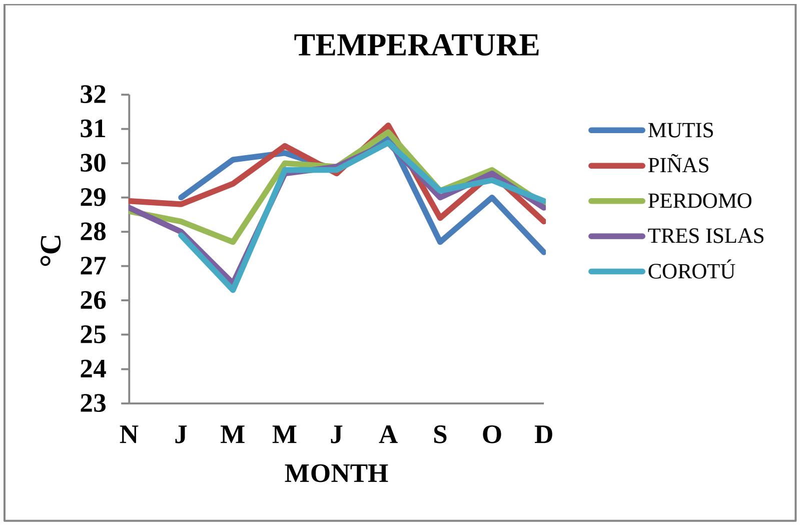
RESULTS

Hydrological parameters

Figure 2 shows the values of the main hydrological parameters in the gulf of Montijo. Water temperature in the gulf averaged 29.2 °C and ranged from 28°C in March to 30.8°C in August. Mean Secchi depths increased from inshore to offshore stations. Although it is difficult to identify a temporal pattern for Secchi fluctuations, higher transparences were found mainly in March and October whereas June showed lower values in almost all stations. A seasonal pattern of rainfall prevailed with higher values from May to December (Cumulative, 1904.7 mm) whereas lower values were registered from January to April (Cumulative, 73.5 mm). Cumulative precipitation peaked in June, September and November and the total annual was 1978, 2 mm. Mean monthly salinity fluctuated from a minimum of 19.1 psu in September to 30.3 psu in March. The annual salinity profile was more variable into than outer estuary.

Temporal diatom – copepod abundances

Monthly surface variations in total diatoms and copepod abundances are presented in Figure 3. Centric diatoms dominated the community structure throughout the study. Two peaks in diatom cell counts were observed, one in November 1996 and the other in December 1997, both at the beginning of the dry season. Only small fluctuations were observed during the rest of the year. Diatom annual mean of counts was 5518 cell/liter. On the other hand, copepods and nauplii dominated throughout the year and both groups accounted for the 96.8% of the zooplankton counts. Mean abundance of copepods during the study period was 76.8 individuals/10 liter (7680 individuals/m^3).


TEMPERATURE
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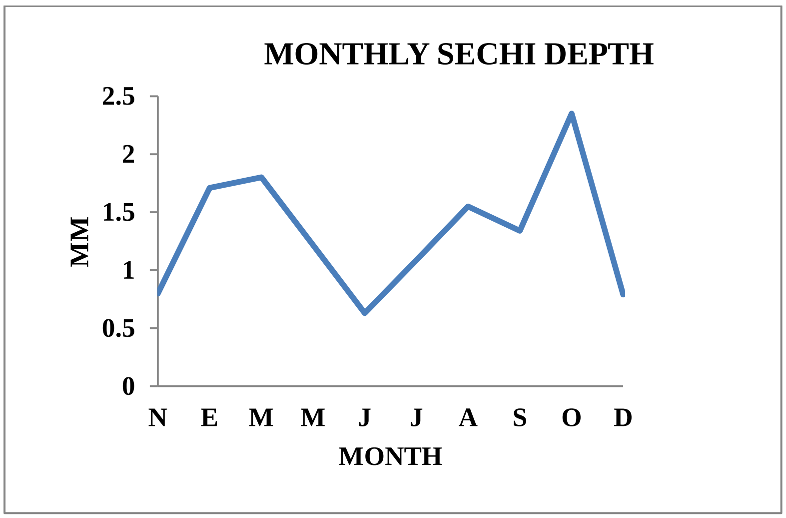
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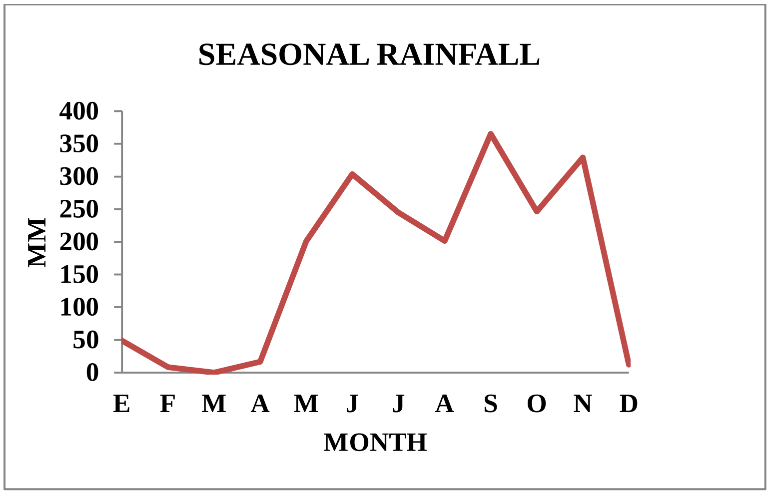
Fig.2a.



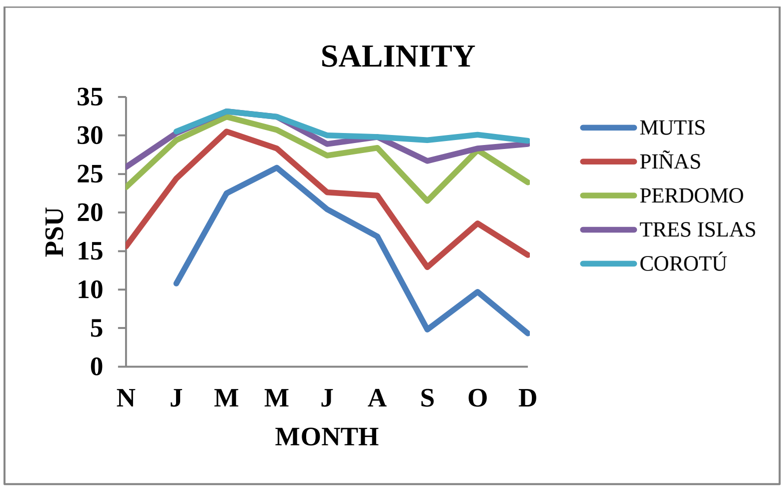


Fig.2b.

Fig.2a. y Fig.2b. Monthly hydrological parameters in the gulf of Montijo from November 1996 to December 1997.

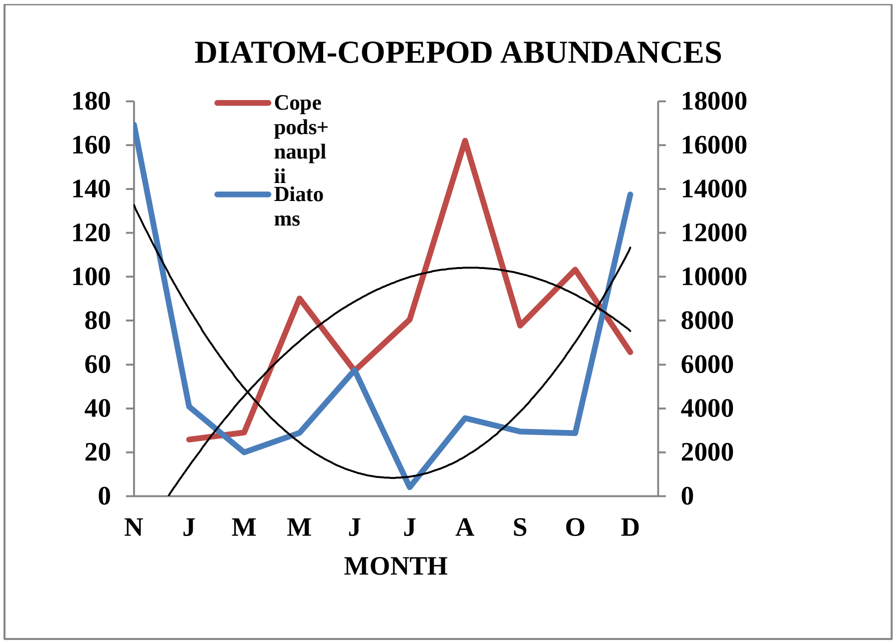


Fig. 3. Monthly diatoms and copepod + nauplii abundances in different station of the gulf of Montijo between November 1996 and December 1997. Values are annual mean and counts are expressed in individuals/10 liter for copepods and nauplii (left scale) and cel/liter for diatoms (right scale). Polynomial tendencies are showed (Black lines).

The highest mean count occurred in August with 162 individuals/10 liter (16200 individuals/m^3) whereas the lowest was in January with 25.8 individuals/10 liter (2 580 individuals/m^3).

Spatial diatom-copepod abundances

Figure 4 shows the annual means of diatom and copepods+ nauplii counts in different stations of the gulf of Montijo. Copepod and nauplii abundances decreased from inshore to offshore stations and was higher at Piñas station (One-way ANOVA; p= 0.0894). On the other hand, diatoms showed an opposite pattern increasing until a maximum at Perdomo station.

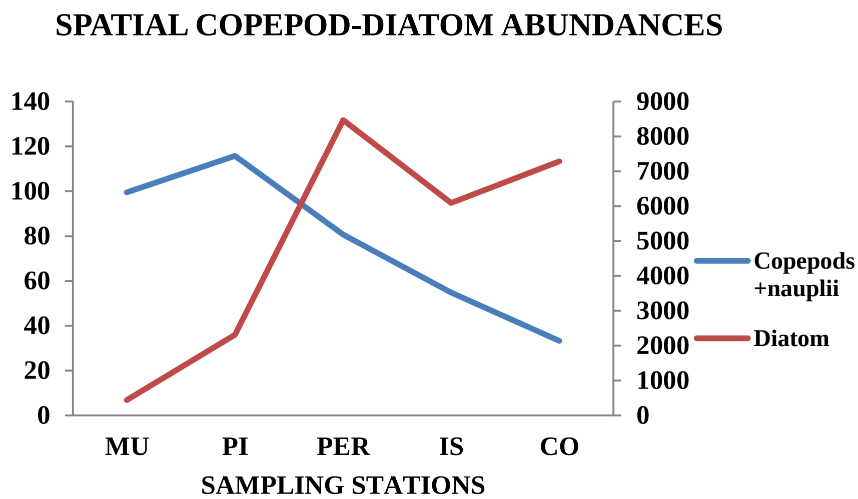


Fig.5. Abundances of diatoms and zooplankton in different station of the gulf of Montijo between November 1996 and December 1997. Values are annual mean of sampling stations and counts are expressed in individuals/10 liter for copepods and nauplii (left scale) and cel/liter for diatoms (right scale). (MU- Puerto Mutis; PE-Perdomo; PI- Piñas; IS-Tres Islas; CO-Punta Corotú).

DISCUSSION

Diatoms have long been considered as a major food source for planktonic copepods and traditionally have been regarded as beneficial to the growth of marine organisms and a key piece to the transfer of organic material through the marine food chain to top consumer (Cushing 1989, Legendre, 1990). However, different laboratories worldwide have demonstrated an inhibitory effect of diatom on copepod reproduction (Poulet *et al*., 1994, Syuhei *et al.*, 1997, Miralto *et al.*, 1999). As a consequence, a new biological model has been postulated to explain the apparent paradox of diatom-copepod interactions in the pelagic food web. According to the model while diatoms may provide a source of energy for copepod larval growth, they often reduce fecundity or hatching success or both (Ianora *et al.*, 2003, Roy & Chattopadhyay, 2007). This strategy allows diatoms to reduce the grazer population and since herbivorous copepods are the major predator of diatoms one may to expect correspondence between their abundances on different temporal and spatial scales. Field observations in the gulf of Montijo during the study period 1996-1997 were consistent with the model. Copepods and nauplii were numerically the major component of the zooplankton community whereas phytoplankton was diatom dominated. Both groups showed a distinct seasonal pattern. Copepods were dominant during the rainy season when diatoms abundances were low whereas on the dry season tendencies reverse. In estuarine environments, all living organism are well known to be subjected to diverse physical, chemical and biological factors and observed changes of biomass reflects the net result of these forces. It remains to be demonstrated if deleterious effect of diatom over copepods is responsible by the copepod-diatom pattern observed.

CONCLUSIONS

Field observations of copepod and diatom interactions in the gulf of Montijo during 1996-1997 periods were consistent with an inhibitory strategy of diatom on copepod abundances. Since changes in abundances might be the outcome of some other factors, it remains to be demonstrated if an inhibitory effect is responsible of observed changes.

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